

武蔵野台地における地質条件を反映した地下の熱伝導率と地下水流動の検討 Geothermal property and groundwater flow estimated from the lithology in the late Pleistocene terrace area, Tokyo, Japan

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Introduction

The ground source heat pump (GSHP) is a highly efficient and renewable energy technology for space heating and cooling, with benefits including energy conservation and reduction in greenhouse gases emission. After the Great Japan Earthquake and following nuclear disasters, GSHP is getting noticed by media and some local governments are introducing GSHP.

On the other hand, the GSHP installation under the ground might enhance pollutions in geo- heat environment or change groundwater flow due to thermal disturbance released from GSHP. In this study, the effect of the GSHP was estimated based on the 3D geological model in the Su Tokyo.

Geological model

The Tokyo metropolitan area is surrounded by the Late Pleistocene terraces called Musashino uplands. These areas are densely populated residential area. The Shimosueyohi surface is one of these terraces, which was formed along the Tama River, during the last deglacial period.

The CRE-NUCHS-1 core (Funabiki et al., 2011) was obtained from this area to know the lithology, heat transfer coefficient and chemical characteristics of the sediments. In this study, we collected borehole data logs within 5km square surrounding the core site, and created the 3 dimensional geological model. The lithology of this area consists of the Pleistocene Kazusa Group, terrace gravels, and volcanic ash layer called Kanto loam, in ascending order. The terrace gravel layer is located mainly beneath the Kanda, Kitazawa, and Karasuyama Rivers. These rivers flow parallel with the Tama River. At the center of the terraces, Kanto loam covered the Kazusa Group without terrace gravel.

Geothermal disturbance and groundwater flow

Using the geological model, heat transfer coefficient and groundwater flow velocity was calculated. In areas with thick terrace gravels, the heat transfer coefficient is high and groundwater flow is relatively fast. Since the terrace gravel is located at relatively shallower level (8-20m in depth), its thickness is one of the elements to affect the geothermal disturbance and groundwater flow in this area.

Acknowledgement

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Reference

Funabiki et al., (2011) Sedimentary facies and physical properties of the sediment core CRE-NUCHS-1 in Setagaya district, Tokyo, central Japan. Abstracts (Section B) for 2011 joint annual meeting of Japan Association of Mineralogical Sciences and the Geological Society of Japan.

キーワード: 地下熱汚染, 地下水, 熱伝導率, 段丘礫層

Keywords: Geothermal disturbance, Groundwater, Heat transfer coefficient, Terrace gravel

Numerical Analysis of Changes in Ground Temperature Caused by Ground Source Heat Pump System using HYDRUS

Numerical Analysis of Changes in Ground Temperature Caused by Ground Source Heat Pump System using HYDRUS

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Ground source heat pump systems (GSHP) that use ground or groundwater as a heat source can achieve much higher coefficient of performance (COP) than conventional air source heat pump systems because the temperature of the ground is generally much more stable than that of the air. Heat energy in the ground is then viewed as one of the renewable energy sources. GSHP has been receiving great interests among countries in North America and Western Europe, as well as some developed countries in Asia because it can potentially reduce energy consumption and greenhouse gas emission. While GSHP can inject heat from the buildings to the ground for cooling during the summer, it can pump heat stored in the ground for heating during the winter. Although it is rarely considered, installing too many GSHP systems nearby and/or running GSHP systems for long time may disturb the ground heat source. As some physical, chemical, and biological properties of the ground and groundwater are temperature dependent, this can eventually affect groundwater quality.

The effect of heat injection and pumping on the ground and groundwater temperatures therefore needs to be accurately quantified for assessing environmental impacts. Although there have been a number of studies predicting GSHP heat injection and pumping rates, their goals were usually to design optimum GSHP systems. The main objective of this study was to develop a model that allows predicting not only ground and groundwater temperatures but also changes in physical, chemical, and biological properties with GSHP under operation.

In this particular study, we used HYDRUS software to simulate heat exchange and transfer processes in the ground for a vertical-loop closed GSHP system. HYDRUS allows one to simulate variably-saturated water flow and solute and heat transport in porous media numerically in two- and three-dimensional domains with great flexibility in defining boundary conditions. At first, for model verification, changes in ground temperatures measured at every 5-m in the 50-m observation well installed 3.7 m from the 50-m long heat exchange boreholes, in which polyethylene heat exchanger tubes had been installed, were predicted in response to Thermal Response Test (TRT) conducted at our study site. Then, heat exchange and transfer processes for the vertical closed-loop GSHP systems were simulated to predict changes in ground and groundwater temperatures using three-dimensional domains. In this simulation, inside the polyethylene heat exchanger tube and the tube itself were assumed to be porous media. Very high hydraulic conductivity was assigned to the former, while very low hydraulic conductivity was assigned for the latter so that there would be only negligible water exchange between the ground and the heat exchange tube. This study demonstrated that HYDRUS was a very effective tool to assess the environmental impact, especially the temperature changes, when GSHP systems were used for injecting heat to the ground and pumping heat from the ground.

単粒・団粒構造を有する土壌の熱特性：粒径および形状による影響 Thermal Properties of Non-aggregated and Aggregated Soils: Effects of Particle Size and Shape

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土壌の熱特性（熱伝導率、熱容量）は廃棄物処分場や、熱処理技術による汚染土壌の除去などの熱移動過程を理解するために非常に重要である。

これまで様々な土壌において、水分状態や締固め度などの熱特性に対する影響は研究されてきた。しかし、土粒子の粒径や形状などのミクロな視点で熱特性との関係を記した研究は少ない。粒径や形状は土壌の充填構造（固相の屈曲度、接触数）に大きな影響を与えている。

本研究は異なる粒径や形状の単粒・団粒土を用い、様々な水分条件で熱特性を測定する。ミクロな視点で土壌の間隙構造を調べるために X 線 CT 装置を用いた。石英のような試料の鉱物組成の測定も行った。異なる水分状態で土壌の構造と鉱物組成がどのように土壌の熱特性に関係しているのか研究することが本研究の目的である。

キーワード: 熱特性, 熱伝導率, 土粒子粒径, 土粒子形状, 土壌間隙構造, 水分状態

Keywords: Thermal property, Thermal conductivity, Particles size, Particle shape, Soil-pore structure, Moisture condition

放棄された開放投棄地内の埋立ガスについて：スリランカ中央州・ウダパラータ/ガンボラサイトにおける研究事例 Landfill Gases at an Abandoned Open Dump: A Case Study from Udapalatha/Gampola Site in the Central Province of Sri Lanka

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Haphazard dumping of the municipal solid waste mostly observed in developing countries, where the waste is dumped in an uncontrolled manner. Although landfill gas is an important factor which causes odor and firing and indicates stability of the waste, there are very limited studies on the uncontrolled open dumps. In this study, landfill gas samples at 1 m depth from an abandoned open dump in Udapalatha (N 7° 09', E 80° 35') in the Central Province of Sri Lanka were collected on the end of November 2011 and the typical landfill gas composition such as O₂, N₂, CH₄, CO₂, H₂, H₂S, and N₂O were measured. Buried waste samples at 1 m depth were also taken from the site and organic carbon and nitrogen contents in the residue (smaller than 2 mm) were measured. The samples were taken from some marked plots inside the dump with waste ages of around 0.5 and 7 years (AOD_{0.5} and AOD₇) and outside intact. For comparison, landfill gas samples were also taken from another open dumping, Gohagoda (N 7° 19', E 80° 37') and an engineered landfill in Nuwara-Eliya (N 6° 58', E 80° 48'), those are under operation, in the same province.

