Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-01 Room:102B Time:May 20 14:15-14:30

Temperature effects on the solute diffusion process in kaolin clay

Ei Ei Mon[1*], Schoichiro Hamamoto[1], Ken Kawamoto[1], Toshiko Komatsu[1], Per Moldrup[2]

[1]Saitama University, Japan, [2]Aalborg University, Denmark

Widespread, below-ground constructions of waste storage, geothermal energy, and infra-structure facilities such as nuclear waste deposits, ground source heat pump systems, and underground subways have lead to local subsurface temperature anomalies.Soil temperature markedly affects solute transport and retardation processes in sediments, including diffusion, adsorption, and desorption. In this study, the effect of temperature on solute diffusion was investigated. The diffusion of KCl in water-saturated kaolin clay with different void ratios was measured at three different temperatures (6,15, and 40 degree Celcius) using a newly-developed specified volume diffusion apparatus (SVD). The diffusion processes of both Cl^- ion and K^+ ion in kaolin clay as a function of void ratio and temperature will be discussed in detail, and proxy-functions for predicting the influence of temperature and compaction on the solute diffusion coefficient in kaolin clay will be presented.

Keywords: solute diffusion, temperature, kaolin clay, compaction

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AGE04-02 Room:102B Time:May 20 14:30-14:45

Numerical simulation of heat exchange process during thermal response test.

Hirotaka Saito[1*], Hiromu Muto[1], Yuji Kohgo[1], Shoichiro Hamamoto[2], Toshiko Komatsu[2]

[1]Tokyo University of Agriculture and Technology, [2]Saitama University, [3]CREST, JST

Ground source heat pump systems (GSHP) use ground or groundwater as a heat source. They 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. 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.

A reliable simulation tool is needed to evaluate GSHP performance and to assess environment impact. In this study, we used FlexPDE software to simulate heat exchange and transfer processes during thermal response test (TRT) in the ground using a vertical-loop closed GSHP system. FlexPDE allows one to solve multi-physics partial differential equations in multi-dimensions based on finite element solutions. To simulate GSHP processes, 3D conduction and 1D convection of heat transport model was used as fluid flow inside U-tube of GSHP can be considered one dimensional.

This simulation study shows that, while initial heat exchange process is strongly affected by layering, the effect diminishes as time elapsed. This confirms the applicability of the infinite line source model to analyze TRT data.

Keywords: Thermal response test, Ground source heat pump, Numerical simulation

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(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-03 Room:102B Time:May 20 14:45-15:00

Changes in subsurface temperature and groundwater quality induced by in-situ long-term thermal loading test

Takeshi Saito[1*], Shoichiro Hamamoto[1], Takashi Ueki[2], Keisuke Tateishi[2], Shigeo Matsukura[1], Toshiko Komatsu[1]

[1]Saitama University / JST-CREST, [2]Saitama University

Ground source heat pump (GSHP) systems have gradually become popular for space cooling and heating in recent years. The GSHP systems discharge waste heat into subsurface environment for cooling or taking up heat of groundwater for heating, inducing the thermal disturbance. The thermal disturbance might affect the subsurface environment including groundwater quality. However the influences of GSHP systems on the subsurface environment have not been well understood and studied. In this study, the changes in subsurface temperature and groundwater quality by operating the GSHP system over a long time period were monitored and discussed.

The GSHP system was installed with 50 m length U-tube as a heat exchanger at the campus of Saitama University. Four groundwater monitoring wells were installed for the upper (GL-16.25 m to 17.80 m) and lower (GL-38.70 m to 40.15 m) aquifers at 1 m (W1), 2 m, 5 m and 10 m distance from the U-tube heat exchanger. At each monitoring well, resistance-type temperature detectors were placed at 10 depths with 5 m interval. For in-situ thermal loading test, 40 C hot water has been circulating inside the U-tube since August 2012. The groundwater have been continuously sampled from all monitoring wells for every 1-2 weeks, and chemical properties (pH, EC, DO, ORP, dissolved gases, dissolved organic carbon, dissolved inorganic ions and heavy metals) were measured.

The subsurface temperature has increased from 15-18 C to 22-24 C at the monitoring well ”W1” by the thermal loading test for 5 months. For the groundwater from upper aquifer, some heavy metals such as Li and B clearly increased at the monitoring well ”W1” with the temperature rise, while for the groundwater from lower aquifer, there were no specific variations.

