Environmental magnetic studies of roadside pollution: Identification of spatial distributions of vehicle-derived material at Mt. Hakusan, Japan.

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Environmental magnetic techniques have been shown to be useful for investigating roadside pollution. Previous studies have reported a positive correlation between: a) magnetic susceptibility and heavy metal concentration; and, b) the distance from a road and magnetic susceptibility. However, few systematic magnetic investigations on the spatial distributions of such roadside pollution have been reported in Japan. This deficiency is due to: a) lots of volcanos that supply great amount of magnetically-enhanced fly ashes; and, b) the dense population that cause huge amounts of magnetic noise. The environmental magnetic studies are reported for the Mt. Hakusan National Park in Ishikawa and Gifu prefectures. The Mt. Hakusan is an active volcano and its most recent eruption occurred in 1659. In-field as well as in-laboratory magnetic susceptibility of top soils along the Hakusan Shirakawa-go White Road show that the higher magnetic susceptibility is observed on soils collected near the road. In addition, there is a positive correlation between mass susceptibility and heavy metal contents. Based on rock magnetic measurements, the major magnetic mineral in top soils is pseudosingle- to multi-domain magnetite. The Day plot and crossover plot analyses indicate additional inputs of multi-domain magnetite to the top soils near the roadside. Furthermore, the rock magnetic and geochemical analyses of Japanese cedar tree barks show a positive correlation between saturation isothermal remanent magnetization intensity and Zn concentration and estimate the spatial distribution of single-domain magnetite derived from passing vehicles. The results show that detailed environmental magnetic analyses of top soils and tree barks are effective methods to monitor spatial distribution of pollution associated with vehicle traffic even in an active volcanic region.

Keywords: Environmental magnetism, Roadside soil and tree bark contamination, Active volcano, Japan

Distribution of radioactive Cs in Iitate soil, Fukushima: Multivariate analysis and numerical modeling approaches

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The transport of radioactive Cs in soil has been extensively studied. Many complex numerical models have been introduced to elucidate the migration mechanism of Cs in soil. The models usually required a lot of parameters which are not always available or hard to get, thus their applicability is still limited especially in a large field due to lack of input data. Moreover, the uncertainties and heterogeneity of soil physical and chemical properties may cause the simulation and prediction to be less accurate. We hypothesized that all parameters theoretically associated with the transport of Cs in soil were not always important for the prediction. Depending on specific field conditions, the prediction could be done solely based on fewer important parameters yet getting adequate prediction accuracy. This study aimed to elucidate the distribution and migration of Cs in surface soil, and to support future development of mechanism model for effectively predicting Cs transport in Iitate soil. Cs concentrations in top 30-cm surface soil were monitored in 2013-2015 at 12 plots in an abandoned forest located 40 kilometers northwest of the Fukushima Daiichi NPP. We used multivariate statistical analysis techniques to classify and compare the differences in distribution of Cs under field conditions. The analysis characterized the distribution states and pointed out the most important parameters that possibly influenced the migration of Cs in Iitate soil. A mechanism model was developed based on the physical and chemical processes associated with the above important parameters to simulate and predict Cs transport in surface soil. The results indicated soil organic carbon was highly associated with the distribution of Cs in soil. Soil erosion, and soil deposition tent to be the most important processes affect the transport of Cs in surface soil, while litter layers significantly affected the downward migration of Cs in soil profile.

Keywords: radioactive cesium modeling, multivariate analysis, Fukushima

How important is soil aggregation in regulating the activity of enzymes involved in the depolymerization of soil organic nitrogen?