Measured CH₄ concentration for AOD_{0.5} and AOD₇ ranged in 19-58 % and 0-12 %, respectively, suggesting that the dumped waste at 1 m depth was in the process to be the 'stabilization phase', where the CH₄ concentration is normally less than 45 %, at least 7 years after dumping. This is likely to be a much shorter time period to reach the phase after dumping than those in mid-latitude regions (typically in several decades). Measured CH₄ concentration for both Gohagoda and Nuwara-Eliya ranged in 56-57 %, suggesting that the waste inside were not stabilized. The carbon contents in the waste residue in AOD_{0.5} and AOD₇ were 151 and 29 mg g⁻¹, respectively, implying that high waste decomposition and leaching of organic compounds might be enhanced due to high temperature and precipitation at the site. A further study for the landfill gas and waste quality in the deeper layer is required to judge whether whole of the dumpsite had reached the stabilization phase rapidly. Besides, relatively high values of N₂O concentration were observed in some plots at AOD₇ (95 and 39 ppmv), suggesting that nitrification was stimulated due to time-dependent aerobic conditioning in the 1 m depth (measured O₂ concentration for the plots ranged in 13-18%). This indicates that nutrient leaching through runoff and surface water might give an impact to groundwater environment at open dump sites even in the stabilization phase.

キーワード: 埋立ガス, 栄養塩流出, 開放投棄地, 有機炭素, スリランカ, ゴミの分解

Keywords: landfill gas, nutrient leaching, open dump, organic carbon, Sri Lanka, waste decomposition

ガス・熱輸送係数に土壤水分ヒステリシスが及ぼす影響 Effects of soil-water retention hysteresis on gas and heat transport parameters

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Knowledge of soil-gas and heat transport parameters is essential for understanding and simulating behaviors of greenhouse/toxic gases and changes in soil temperature at landfill sites. Degree of water-saturation at different water potentials (i.e., water retention characteristic) highly affects these gas and heat transport parameters. In this study, the effects of water retention hysteresis on the soil-gas diffusion coefficient (D_p), air permeability (k_a), and thermal conductivity (K_T) were investigated. Different sand particle size fractions with different particle shapes were used for measuring gas and heat transport parameters. The soil-water retention hysteresis highly affected the gas transport parameters, showing higher D_p and k_a values for the wetting processes than those for drying processes at the same air content. This suggests that the more continuous air-filled pore-networks in the wetting processes enhanced diffusive and advective gas transport. As compared to gas transport parameters, the effect of soil water retention hysteresis on the K_T was insignificant for all sand materials.

キーワード: 土壤水分ヒステリシス, ガス輸送係数, 熱輸送係数

Keywords: soil-water retention hysteresis, gas transport parameter, heat transport parameter

5線熱パルスセンサーを用いた飽和・不飽和水分フラックスの推定 Estimation of Water Flux in Variably Saturated Soil with a Penta-Needle Heat Pulse Probe

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The penta-needle heat pulse probe (PHPP) employs a central heater needle surrounded by an orthogonal arrangement of four thermistor needles. By inversely fitting an analytical solution for two-dimensional heat transport with an infinite line source, both components of the flux in a plane normal to the axis of the PHPP needles, J_x and J_y , thermal conductivity, and thermal diffusivity can be estimated. Using estimated J_x and J_y , water flux magnitude and direction can also be calculated. In this study, the applicability of PHPP estimations was tested in both of saturated and unsaturated water flows in sand. Laboratory column experiments under steady-state saturated (flux range of 180-430 cm/d) and unsaturated (1.9-130 cm/d) water flow conditions were conducted. Two PHPPs were installed with orientations to yield water flow directions of 30° and 45°. In case of saturated flow condition, estimated J_x and J_y agreed well with measured water fluxes (less than 25 % relative errors), resulting in good estimations of water flow magnitudes and directions. In case of unsaturated flow condition, water fluxes estimated by PHPP with 30° agreed well with measured flux. However, one component (J_x) from PHPP with 45° showed a constant discrepancy (-55 cm/d) in any flow rates. This result indicates that differences of constant resistance between sand and needle, heterogeneity of the sand-water-air system, and heterogeneity of microscopic unsaturated flow in measurement area resulting from water content changes ($0.38 \text{ cm}^3/\text{cm}^3$ for saturated flow to $0.10 \text{ cm}^3/\text{cm}^3$ for unsaturated flow) affect PHPP estimations.

人工マクロポアによる湿潤領域の数値シミュレーション Numerical simulation of wetting zones generated by artificial macropores

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はじめに

土壌中のマクロポアは歴史的に認識されてきた(例えば Schumacher, 1864)。マクロポアの保水性は、毛管圧を用いて定量的に記述されてきた(例えば Nelson & Baver, 1940)が、マクロポア質土壌を介した輸送現象は未だに地球科学における研究課題の1つである。マクロポア質土壌における層流は、二重間隙モデル(Gerke & van Genuchten, 1993)などによって推定されている。一方、マクロポア中の速い流れを推定するためには、土壌中のマクロポアの非破壊測定技術による可視化(例えば、Capowiez ら, 2011)、マクロポア体積の定量(例えば Nakashima & Kamitani, 2007)およびマクロポア質土壌における輸送パラメータの定量的評価(Elliott ら, 2010)などが必要である。このような土壌マクロポア評価のためのツールが発展するとともに、マクロポアによって生成される自然のプロセスを活用するための様々な取組が行われている。Shipitalo と Gibbs (2000) はミミズの巣穴のネットワークを介した排水処理法を提案した。Hirth ら(2005) は土壌にライグラス幼苗を導入するための人工バイオポアを開発している。著者らは、地中の流れを促進するための人工マクロポアを開発した。この人工マクロポアは、細い(直径約 1cm)のオーガーホールを粗い繊維材料で満たしたものである(森, 2009)。繊維材料を充填することにより、マクロポアの壁面の浸食軽減が期待される。マクロポア中の急速な流れは充填材によって緩和され、地中の湿潤領域を拡大させる。このような効果は、土壌汚染物質の浸出、バイオレメディエーション、炭素貯留などで有用である。本研究では、人工マクロポアによって形成される土壌中の湿潤領域を評価するために、Hydrus2D(PC-Progress, s.r.o.)を用いた数値シミュレーションを2種の降雨強度(2、20mm/hr)と3種の斜面勾配(0、5、10度)のもとで行った。

方法

人工マクロポアの適用対象として、表層にクラストが形成されたローム質土壌を想定した計算を行った。土壌の透水係数は 5.56×10^{-7} m/s (約 2mm/hr) とした。人工マクロポアの充填剤には爆砕竹を用いることを想定した。この充填剤の飽和透水係数は 7.00×10^{-3} m/s (定水位頭法による実測値) に設定した。また、Hydrus2D によって表面流をシミュレートするために、2種のアプローチを採用した。

(1) Hydrus2D で湛水部を表現する仮想の層を導入する方法

実際の地表面の上部に湛水のための仮想の層(Rassam ら, 2003)を設けた。この層の飽和透水係数は、流れの遅滞を避けるために 5 m/s とした。計算対象の地形は、人工マクロポアの設置に理想的と考えられる谷状とした。