Keywords: thermal loading test, subsurface temperature, groundwater quality, heavy metals

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-04 Room:102B Time:May 20 15:00-15:15

Mechanism of water pressure propagation in the hillslope aquifer

Takuhei Yamasaki[1*], Hiromi Imoto[1], Taku Nishimura[1]

[1]University of Tokyo

In hillslope hydrology, saturated lateral flow along soil-bedrock interface greatly contributes to the increase in rainfall runoff volume[1)]. van Meerveld and McDonnell (2006) reported interesting phenomena that during rainfall, groundwater level at the upslope wells responded earlier than that sited downslope, and traveling velocity of peak water level between the wells was about ten times as fast as pore water velocity[2)]. Various theories have been proposed to explain rapid water movement in soil and quick runoff response (macropores and soil pipes, translatory or piston flow, groundwater ridge and so on). However, difference between traveling velocity of peak water level and pore water velocity is not clarified sufficiently. The objective of this study is to clarify the mechanism of the peak water level traveling through the slant aquifer by the model experiment and numerical analysis.

We packed toyoura sand homogeneously to form a model slope of 210 cm long, 100 cm high and 5 cm wide, with a reservoir at the upslope boundary, and an outlet at the downslope end. Nine tensiometers were inserted to monitor reservoir water level and groundwater level. Tipping bucket was used to measure flow rate from the outlet. First, we kept reservoir water level constant in order to make steady state water flow in the slope. Then, we added water to the reservoir to simulate groundwater level fluctuation. In the numerical analysis, we tried to reproduce the model experiment using HYDRUS-2D, which simulated two dimensional water movement through soil in the model slope and reservoir. Reservoir water level was controlled by the water flux boundary condition (BC) at the top of the reservoir. Downslope outlet was assigned as seepage face BC, and the other boundary surrounding the model slope was no flux BC. Soil hydraulic function was described by the van Genuchten-Mualem model.

As soon as reservoir water level rose, all the tensiometers and flow rate at downslope outlet responded simultaneously. This result means that fluctuation of groundwater level in part may influence groundwater level of whole aquifer. Groundwater level peak occurred at upslope and transferred to downslope, and maximum discharge was observed just after the groundwater level peak at the vicinity of the downslope outlet was detected. Traveling velocity of peak water level was 5-35 times as fast as pore water velocity. As packed toyoura sand was a homogeneous medium, translatory flow could explain the difference between traveling and pore water velocity. Numerical simulation quantitatively reproduced amplitude of the groundwater level fluctuation, but time required to transfer the fluctuation toward downslope part was overestimated. In conclusion, translatory flow might play an important role in the rapid traveling of peak water level. Quantitative discussion of traveling of peak water level in aquifer is important to understand quick runoff from hillslope at the rainfall event.

References 1) van Meerveld and McDonnell. 2006. *Water Resour. Res.* 42 W02410, 2) van Meerveld and McDonnell. 2006. *Water Resour. Res.* 42 W02411

Keywords: groundwater level, traveling velocity

Japan Geoscience Union Meeting 2013
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AGE04-05 Room:102B Time:May 20 15:15-15:45

Geostatistical Modeling of the Spatial Distribution of Soil Arsenic around a Smelter: From Sampling to Remediation

Pierre Goovaerts[1*]

[1]BioMedware, Inc 121 W. Washington St., 4th Floor-TBC Ann Arbor, MI 48104

For almost 100 years, the Asarco Company operated a copper smelter in Tacoma, Washington State. Air pollution from the smelter settled on the surface soil over more than 1,000 square miles of the Puget Sound basin. As part of the Tacoma Smelter Plume project, there have been a number of studies looking at soil arsenic contamination, leading to the collection of more than 5,000 soil samples over the years. In 2009, the State of Washington received a settlement from Asarco, including a lump sum to pay for partial cleanup. The present study aimed to pool all of the sampling results to create a model that can be used to further prioritize areas for additional sampling and remediation since not enough money is available to clean all parcels.