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The process of nitrogen (N) mineralization in soils is regulated by extracellular N-acquiring enzymes (e.g. protease and chitinase) as N- containing organic polymers such as protein and chitin need to be depolymerized into monomers prior to microbial uptake and intracellular metabolism. In addition, this depolymerization could be regulated by the presence of soil aggregates which can protect soil organic N from enzymatic attack. However, the direct impact of soil aggregation on modulating the activity of enzymes involved in N mineralization has not been fully elucidated. Thus we tested the following hypotheses: (1) soil de-aggregation would promote N mineralization due to increased availability of organic N, and (2) there would be a stronger correlation between the mineralization rate and potential enzyme activities in de-aggregated soils than aggregated ones. In the present study two different soils from grassland (GL) and arable land (AL) respectively were air-dried and sieved for isolation of three fractions (4.75-2mm, 2-0.25mm and 0.25-0.063mm) of soil aggregates. For aggregate soil samples, three fractions were mixed based on the following proportion: 24g of 4.75-2 mm, 24g of 2-0.25 mm and 6g of 0.25-0.063 mm fraction. Corresponding de-aggregated soil samples were prepared by physical disruption with a pestle and mortar. To quantify N mineralization rate, anaerobic incubations of the soils at 26 were conducted for 10 days. Using the soils harvested from the aggregated and de-aggregated samples, potential protease and chitinase activities were determined using colorimetric assays.
The first hypothesis was supported for both land uses as N mineralization rates were significantly higher in de-aggregated soils than in aggregated ones ($P < 0.05$). The second hypothesis was supported in the case of the GL soil: significant correlations ($P < 0.05$; $r > 0.89$) between N mineralization rate and protease and chitinase activities were detected in de-aggregated soil whereas correlations for aggregated soils were weaker and not significant ($P > 0.05$; $r > 0.7$). For AL soils, only chitinase activity was reliably above the limit of detection of the assay. There were no significant correlations between the chitinase activity and N mineralization rate for both treatments, however, there was a positive correlation ($r > 0.7$) for de-aggregated soils.
The stronger correlations for the GL de-aggregated soil indicated that soil proteases and chitinases had access to, and depolymerized, organic polymer N which was physically protected before de-aggregation. We concluded that the difference between two land uses could be attributed to tillage effects on the relative location of extracellular enzymes and their substrates.

Keywords: Soil aggregate, Extracellular enzyme, Nitrogen minralization, Depolymerization

Quantifying soil ice content with a heat pulse probe for an entire range of temperature during soil freezing and thawing

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Soil freezing and thawing is important for winter hydrology. Despite its importance, measuring in-situ soil ice content θ_I has been difficult. Volumetric heat capacity measurement with a heat pulse probe (HPP) has been used to quantify θ_I (hereafter, VHC method). The VHC method determines θ_I only when soil temperature is below -5°C. In this study, we propose a new method to determine θ_I from HPP by considering sensible heat balance in soils (hereafter, SHB method). We tested both VHC and SHB methods for θ_I determination.

A HPP measures soil temperature T, volumetric heat capacity C, and thermal conductivity λ. For the VHC method, only C is used to determine θ_I. For the SHB method, a HPP is inserted into soil such that each needle is located at a different depth. When the heat balance of a thin soil layer which has boundaries at the middle of each HPP needle is considered, there is conductive heat flux at the first boundary H_1, conductive heat flux at the second boundary H_2, change in sensible heat storage ΔS, and latent heat flux L, *i.e.*, H_1-H_2-ΔS=L. H_1, H_2 and ΔS can be estimated from HPP measurements and equations, thus, L can be calculated. When T is < 0°C, L is associated with soil freezing and thawing. Thus, change in θ_I can be determined by dividing L by latent heat for water freezing L_f. θ_I can be determined by integrating $\Delta\theta_I$ with respect to time once T drops below 0 °C.

Soil was packed into 0.3 m long PVC columns with 0.28 m^3 m^{-3} water content. A HPP was inserted through the column wall. Additional columns were prepared for destructive sampling to determine total soil water content after soil freezing. Upper boundary temperature was initially 5°C, and then it was decreased to -15°C gradually within 24 hours. After 6 days, the temperature was increased to 5°C within 24 hours. The temperature for the lower boundary was maintained at 5°C. Transient θ_I was estimated with VHC and SHB methods.

θ_I determined by sampling was around 0.20 m^3 m^{-3}. θ_I estimated with the VHC method was close to 0.20 m^3 m^3 when T was < -5 °C. The SHB method could additionally estimate transient θ_I when T was between 0 and -5 °C but failed at T < -5°C. Thus, we measured θ_I for a whole T range by using the SHB method with T between 0 and -5°C and using the VHC method with T < -5°C.

A combination of SHB and VHC methods allowed determination of transient θ_I for the entire range of temperature during freezing. Accordingly, a HPP can be a useful sensor for monitoring θ_I under freezing and thawing conditions.