(2) Hydrus2D 用の地表流計算モジュールを使った方法

Hydrus2D 用の地表流計算モジュールを使った方法(Simunek, 2003; Kohne ら, 2011)では、湛水部の変動を波動関数で近似し、地表面での摩擦をマンギングの経験式で求める。マンギングの粗度係数は、下層植生が発達した森林を想定して 0.030 とした。シミュレーション対象とする地形は、このアプローチのために単一の斜面に簡素化した。土壌の保水性・透水性を記述するパラメータは、正圧時の含水率変動を抑えるために最適化し直した。

結果と考察

20 mm/hr の降雨強度では、人工的マクロポア周囲に湿潤領域が形成された(Figure 1)。谷状地形でも単一の傾斜面でも、湿潤領域の幅は約 140 cm であった。水平な土地では人工マクロポアによる下方浸透効果は限定的であった。2 mm/hr の降雨強度では人工マクロポアによる効果は認められなかった。これらの結果から、人工マクロポアの適切な間隔は、緩やかな傾斜を持つクラスト化したローム質土壌において、140 cm 未満とする必要があることが示された。より現実的な地形での推定は、COMSOL を使用して行う予定である。

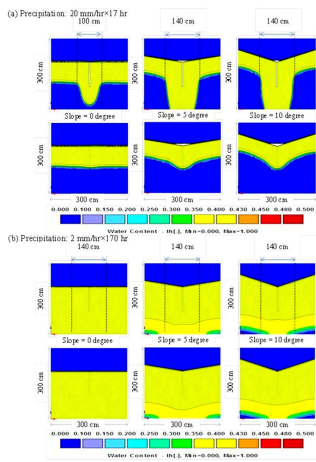
キーワード: 人工マクロポア, ハイドラス, 炭素固定, 溶脱, 湿潤領域, 数値シミュレーション

Keywords: artificial macropore, Hydrus, carbon sequestration, leaching, wetting zone, numerical simulation

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人工マクロポアが土壌中の有機物量に及ぼす影響 The Effect of Artificial Macropores on the Amount of Organic Matters in soils

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I. Introduction

Reclamation of impervious soils is desirable, because soil erosion by surface runoff may have unfavorable effects on environments (e.g. nutrient loss from soils, eutrophication of downstream lakes). In this study, we scrutinized the effect of an artificial macropore system, i.e., a technique for permeability control, on the amount of organic matters in soils.

II. Experimental method

We installed the artificial macropores at an inclined site with red-yellow soil in Matsue Experimental Station of Shimane University, Japan. The adjacent plot without the artificial macropores was also monitored as a control plot. Total carbon (TC) and water content of soil samples, and ion concentration of infiltrated water samples were measured for both plots.

III. Results and discussion

Temporal variation in TC of the soil showed a trend of slight reduction at the treated plot. Cumulative amount of NO_3^- in the infiltrated water was greater in the treated plot than the control, while that of NH_4^+ was high in the control. The scatter diagram of Cl^- concentration of the infiltrated water versus cumulative rainfall during the interval of sampling suggested three categories of chloride dynamics (A, B, and C). At high cumulative rainfall, data from both the plots were laid in the same area (A) of the diagram. In contrast, when there was little rainfall, data from the treated and the control plot were classified into B and C, respectively. The gradient in the scatter diagram for B is similar to that of A, which indicates high efficiency of infiltration by the artificial macropores. Based on the results, we concluded that the artificial macropore system had promoted digestion of soil organic matter and leaching of NO_3^- through nitrification.

キーワード: 環境修復, マクロポア, 浸透現象

Keywords: environmental restoration, macropore, infiltration

微生物生息および土壌環境因子に基づく VOCs バイオレメディエーションの評価 Assessment of VOCs Bioremediation Considering Microbial Inhabitation and Soil Environmental Factors

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Volatile organic compounds (VOCs) like tetrachloroethene (PCE) and trichloroethene (TCE) spread throughout the fields in Japan, which causes significant problem of soil and water pollution. PCE and TCE are biotic or abiotic decomposable pollutant. In recent years, bioremediation, purification method utilizing microbial metabolism, has become a remarkable technique due to its low-cost and environmental friendly points.

PCE and TCE can be entirely decomposed to ethen only by *Dehalococcoides*, through dichloroethene (DCE) and vinyl chloride (VC); *Dehalococcoides* is key microbes for the bioremediation. Inhabitation of *Dehalococcoides* in polluted sites is essential for in-situ bioremediation, especially biostimulation, while the distribution of the microbes and the environmental factors constraining microbial activities have not been elucidated.

To investigate the *Dehalococcoides* inhabitation and environmental factors like soil organic carbon, undisturbed cores including sandy and clayey soils were taken from several polluted sites. The cores were divided by soil texture, and the microbes and the factor items in the divided samples were analyzed.

The factor items were categorized into some groups related to anaerobic conditions, energy source, nutrients, osmotic pressure, and so forth. As an example, soil organic carbon was considered to affect appropriate anaerobic conditions, energy source, and nutrients during reductive bioremediation. The feasibility of the bioremediation was assessed based on a series of experimental data and considerable affecting items.

キーワード: VOCs, *Dehalococcoides*, バイオレメディエーション, 環境因子, 土壌有機炭素

Keywords: VOCs, *Dehalococcoides*, Bioremediation, Environmental factor, Soil organic carbon

クロロエチレン類の原位置バイオレメディエーションにおける進展と制限要因 Advances in and Limitations Associated with In-Situ Bioremediation of Chlorinated Solvents

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Chlorinated solvents, like perchloroethene (PCE) and trichloroethene (TCE), have been widely used by many industries, especially in developed countries like Japan. Because of their wide applications, lack of proper regulation, poor handling, storage and disposal practices in the past, chlorinated solvents have become a type of the most prevalent contaminants for soil and groundwater pollution. In recent years, the environmental concern and interest is growing for bioremediation of such chlorinated solvents, commonly called VOCs in Japan, in soil and groundwater including aquatards. Research works in the recent decades have demonstrated 3 types of biodegradation resulting in degradation of VOCs.

In this presentation, the 3 types of bioremediation, specifically reductive dechlorination, cometabolism and direct oxidation together with some recent advances in bioremediation are overviewed. The overview presented the current research trend in understanding the mechanisms of biodegradation with regard to in situ applications, including potential application to aquatards. Limiting factors in bioremediation are examined from biochemical, geochemical and hydro-geological aspects. In addition, the fusion of technologies that could be used to enhance or accelerate the bioremediation are discussed and proposed.