A simulation-based approach was first developed to: 1) incorporate wind rose information, elevation, proximity to the smelter and field measurements in the geostatistical mapping of arsenic concentration estimates at the residential parcel level, and 2) compute the probability of exceeding specific arsenic levels at the parcel and block-group levels. Results indicate higher arsenic concentrations on undeveloped parcels, closer to the smelter and along the prevailing wind directions. The simulation-based approach also allowed the computation for each block-group of the expected number of parcels where a given arsenic concentration threshold is exceeded with a minimum probability. This information will be used to select widely contaminated block-groups where all parcels will be systematically sampled and the ones exceeding a target threshold (e.g. 90 or 100 ppm) will be remediated.

A design simulation study was conducted to compare the power of different composite sampling design options when deciding whether the average arsenic concentration within a residential parcel exceeds or not decision criteria of 90 or 100 ppm. The expected rates of false positives and false negatives were computed for six different sampling design options that included: composite samples at 4:1, 6:1, 8:1, 10:1, and 12:1, as well as an MIS design at 30:1 for comparison purposes. Based on the power curves and field practicability/cost issues, the 8:1 composites were selected by the local agency.

Keywords: sampling design, remediation, interpolation, pollution, soil arsenic

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-06 Room:102B Time:May 20 16:15-16:30

Effects of Mineral and Organic Compositions on Dissolution of Lead from Naturally Polluted Soils

Ming Zhang[1*], Mihoko Hoshino[1], Junko Hara[1], Miho Yoshikawa[2]

[1]AIST, [2]Chemical Grouting Co., LTD

A recent amendment to the Japanese Soil Contamination Countermeasures Act requires the treatment of soils including those naturally polluted by heavy metals. Naturally polluted soils have great variety, and contain different kinds of chemical, mineral and organic compositions. Dissolution and/or leaching of heavy metals from naturally polluted soils can be significantly affected by their compositions, because both clay minerals and organic matters have strong adsorptivity. The knowledge about the effects of mineral and organic compositions on dissolution of heavy metals from naturally polluted soils is of fundamental necessity for the design of remediating naturally polluted sites.

In this study, more than 10 types of naturally polluted soil samples containing the heavy metal of Lead (Pb) were collected from abundant metal mine areas. A series of tests including X-ray Fluorescence Analysis (XRF), X-ray diffraction analysis (XRD), organic matter analysis, standard dissolution tests and sequential leaching tests were performed to exam the effects of mineral and organic compositions on dissolution of Pb from the naturally polluted soils. In addition, an artificially polluted soil by mixing a commercially available natural soil with Pb(NO3)2 was also prepared and similar analyses were carried out for a comparison. This presentation illustrates the details of the above experimental study, indicates the difficulties with clean-up of naturally polluted sites and proposes a methodology for assessing the applicability of remediation techniques.

Keywords: Natural pollution, Heavy metals, Mineral, Organic matter, Dissolution, Sequential leaching

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-07 Room:102B Time:May 20 16:30-16:45

Immobilization of Phosphorus and Heavy Metals in Swine Manure Using Activated Red Mud

Xianjia Peng[1*], Li Shi[1], Chuan Liang[1], Ming Zhang[2]

[1]Chinese Academy of Sciences, [2]AIST

Swine manure contains large amounts of water-soluble pollutants such as phosphorus and heavy metals. When it is applied to land, theses pollutants may pose serious threat to soil and groundwater quality through running off. In this study, an immobilization material was prepared from red mud (RM) and used to immobilize the pollutants in swine manure. It was found that phosphorus and heavy metals were effectively immobilized by the prepared immobilization material and the efficiency increased with the increase in activation temperature and the RM dosage. Leaching experiments showed that the immobilization efficiency of phosphorus, copper, zinc, and arsenic reached 84%, 65%, 47%, and 89% respectively as the swine manure was amended with 10% RM. Sequential extraction experiments suggested that the mechanism for immobilization reaction was mainly co-precipitation that transformed labile phosphorus and heavy metals into stable forms.

Keywords: Phosphorus, Heavy Metals, Immobilization, Swine Manure, Activated Red Mud

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-08 Room:102B Time:May 20 16:45-17:00

Radioactive fallout removal from the surface soils by enhancing vertical transport.