Intra-Wellbore Head Loss with both *Kinematic and Friction*

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Riverbank filtration or withdrawal of groundwater from the bank of a river is commonly practiced in many countries for obtaining sustainable and good quality of water. Groundwater flow to a well installed at the bank of a river is closely related to the aquifer-steam interactions. Up to present, most studies associated with riverbank filtration are concentrated on the vertical wells that may produce a large drawdown cone near the well. In recent decades, horizontal wells have become an interest of research among hydrogeologists, environmental scientists and engineers, due to many technical advantages over the vertical wells for thin aquifers, such as the decreasing operational cost and many technical advantages over the vertical wells. However, many previous studies on the flow into horizontal wells were based on the uniform flux boundary condition (UFBC) when treating horizontal wells, which could not reflect the physical processes of flow inside the well accurately. In this study, we developed solutions of transient flow into the horizontal well in an anisotropic confined aquifer between two streams for three types of boundary conditions of treating the horizontal well, including UFBC, uniform head boundary condition (UHBC), and mixed-type boundary condition (MTBC). The MTBC model considered both kinematic and friction effects inside the horizontal well, in which the kinematic effect referred to the accelerational and fluid inflow effects. The solution of UFBC was analytically derived by superimposing the point sink/source solutions along the axis of the horizontal well with a uniform strength. The solutions of UHBC and MTBC were obtained by coupling the analytical and numerical methods. Based on this study, one can draw the following conclusions: (1) At the early stage, well specific inflow (WSI) increases with the distance along the wellbore for the MTBC model, and follows a cubic polynomial function. (2) When the point of intake is at the well heel, the values of specific capacity (SC) follow the orders of UFBC, UHBC and MTBC from high to low. (3) Comparing the solution of UFBC, UHBC, $MTBC_{Friction}$ and MTBC, one could find that the difference between them is obvious, and the dimensionless drawdown of UFBC and UHBC solution are independent to the flow rate. However, the difference of the dimensionless drawdown between $MTBC_{Friction}$ and MTBC increases with the greater flow rate. The new solution can be used not only to interpret the aquifer test data, but also to provide reference solutions to check the accuracy of numerical simulators.

Keywords: Accelerational effect, Mixed-type boundary condition, Specific capacity

One dimensional solute transport in low permeability homogeneous and saturated soil columns

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Solute transport in low-permeability media such as clay has not been studied carefully up to present, and we are often unclear what is the proper governing law for describing the transport process in such media? In this study, we composed and analyzed the breakthrough curve (BTC) data and the development of leaching in one-dimensional solute transport experiments in low-permeability homogeneous and saturated media, to identify the parameters controlling transport. Sodium chloride (NaCl) was chosen to be the tracer. A number of tracer tests were conducted to inspect the solute transport under the conditions of having the same column diameter but with different column lengths, or having the same column length but with different column diameters. Tracer tests with non-smooth inner walls of the soil columns were also conducted. The modeling approaches considered were the Continuous Time Random Walk (CTRW), Two-Region Model (TRM), Classical Convection-Dispersion Equation (CDE) and Fractional Advection-Dispersion Equation (FADE). Both the breakthrough process and the leaching process were analyzed and the results indicated that the breakthrough process was Fickian, whereas the leaching process was non-Fickian. Higher values of coefficient of determination (R^2) and lower values of root mean square error (RMSE) were observed with respect to the fits of CTRW, CDE, TRM and FADE. However CDE and TRM failed to characterize the transport behavior in leaching. The CTRW and FADE models were better in capturing the full evaluation of tracer-breakthrough curve and late-time tailing in leaching.

Keywords: Solute transport, Low permeability media, Breakthrough curve

Computation of seepage-induced erosion of soils by solving the Darcy-Brinkman equations

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The numerical analysis of the soil erosion induced by seepage flows is presented. To the end, the following three aspects need to be computed: Water flow fields, onset and speed of erosion and boundary tracking between the soil and the water phases. The author employ the Darcy-Brinkman equations in order to compute the water flow fields around the soils, which easily enable the simultaneous analysis of the seepage flows in the porous media and the water flows in the fluid domain. The onset and the speed of the seepage-induced erosion is predicted by an empirical formula from the flow velocity and the pressure gradient of the seepage water. The boundary tracking scheme based on the phase-field equation is applied for tracking the soil boundary changing with the erosion. The numerical results have revealed that the combination of the above three aspects achieves the stable computation of the seepage erosion.

Keywords: Internal erosion, Numerical analysis

Pollution on the grounds broken by open-cast mining and of their rational ways of re-vegetation inside Mongolia.