キーワード: バイオレメディエーション, VOCs, 還元的脱塩素分解, 共代謝, 直接酸化, 制限要因

Keywords: Biodegradation, VOCs, Reductive Dechlorination, Cometabolism, Direct Oxidation, Limiting Factors

発光バクテリアを用いたバイオアッセイによる土壌汚染評価手法の開発 - 土壌溶出成分の影響 -

Development of evaluation method on soil pollution by luminous bacteria -Effects of elution components of soil-

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近年、重金属類や揮発性有機塩素化合物等による土壌汚染が顕在化しており、社会的にも土壌汚染の調査・対策等が求められ、汚染物質の簡易検出技術や急性毒性評価手法として、発光バクテリアを用いたバイオアッセイが注目されつつある。しかしながら、バイオアッセイを適応させる汚染土壌の抽出液には、汚染物質以外にも各土壌の構成成分が溶出しており、これら諸成分の影響についてあらかじめ評価を行っておくことが必要不可欠である。そこで、本研究では土壌から溶出する主要な成分としてアルカリ金属イオンやアルカリ土類金属イオンおよび各種陰イオン成分に加えて、Al、Si、Feの各溶存成分に着目し、これら各成分が発光バクテリアの発光強度に及ぼす影響を実験的に検討した結果を報告する。

キーワード: バイオアッセイ, 発光バクテリア, 土壌汚染評価手法, 土壌溶出成分

Keywords: bioassay, luminous bacteria, soil pollution evaluation method, soil elution components

Heavy Metal Removal in Landfill Leachate Using Agricultural Waste Materials: A Case Study in Sri Lanka

Heavy Metal Removal in Landfill Leachate Using Agricultural Waste Materials: A Case Study in Sri Lanka

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Heavy Metal Removal in Landfill Leachate Using Agricultural Waste Materials: A Case Study in Sri Lanka

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Abstract

Open dumping of Municipal Solid Waste (MSW) is a common practice and identified as a source of pollution for surface and groundwater resources in Sri Lanka. The objective of this study was to identify the heavy metals in leachate and soils in the vicinity of MSW dump site and to assess locally available agricultural waste materials to use as adsorbents to remediate heavy metals from polluted water. Coconut husk (CH) and saw dust (SD) was used as the adsorbents in the column and field experiments. The influent solutions were introduced from the bottom of the column using a submersible pump. Field experiment was carried out in the selected MSW landfill using concrete cylinders with 0.3 and 3 m in diameter and length, respectively. These were filled with CH and SD. Cadmium and Lead concentrations were measured in influent and effluent with time. Cadmium and Lead was found to be the most critical heavy metals in landfill leachate which possess quality rating scales of 620% and 108% based on the general standards for portable water. Removal efficiencies of both Cd and Pb by CH and SD were >85% at the beginning and decreased with time until the equilibrium is achieved in column experiment. In contrast, at the field, average removal efficiencies of them were >50% which could be due to the presence of other ions, and large particle size and variable concentration of heavy metal in the field. Hence, these agricultural wastes have potential to mitigate heavy metal pollution and more studies are needed to optimise the effective removal and to increase the efficiency of CH and SD.

Key words: coconut husk, dumping site, heavy metals, leachate, saw dust

キーワード: coconut husk, dumping site, heavy metals, leachate, saw dust

Keywords: coconut husk, dumping site, heavy metals, leachate, saw dust

Contamination of wetlands through transport of pollutants generated from the municipal solid waste open dumpsite, Kandy, Contamination of wetlands through transport of pollutants generated from the municipal solid waste open dumpsite, Kandy,

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Landfill leachate is well reported as a contaminant source polluting surface and ground water. Since the predominant waste disposal method still in Sri Lanka is open dumping which leads to generate significant amount of leachate mostly to nearby water sources. Gohagoda open dump site is one such location at the world heritage city, Kandy, in Sri Lanka. This leachate directly flows to the Mahaweli River which is the main water source for entire province due to absence of proper lining system or any treatment mechanism before disposal. Hence, this study was focused on characterization of leachate generated from Gohagoda dumpsite, assess their spatial and temporal variations, identify subsurface canals and perched water bodies in the wetland system affected by the leachate flow.

Leachate samples were collected monthly for one year from different points of the leachate drainage channel and tested for quality parameters as pH, temperature, EC, TDS, TS, VS, TSS, VSS, BOD₅, COD, alkalinity, hardness, nitrates, phosphates, ammonium nitrogen, chloride and heavy metals (Fe, Mn, Zn, Cu, Pb, Ni and Cr). Moreover, 1D and 2D modes of resistivity data were collected from Vertical Electrical Sounding (VES) at the abandoned paddy field at the downstream of the dumpsite, towards the Mahaweli River.

Results demonstrated average values of pH 8.37, BOD₅ 380 mg/L and COD 1835 mg/L. Nitrate and phosphate seemed to range between 1-765 mg/L and 2-258 mg/L and high levels were observed towards wet season exceeding the allowable limits for wastewater discharge. Some heavy metals were reported in high concentrations such as Zn, Pb, Ni, Cu, Cd and Cr in average concentrations of 0.3710, 0.217, 0.207, 0.135, 0.092 and 0.061 mg/L respectively. Concentrations were decreasing with the distance from the landfill. Leachate characteristics indicated that the leachate is in the methanogenic phase. VES results revealed that the depth to the bedrock is about 3-5m and bedrock is plunging towards the river with a gentle slope. Further, few subsurface canals were found in the abandoned paddy field area and the leachate flow is mainly confined to the near surface. In addition, no perched water pockets were observed and that may be due to the continuous flow in the subsurface. The results strongly suggest that the leachate generated from Gohogoda dumpsite may pollute the soils and waters in the close by wetland systems and the drinking water sources. The geophysical findings can be effectively used to obtain an understanding of the subsurface flow and transport of the leachate from open landfills without landfill liners.

キーワード: Landfill leachate, subsurface canals, Chemical oxygen Demand

Keywords: Landfill leachate, subsurface canals, Chemical oxygen Demand

EFFECT OF SINGLE-SPECIES SALT SOLUTIONS ON GEOTECHNICAL PROPERTIES IN BENTONITE EFFECT OF SINGLE-SPECIES SALT SOLUTIONS ON GEOTECHNICAL PROPERTIES IN BENTONITE

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The importance of bentonite in engineered barrier systems is well recognized. This naturally occurring clay has unique properties of swelling on contact with water and very low hydraulic conductivity to liquids. In addition to these, its high cation exchange capacity (CEC), large specific surface area and ability of self-healing has made it a necessary component for the liner system of the modern engineered landfills. However, leachate produced in the landfill due to the biodegradation of waste can react with bentonite chemically and may affect its engineering characteristics. The increase in hydraulic conductivity can cause leachate to enter subsurface and pollute the subsurface environment including ground water table. On the other hand change in liquid limit is an indicative of change in other geotechnical properties including shear strength and swelling behavior of bentonite. Therefore, it is necessary to analyze the effect of chemicals present in landfill leachate on geotechnical properties in bentonite.

This study investigated the individual effect of such chemicals using single-species salt solutions of different cations, concentration and valance on the liquid limit and hydraulic performance of bentonite. A total of thirteen solutions including de-ionized water and three different solution concentrations (0.01M, 0.1M, and 1M) of four major exchangeable cations Na^+ , K^+ , Ca^{2+} and Mg^{2+} were used in this study.

Liquid limit tests were carried out using all the thirteen type of solutions on sodium bentonite. It was observed that liquid limit decreases with increase in salt concentration. At very high and very low concentrations, both monovalent (Na^+ , K^+) and divalent cations (Ca^{2+} , Mg^{2+}) showed similar liquid limit. However, there is a large difference in liquid limit values for monovalent and divalent cations at intermediate concentrations. Effect of concentration and valance on hydraulic conductivity of bentonite was analyzed using different concentrations of NaCl and intermediate concentrations (0.1M) of all the four cations. It was observed that both concentration and valance have little effect on hydraulic conductivity of bentonite. The results suggested that hydraulic conductivity is likely to be highly controlled by the effective porosity and effective void ratio of bentonite. The tests were run upto 100 days to investigate the effect of time on hydraulic performance of bentonite and it was observed that hydraulic conductivity does not change significantly with time.

キーワード: Bentonite, Hydraulic Conductivity, Liquid limit, Landfill leachate, Effective void ratio, Effective porosity
Keywords: Bentonite, Hydraulic Conductivity, Liquid limit, Landfill leachate, Effective void ratio, Effective porosity

Sorption of heavy metals on soil and colloidal solutions and transport facilitated by soil colloids

Sorption of heavy metals on soil and colloidal solutions and transport facilitated by soil colloids

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Heavy metals are amongst various contaminants that are released daily in the soil environment as a result of various anthropogenic activities. Soil has the ability to immobilize contaminants like heavy metal ions and sorption is a major process for the retention of heavy metals in soils. However, mobile colloids have strong ability to sorb inorganic (heavy metals, radionuclides etc.) and organic contaminants and transport these contaminants to deeper depths or groundwater. The sorption of heavy metals on soil and colloidal solutions, and transport of heavy metals facilitated by soil colloids were investigated by batch sorption and column transport experiments respectively. Batch sorption experiments of heavy metal, (Cu), were performed on red-yellow soil and colloidal solutions (<1 micro meter size) generated from the red-yellow soil at natural pH and low pH conditions. The results showed that at high concentration range of Cu (10 to 200 mg/L), the sorption capacity (K_d) of Cu for the soil was greater than low concentration range (0 to 10 mg/L) and high K_d values were obtained at natural pH conditions. Similarly, sorption capacity (K_d) of Cu for colloidal solutions was greater at high concentration range of Cu and natural pH conditions. However, the K_d values for colloidal solutions were much higher; 10 to 50 fold more than for the red-yellow soil. Therefore, the colloidal solutions have greater sorption affinity for Cu than soil. In column transport experiments, the colloidal fractions played a significant role in transporting Cu and almost 76% of the total applied Cu was transported by soil colloidal fractions. The mobility caused by coarse colloidal fractions (0.2-1 micro meter size) was greater, as 85 % of the total leached Cu was associated to coarse colloidal fractions. Analysis of soil after the column leaching test indicated depth dependent phenomena of Cu distribution in the soil. Therefore, this study concludes that soil colloids play an important role in facilitating heavy metal (Cu) transport through soil which may lead to contamination of groundwater.

キーワード: Sorption, Heavy metal (Cu), Soil, Colloidal fractions, Sorption capacity, Transport

Keywords: Sorption, Heavy metal (Cu), Soil, Colloidal fractions, Sorption capacity, Transport

撥水性土壌の表面で配向している有機炭素のキャラクタリゼーション Characterization of organic carbons orienting on the surface of water repellent soils

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Water repellency of soils has been observed in various soil types such as sandy, loamy, clayey, peaty, and volcanic ash soils. Water repellency can have a range of soil hydrological consequences such as reduction of infiltration rates, acceleration of surface runoff and erosion, and occurrence of fingering flow. Therefore, proper managements of the water repellent soils are important for optimizing sustainability and productivity of farming system. In the present study, two water repellent soils were collected from a brown forest soil in Aichi Prefecture and an allophanic volcanic ash soil in Fukushima Prefecture, and the surface orientation of organic carbons on the water repellent soils were characterized by measuring pulse saturation transfer magic angle spinning (PSTMAS) ¹³C nuclear magnetic resonance (NMR) and cross polarization magic angle spinning (CPMAS) ¹³C NMR spectra. In PSTMAS spectra, mobile portions of organic carbons are intensified when comparison is made with CPMAS spectra. This phenomenon was confirmed by measuring PSTMAS and CPMAS spectra for silica particle coated with octadecyl group and its mixture with dimethylsulfoxide. In the PSTMAS spectra of two repellent soil samples, it was clearly shown that the peaks at around 12 and 23 ppm were intensified, indicating that the intensified carbons are highly mobile and located on the most outer surface of the soil particles. Judging from the chemical shift values of the NMR spectra, the intensified carbons were assigned as aliphatic carbon chains, such as $-(CH_2)_nCH_3$. In conclusion, at least a part of aliphatic chain would present on the most outer position of the water repellent soils, and they would prevent wetting and water penetration in the soils.

キーワード: 核磁気共鳴, NMR, 撥水性土壌, 表面配向, 土壌有機物, 土壌有機炭素

Keywords: Nuclear magnetic resonance, NMR, Water repellent soils, Surface orientation, soil organic matter, soil organic carbon

Puの地表出現を遅らせるフェリハイドライト・コロイド Colloidal ferrihydrite retards the appearance of Pu on the Earth's surface

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Radioactive wastes from nuclear power plants must be disposed of safely. A large amount of Pu in the wastes is sorbed to colloidal ferrihydrite and moves in groundwater. This paper describes the behavior of Pu sorbed to colloidal ferrihydrite in nuclear waste disposal sites. When the concentration of ferrihydrite is higher than 10-5 mol Fe /L, most Pu is sorbed to the ferrihydrite. Ferrihydrite persists in groundwater as long as nitrate is present. When the filtration effect of geologic media is small, the gravity moves colloidal ferrihydrite to deep underground; the velocity is 0.12 m/year when the size of ferrihydrite is 70 nm. When the filtration effect is large, ferrihydrite is not transported further. In both the cases, ferrihydrite retards the appearance of Pu on the Earth's surface.

キーワード: コロイド, フェリハイドライト, プルトニウム, 核種移行, 重力効果, 吸着

Keywords: colloid, ferrihydrite, plutonium, transport of radionuclides, gravity effect, sorption

日本およびニュージーランドの火山灰土における水分量が撥水性に与える影響 Effect of water content on the soil water repellency for Japanese and New Zealand volcanic ash soils

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Water repellency (WR) of soil can induce significant hydraulic problem such as reduced water infiltration, enhanced surface runoff and erosion and the forming of preferential flow patterns in soils. Soil water repellency is reported in many parts of the world at different climatic conditions and soil types. Although WR has been observed in many countries including Japan and New Zealand, relatively few studies evaluated WR of aggregated volcanic ash soils. In the present study, the effects of water content on the water repellency of Japanese and New Zealand volcanic ash soils at different depths were investigated. Secondly, the time dependency of the contact angle in these soils at different water contents was evaluated. The degree of water repellency of the moisture content adjusted samples was assessed with the sessile drop method (SDM), the molarity of ethanol droplet (MED) test and the water drop penetration time (WDPT) test. The degree of WR varied considerably by region and depth. For the Japanese volcanic ash soils, the contact angle increased sharply with increasing water content, reached the maximum contact angle at water contents around 0.3 cm³/cm³, and then gradually decreased to 0° at field water content. A similar pattern was found for the New Zealand volcanic ash soils. However, the contact angle of the New Zealand volcanic ash soils was greater than 100° at field water content. Directly measured contact angles using the SDM were in good agreement with indirectly obtained contact angles using the MED test. The contact angle sharply decreased with soil-water contact time in volcanic ash soil samples at higher water contents.