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Abstract-Open-cast mining of deposits brings the greatest damage to an environment. Under current legislation, all opened cast mining should be voluntarily corrected. Extraction of minerals - process of extraction of mineral raw material of bowels. Such resources of Mongolia are gold, silver, copper, uranium, and coal. Extraction of these minerals can affect an environment very strongly. Waste which very often contains heavy metals and chemicals, can seriously pollute soil and superficial waters. The people living near to places of extraction of minerals, depend on access to pure fresh water. Outflow of toxic substances adversely influence with support of existence and a biodiversity. The majority of technologies of extraction of minerals demand enormous quantity of water. For a branch of valuable metals, pure coal or minerals from sand or rock, it leads to downturn in the level of waters, complicating access to water sources without the corresponding equipment. By development of deposits of uranium ore people can receive a harmful doze of irradiation at extraction, transportation, use, and accommodation of waste.

Keywords: mining;dust;pollution;coal;waste;

DIFFUSION OF VARIOUS ION SPECIES THROUGH GEOSYNTHETIC CLAY LINER UNDER ELEVATED TEMPERATURES

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Geosynthetic clay liners (GCLs) are used as a major component of landfill bottom liner in most of the modern engineered landfills. Their performance as a hydraulic barrier to landfill leachate is well known due to their very low hydraulic conductivity. However, when hydraulic conductivity is too low, the main transport mechanism through the liner is diffusive transport of solute or leachate. The diffusion properties of liner material are expected to be highly dependent on the nature of chemicals present in landfill leachate as well as landfill temperature. Recent studies have shown that temperature inside the landfill increases near the base liner due to weight of overlying waste and chemical processes involved in its biodegradation. Therefore it is necessary to investigate the performance of GCL against diffusion migration under high temperature conditions using different chemical species.

In this study solute diffusion tests were performed on bentonite component of a commercially available typical GCL Bentofix®. This GCL employs Na-bentonite which is mainly responsible for its hydraulic performance. The tests were performed on pre-hydrated samples of bentonite to avoid its further swelling during the test. Salt solutions of four major exchangeable cations (Na^+, K^+, Ca^{2+} and Mg^{2+}) each at a concentration of 0.01M were used as source solutions. Deionized water was used as receptor solution. The tests were carried out at two different temperatures 20 ^oC and 40 ^oC under atmospheric pressure.

The results showed that concentration of anion (Cl^-) in the source solution decreased with the passage of time and equal amount of concentration increased in the receptor solution for all the four types of solutions. However, the cations showed a different behavior depending on the nature of each cation. The concentration of Na^+ in the source solution did not decrease significantly with time which was possibly due to presence of abundant Na^+ cations at the exchange sites of the bentonite sample. These exchanged cations resisted further diffusion of Na^+ cations from the source solution. However, an increase in Na^+ cation was observed in the receptor solution with the passage of time which is mainly due to diffusion process occurring between the sample and the receptor solution. Contrarily, the concentration of cation in source solution decreased with time for all other cation solutions. The increase in concentration of these cations in the receptor solution was found negligible. A further examination of the samples taken from receptor solution showed that a significant amount of Na^+ diffused from the bentonite sample to balance the net negative charge in the sink compartment arising due to diffusion of anions. The results were interpreted as the possible cation exchange process occurring in the bentonite sample due to high affinity of K^+, Ca^{2+} and Mg^{2+}.

Temperature was found to have significant effect on solute diffusion coefficient for all the given ion species. The diffusion coefficient was found to increase significantly with increase in temperature. Further investigations are being carried out to study the effect of a further increase in temperature on diffusion coefficient of GCL.

Keywords: Diffusion, Contaminant transport, Elevated Temperature, GCL, Leachate

Mass transport in fault zones: transition from nonlocal to normal transport

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Fault zones clearly affect the flow paths of fluids at the scale of geothermal reservoirs. Fault-related fracture damage decreases to background levels with increasing distance from the fault core according to a power law. This study investigates mass transport in such a fault-related structure using nonlocal models. A column flow experiment has been conducted to create a permeability distribution that varies with distance from a main conduit. The tracer response curve describes a preasymptotic curve implying subdiffusive transport, which is slower than the normal Fickian diffusion. As long as permeability of the surrounding layers varies with distance from a main conduit, the tracer response can be modeled by the time fractional advection dispersion equation (time fADE). In contrast, if the surrounding area is a finite domain, an upper truncated behavior in tracer response (i.e., exponential decline at late time) is observed. The tempered anomalous diffusion (TAD) model captures the transition from sub-diffusive to Fickian transport, which is characterized by a smooth transition from power-law to an exponential decline in the late-time breakthrough curves.

Keywords: time fractional derivative, fractured reservoir, flow experiment, fractal scaling, truncated power-law distribution