キーワード: 撥水性, 火山灰土, sessile drop method, water droplet penetration test, molarity of ethanol droplet test

Keywords: soil water repellency, volcanic ash soil, sessile drop method, water droplet penetration test, molarity of ethanol droplet test

多周波数電磁探査機による農林地の土壌環境管理の評価

Evaluation of management practices in agricultural and forest lands by the multiple-frequency electromagnetic surveying

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はじめに

農林地は流域面積の中で大きな割合を占めることが多く、水環境の汚濁負荷に対して大きな影響を及ぼす。これまでの研究では、河川水や暗渠排水を採水・分析することから面源負荷量を評価し、大きな成果を挙げている。さらにここで土壌調査を広域で効果的に行えればその効果は非常に大きい、一般に大変な時間と労力を伴う。そこで本研究では調査手法の開発を目的に、非破壊かつ迅速に深部まで土壌調査を行う事が出来る多周波数電磁探査機を用いて電気伝導度 (EC) を測定し、農林地の管理が土壌環境に与える影響を調べた。主に島根県隠岐郡隠岐の島を調査対象とし、島の面積大部分を占める森林についての調査を行った。

実験の方法

隠岐の島では森林面積の割合が非常に多く、水源涵養という役割の大きい森林の状態とその土壌環境について調査した。2010年8月30-31日に9サイトにおいて土壌環境の調査を行い、管理が土壌環境に与える影響について評価した。島の中の9サイトについて、電磁探査機 (米国 Geophex, GEM-2) を用いて、GPS による位置情報と合わせて電気伝導度を測定した。周波数は、47970, 24510, 7950, 3870, 2310Hz に設定した。さらに、土壌水分計 (米国 Stevens 社) を用いて土壌水分、電気伝導度と土壌温度の測定も行った。

実験結果と考察

電磁探査の結果を鉛直プロファイルで表示すると、土壌環境の違いは表層近くに特徴的に現れることが分かった。そこで最表層を表すデータを従来法電気伝導度計と比較すると高い相関が得られ、計測の妥当性が得られた。

調査地には、間伐処理が行われている森林と行われていない森林が存在し、間伐の行われている森林の方が電気伝導度が低いことがわかった。間伐の行われていない森林は、林内が暗く、下層植生があまり見られなかった。そのため土壌中に存在する可溶性塩類が植物にあまり利用されず、高い電気伝導度が観測されたと考えられた。また間伐が行われていない森林では土壌の透水性が低く、表層に物質が集中する傾向を裏付けた。実際、有機物も浅いところだけに観察されることが多く、浸透性の悪さが表層への物質の集中を促していると推測された。現在は森林として利用されているサイトでも、過去に農地として利用されていた場所では、電気伝導度が高くなる傾向があり、現在の管理以外にも過去の利用履歴が土壌環境に影響していることがわかった。一方、電磁探査の結果は全炭素量との相関は低いいため、可溶性塩類を効果的に計測していると判断された。

まとめ

電磁探査を用いることによって、土地管理や利用履歴を電気伝導度の違いとして面的に評価することができた。短時間に広範囲の調査が可能であり、詳細調査の前のスクリーニングに役立つと考えられた。

キーワード: 電磁探査, 土壌環境管理, 森林

Keywords: Electromagnetic sounding, land management, forest

レーザー回折式粒度分布測定装置を用いた土の粒度試験 Grain size analysis by laser diffraction particle size analyzer.

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土の粒度試験は、土壌の性質を評価する方法の1つで、多くの研究成果が得られている。試験方法としてJIS法が広く用いられているが、多数の土の粒度試験を行う場合、試験に時間がかかり大きな労力を必要とする。本研究では、LDPSAを用いて土の粒度を評価し、土の粒度試験におけるLDPSAの有用性を検討した。その結果、JIS法とLDPSAを用いた方法では粒径の細かい領域で差があった。またLDPSAを用いると、試料土に含まれるTCが減少すると細かい粒子が増加することが観察された。これはTCが減少することで土壌の団粒が分解された結果と考えられる。これらのことから、LDPSAはJIS法の代用に用いることは難しいものの、同一の試料の変化を測定することに有用であると考えられた。

キーワード: レーザ回折式粒度分布測定装置, 土の粒度試験, 土壌有機物

Keywords: Laser Diffraction Particle Size Analyzer, Grain size analysis, Soil organic matter

Input rate of sublacustrine gas into Lake Nyos (Cameroon, West-Africa) inferred from diffuse CO₂-flux measurement and hydrological observations

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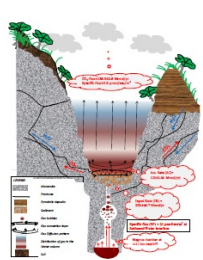
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Because of its importance to understand the mechanism and the origin of the mid 1980s fatale exhalation of gas, mainly magmatic carbon dioxide (CO₂) from Lake Nyos, on one hand, and on the other hand, for the sake of preventing and management of future gas explosion related hazards in Nyos area, the hydrothermal system of the lake was extensively investigated over the last quarter the century with the objective to quantify CO₂ recharge rates and determine the feeding paths. More than 25 years after the catastrophe which killed 1734 people in the North-West Region of Cameroon, we revisit the question which remains of primary importance with regards with the extraordinarily high rate of gas build-up observed soon after the gas disaster. Based on results of diffuse CO₂ measurement (CO₂-flux) surveys we conducted in January 2009 and information on the hydrological system, input rate from hydrothermal system was estimated at 258.4 (0.7) Mmol/yr. The value estimated above using a mass balance equation $CO_2^{input} = CO_2^{acc} + CO_2^{flux}$, (where CO_2^{input} , CO_2^{acc} and CO_2^{flux} stand for inputs from hydrothermal system, accumulation rates and diffuse CO₂ loss respectively) implies about 42.6 (0.3%) of gas supplied from beneath the lake accumulates to constitute the time bomb. If we compare the gas rate and the ground water input rate at depth below 50 m of 9 l/sec estimated from hydrological observations, the ensuing gas-

rich water would attain a concentration of 0.9 mol/l implying 136% saturation (e.g saturation level of 0.630 mol/l maximum) at system pressure (210 m depth). We believe that the high gas-rich water supply type model which was more or less accepted for past several years is incompatible with observations above because of the plumes gas oversaturated waters may generate. Instead, we advocate for a diffusional type model in which gas is supplied in the form of pure CO₂ distributed throughout sediment/water interface where the specific flux would be 23 micromol/sec/m². The view complements well the absence of horizontal anomalies (gas is evenly distributed) as suggested by several transect profiles of the lake. Else, this study permits distinguish between the recharge rate (=accumulation rate) which relates to time required for the event to repeat itself and the input rate related to activity of sublacustrine system.

キーワード: CO₂-flux, Lake Nyos, gas exhalation, time bomb

Keywords: CO₂-flux, Lake Nyos, gas exhalation, time bomb



LAT-PIV 手法を用いた間隙流速測定と CTRW モデルのパラメータ推定 Measurement of pore velocity by using LAT-PIV, and parameter estimation of CTRW

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In recent years, the problem of soil pollution has been concerned in Japan. Soil pollution has some problems. For example, while soil pollution is close to us, but we could hardly feel the pollution itself. Furthermore, the remediation of ground requires enormous costs and long time. This is the reason why we have to predict and take measures in early stages.

Recently CTRW (: Continuous Time Random Walk) model has been widely attempted to predict the behavior of substances in the groundwater. This model can describe the anomalous diffusion that it is difficult for ADE (Advection-Dispersion Equation) to describe. However, in the CTRW model, it is one of the most difficult problems that the model parameters cannot be fixed a priori.

In this study, we proposed a method to estimate the parameter A of CTRW by using the LAT-PIV (Laser Aided Tomography-Particle image velocimetry) method. LAT-PIV is a method that can visualize the internal structure of porous medium, and the behavior of tracers in fluid. We packed the glass beads of 2mm-5mm and 5mm-10mm in the clear plastic box (10 cm in length, 10 cm in width, 40 cm in height), and then filled the acrylic box with silicone oil and tracer particles. Silicone oil is poured with the pump at constant flow velocity, and razor sheet is irradiated to the plastic box from the side. We can hereby observe the internal behavior of porous medium. We conducted experiments and obtained the histogram of the pore velocity in the porous medium. After that, we calculated the value of A from the shape of histogram.

In this computer program which outputs pore velocity, the pore velocity is calculated by comparing two continuous visualized images. In this process, every image is divided into 1536 parts (48 by 32 parts) and the pore velocity is calculated at each grid. At this time, each grid searches the grid where tracers moved.

However, we found two problems in this process. When searching the exact grid where tracers moved, some unexpected pore velocities are calculated because the glass beads are distributed in various places. To avoid calculating these abnormal velocities, we improved this computer program. The glass points are shown by black pixels in images. We replaced these black points with red pixels that shows pore fluid. Because of this improvement, we succeed in reducing some unexpected pore velocities.

Another problem is that the zero velocity is calculated at the almost black grid (showing almost glass beads), which does not actually show the behavior of tracer particles. To make this computer program not to calculate such zero velocity, we set a certain threshold value. Because of this improvement, each grid became able to decrease the zero velocity one tenth in comparison with the original.

As a result of analyzing the images by using improved algorithm, we obtained some pore velocity distributions. From the pore velocity distribution, we estimated the value of A. When we used the glass beads of 5mm-10mm, the value of A was 0.635, and when we used the glass beads of 2mm-5mm, the values of A were 0.979 and 0.916. From this result, we found that the size of glass beads influences the value of A, on the contrary, the flow rate is not related to the value of A.

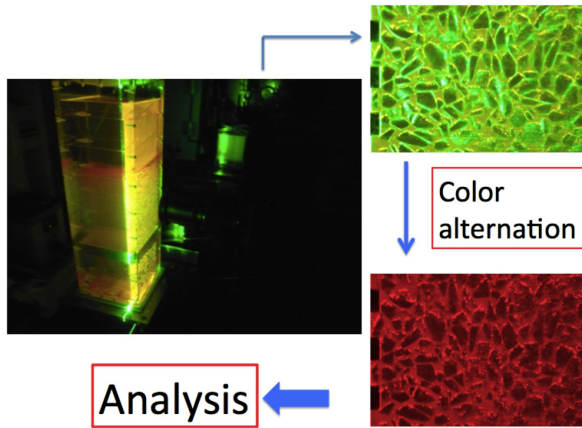
キーワード: 土壌汚染, 異常輸送, 連続時間ランダムウォーク, 不均質, 粒子画像流速測定法, 多孔質媒体

Keywords: soil pollution, anomalous transport, continuous time random walk, heterogeneity, PIV, porous medium

AGE04-P22

会場:コンベンションホール

時間:5月20日 17:15-18:30



Study of the aboveground hydrological processes in an unmanaged coniferous forest Study of the aboveground hydrological processes in an unmanaged coniferous forest

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Through field observations we monitored the hydrological processes by measuring gross precipitation (P), throughfall (TF), stemflow (SF), transpiration (Et) and evaporation (Ef) in the Japanese cypress plantation forest floor throughout the 2011 wet season (June-October) in Karasawa Mt., Tochigi Prefecture, Japan. Previous studies have shown the different hydrological components separately. However the interaction of each and every component as a system has not been investigated in one unit. Therefore, in this study, individual components of the hydrological processes were quantified and below ground water storage was estimated by water mass balance equation. Field measurements and hydrograph analysis showed that of the 882.2 mm of cumulative gross precipitation generated by 30 rainfall events during the study period, throughfall, stemflow, and interception loss accounted about 70.6% (622.8 mm), 11.4% (100.7 mm), and 18.0% (158.7 mm), respectively. 82.0% (723.5 mm) of cumulative gross precipitation reached the forest floor, while 16.2% (152.3 mm) was lost through transpiration and 13.1% (123.1 mm) was evaporated from forest floor. According to water mass balance equation, below ground water storage was about 50.7% (447.5 mm), which composed of almost half of cumulative gross precipitation, in other words, 49.3% (434.7 mm) of gross precipitation were consumed in the unmanaged Japanese cypress forest. Daily stand transpiration varied from 0.09 to 2.53 mm day⁻¹ with a mean value of 1.48 mm day⁻¹, and daily evaporation loss from forest floor spread from a minimum value of 0.26 mm day⁻¹ to a maximum value of 3.7 mm day⁻¹ with a mean value of 1.2 mm day⁻¹. Thus, in the unmanaged and dense Japanese cypress plantation forest, the following water loss order can be identified: canopy interception > transpiration > forest floor evaporation. This implies that through forest management and correcting the canopy density, it is possible to improve the ground water capital and water storage capacity of the entire forest watershed.

キーワード: Precipitation, Throughfall, Stemflow, Transpiration, Evaporation, Japanese cypress

Keywords: Precipitation, Throughfall, Stemflow, Transpiration, Evaporation, Japanese cypress

素過程に基づく化学風化モデリング：簡略化の検討 Process-based modeling of chemical weathering: A step to reduce model complexity

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Riverine export of major and minor elements to the oceans plays an important role in global biogeochemical cycles. Understanding the response of riverine export to environmental changes over various time- and spatial-scales is therefore essential for prediction of future changes in riverine chemistry including nutrients and pollutants.

Although quantification of chemical weathering rates has been recognized as one of the most important challenges to understanding the Earth system, there remain two scientific and technical problems to be resolved: a significant discrepancy between field- and laboratory-scale weathering rates and computational load for integration of process-based weathering models to large scale climate models such as general circulation models.

A new process-based chemical weathering model was developed to examine possibilities of a reduction of the computational load without losing its ability to reproduce riverine major ion concentrations. We applied the model with full complexity (i.e. vertically one-dimensional heat, moisture, gas, and solute transport and dissolution/precipitation of all minerals) to three different small watersheds to verify the model to reproduce major ion concentrations of modern streams. Then, we reduced model complexity by removing its vertical dimension and/or reducing the number of minerals to be considered. We will present sensitivity of the model results to the reductions of model complexity, and discuss how such process-based weathering models can be applied to environmental studies.

キーワード: 化学風化, 数値モデル, 渓流水組成

Keywords: chemical weathering, process-based modeling, stream chemistry

蒸発法とマルチステップ流出法による土壌の水分移動特性の推定

Estimating soil hydraulic properties obtained from evaporation and multi-step outflow experiments

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Inverse modeling using data from transient experimental methods such as multistep outflow (MSO) method and evaporation (EVP) method are frequently used for estimating unsaturated soil hydraulic parameters. However, comparisons between different inverse results obtained from MSO and EVP methods are scarce in the literature, especially for organic-rich soils with low bulk density, e.g. Andosol. The objective of this study was to determine and compare unsaturated hydraulic properties of Andosol from data collected using both methods. Undisturbed soil core samples (5.0 cm in i.d. and 5.1 cm in height) were taken from soil at a depth of 0-5 cm. The packed soil samples were also used for the experiments. After the MSO method, the same soil core samples were saturated again for the EVP method. The MSO method yielded a set of pressure heads (h_{MSO}) or cumulative water outflow (Q_{MSO}) vs. time while the EVP method obtained a set of pressure heads (h_{EVP}) or cumulative water flux (V_{EVP}) vs. time. A one-dimensional model based on Richards' equation, HYDRUS-1D (ver.4.14), was then used to analyze data to estimate soil unsaturated hydraulic parameters. The unknown parameters were accomplished by minimizing the objective functions which described the differences between observed and estimated h_{MSO} , h_{EVP} , Q_{MSO} and V_{EVP} , respectively. The results could be important in determining the agreement of soil hydraulic parameters obtained from both experiments and provide more precise and accurate characterization of water and solute transport.

乾燥地不飽和帯地盤構造調査への地中レーダの適用性 Applicability of Ground Penetrating Radar for investigation of vadose zone in arid land

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We evaluate the applicability of Ground Penetrating Radar(GPR) for characterization of subsurface structure and groundwater in arid land, which control the transport phenomena of water and solute transport in vadose zone.

We conducted the field test in the fields of Arid Land Research Center, Tottori university, using the GPR system with shielded antennas of dominant frequencies, 100,200,400,500,900,1.5GHz. Soil type in the field is almost uniform sand, and water content of soil is around or lower than 5%. Then soil is considered to be lossless media in electric magnetic sense. Penetration depth of each antenna is deeper than values usually reported. For example penetration depth of the system with 100MHz antennas is considered to be in the range from 20 to 30m.

We visualize 3D subsurface structure using the 100 MHz antenna. The obtained image shows the distribution of ground water table and layer which seems volcanic ash seam in sand and will control water recharge process in vadose zone.

キーワード: 地中レーダ, 不飽和帯, 地盤構造, 乾燥地

Keywords: Ground Penetrating Radar (GPR), Vadose zone, Subsurface structure, Arid land

農地土壤中CO₂動態予測に関する研究

Predicting Soil CO₂ dynamics in the vadose zone of Andisol in Western suburb of Tokyo

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Soil retains two to three times more carbon (C) than the atmosphere dose¹⁾. To simulate the soil CO₂ dynamics, the effects of soil respiration on C storage, which is sensitive to soil temperature and moisture, must be evaluated quantitatively. Model investigations of soil CO₂ dynamics have been conducted mainly for forest soils. Recently, C capture and storage by soil has been recognized as a function of agricultural field, and capacity of C storage in arable land has been discussed. For example, compost application to agricultural field has been attempted to increase C storage in soil. The objective of this study is to predict soil CO₂ dynamics in the arable land using HYDRUS²⁾.

For model validation, continuous monitoring has conducted at Institute for Sustainable Agro-ecosystem Services of the University of Tokyo (ISAS) in western suburb of Tokyo. The soil of 0 to 35 cm under the surface was Kuroboku andisol, and below it to 100cm, Tachikawa loam andisol was distributed. A 10 m square bare area was prepared for study site. Soil moisture and temperature at eight depths and soil CO₂ concentration at three depths were measured every 20 minutes from Jul. 2010 to Sept. 2011. CO₂ efflux from the surface was measured with closed chamber method in both summer and winter. Meteorological data was obtained from ISAS and AMeDAS station located in Fuchu city, near the field.

In the simulation, considering the vertical distribution of dry bulk density and soil texture, simulation area was divided in three layers i.e. cultivated, hardpan and Tachikawa loam layer, respectively. Durner-Mualem model³⁾ was employed for soil hydraulic function and parameters were determined by inverse analysis with evaporation method⁴⁾. Volumetric water content at saturation Q_s is an important parameter to predict diffusion of CO₂ through air filled pores in a variably saturated soil. In this study, porosity of the field soil was employed as Q_s . Chung and Horton⁴⁾ model was used for soil thermal conductivity. Parameters for CO₂ production were referred to Buchner et al.⁵⁾.

Simulation of soil CO₂ dynamics, including CO₂ production and transport, was conducted using HYDRUS-1D from 1st Jan. 2010 to 30th Sept., 2011. In the model, since CO₂ production rate is affected by soil moisture and temperature, HYDRUS first simulates the soil water and heat transport and then production and transport of CO₂ are predicted.

Initial conditions (I.C.s) were determined with preliminary calculation from 1st Jan. to 31st Dec., 2010. Boundary conditions (B.C.s) for water movement were hourly observed rainfall and daily evaporation rate which had been calculated with meteorological sub model of HYDRUS. Separately calculated soil surface temperature using meteorological data and energy balance equations were given for thermal B.C.. Atmospheric CO₂ concentration was applied for B.C. of CO₂. The final results of the preliminary calculation were employed as I.C.s for exact numerical simulation. Then simulated values were compared with monitored data for model validation.

The model could describe well the daily and seasonal variation of soil moisture, temperature and CO₂ concentration. Predicted CO₂ concentration at the hardpan layer was higher than other layers because of the small diffusivity of dense hardpan layer. This phenomenon had been observed in other field where hardpan layer existed⁶⁾. Predicted cumulative CO₂ flux for a year was also comparable to the value which was estimated with observed data. HYDRUS could simulate the soil CO₂ dynamics in arable land well.

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キーワード: 土壤中 CO₂ 動態, フィールドモニタリング, 数値計算

Keywords: Soil CO₂ dynamics, Field monitoring, Numerical simulation

Ecosystem Modeling for a Temperate Grassland Wind-Erosion Scheme Ecosystem Modeling for a Temperate Grassland Wind-Erosion Scheme

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Temperate grasslands are significant or potentially significant source for dust emission; however, detailed relationships among dust emission and characteristics of grasslands, in particular the special roles of vegetation and grazing are not well documented. Moreover, existing dust models do not have sufficient capability in modeling vegetation growth and decay, which play a major role in temperate grassland aeolian processes. In this study, we assessed the grassland ecosystem model (DAYCENT) for its capability to provide estimations of vegetation dynamics under different grazing conditions in order to incorporate into a temperate grassland wind-erosion scheme. DAYCENT model was parameterized with the field experiment data (soil physical/chemical properties, vegetation and grazing) at the Bayan Unjuul (BU) site in 2010-2011. BU is located in north of the most frequent dust outbreak region in Mongolia. The results from the model have been validated 8-years (2003-2010) plant phytomass (Live, dead, and litter) and species, and soil data obtained at the grazed and un-grazed areas at the BU. Generally, the model performed reasonably well in simulating seasonal and interannual variations in the observed plant production. However, some discrepancies may be due to the fact that the model does not consider year-to-year changes in plant species composition. It is important to note that the model could simulate realistically the effect of grazing on grasslands and vegetation memory, which suppressed dust outbreaks. Therefore, this model will provide a useful tool for dust emission study in temperate grasslands.

キーワード: Temperate grasslands, Ecosystem modeling, Integrated Wind-Erosion Scheme, Dust emission, Vegetation
Keywords: Temperate grasslands, Ecosystem modeling, Integrated Wind-Erosion Scheme, Dust emission, Vegetation