Tamami Miyamoto[1], Yasushi Mori[1*], Eiko Inao[2], Atsushi Suetsugu[1], Kosuke Noborio[3]

[1]Okayama University, [2]Miyagi Prefectural Institute of Agriculture and Horticulture, [3]Meiji University

Fukushima nuclear power plant damaged by the East Japan Great Earthquake caused radioactive fallout around the Tohoku region. Because radioactive fallout was positively charged, it was reported to being adsorbed to soil surface. Surface soil scraper and deep plowing would be, therefore, effective for the removal of radioactive materials. However, these techniques were available for flat and wide land like school yard or farm land. Field survey revealed that correlation between EC and radioactive dosage were significant, which meant radioactive fallout did not immediately adsorb to soil surface but stayed as exchangeable ion for a while and was transported with surface water.

Thus we applied artificial macropores to effectively remove radioactive fallout from the surface soil. Artificial macropore filled with bamboo fiber was made in soils (Field: d=1cm length=50cm, Lab: d=0.6cm, length=20cm). Zeolite was placed at the bottom of the macrpores (Field: 5cm, Lab: 3cm) to absorb transported Cesium. Four treatment was prepared such as macropore, macropore with ammonium sulfate, no macropore and no macropore with ammonium sulfate. 400mm artificial rainfall was applied in one month.

Results showed artificial macropore effectively transported radioactive Cesium to deeper profile while ammonium sulfate enhanced the amount of Cesium delivered to the deeper profile. No radioactive Cesium was observed from the drainage water.

Field experiment showed significant reduction in macropore plots than no-macropore plots, however, it is not significant for ammonium sulfate plots.

Keywords: radioactive fallout, infiltration, macropore

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-09 Room:102B Time:May 20 17:00-17:15

Surface heterogeneity and flux measurement height in large eddy simulations

Sofia Tu[1*], Annika.Nordbo[1], Antti Hellsten[2], Tiina Markkanen[2], Janne Rinne[1], Timo Vesala[1]

[1]University of Helsinki, Finland, [2]Finnish Meteorological Institute, Finland

Source/sink heterogeneity of a surface is a critical issue for micrometeological measurement methods of turbulent surface fluxes because the surface is heterogeneous in nature which is different from the assumption of horizontal homogeneity by most methods. This affects methods such as the eddy-covariance technique where fluxes are measured in situ from a mast and the source area (i.e. footprint) of the measurements lies upwind from the mast. If the horizontal scale of the heterogeneity is very small compared to the measurement height, effects of surface heterogeneity will be averaged out above a blending height, which would be below the measurement height. Moreover, if the spatial scale of the surface patches is so large compared to the measurement height that the turbulent flux footprint of the measurements will cover only one patch, the area within the footprint will be homogeneous. Hence, we will evaluate the impact of the scale of horizontal homogeneity on the turbulent flux for varying measurement heights. To obtain detailed turbulence information in the atmospheric boundary layer, large eddy simulations (LES) are applied. In addition, a Lagrangian stochastic (LS) model is applied for particle simulations in order to interpret source areas. Neutral and cyclic boundary conditions are set for LES model. Simulations are based on an ideal chess board surface with alternating surface exchange: particles are released from alternating squares and the source height is on the surface (0 m). Each simulated surface has a different, but homogeneous, roughness. This study reveals important information on the relationship between measurement height and horizontal homogeneity of the surface as well as the effects of surface roughness to the blending height. The results of the study can be used in the design of future flux measurement systems, and in the interpretation of results from the existing systems.

Keywords: Large eddy simulation, Lagrangian stochastic model, Blending height

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-10 Room:102B Time:May 20 17:15-17:45

Surface water's quality and definition of risk areas in Agueda's transboundary watershed

Teresa Albuquerque[1*], Sandrina Fidalgo[2], Margarida Antunes[3]

[1]IPCB, [2]IPCB, [3]IPCB

This paper focuses on the environmental characterization of Agueda watershed. The Agueda project is an ongoing work in the framework of the POCTEP program, Portugal and Spain. The main core of the present work is the development of a methodology to be used as a generic and flexible tool for a dynamic risk analysis, allowing the definition of leverage strategies e.g. to land management in this transboundary region.

This work started with the assessment of the quality of surface water. A sampling campaign was conducted between October and December of 2011. Fifteen surface water samples were collected along the tributary rivers and twenty three more along the main river bodies. The following chemical parameters were analyzed: Biochemical Oxygen Demand (BOD), Dissolved Oxygen Concentration (DO), Ntotal; pH, Temperature and Electric Conductivity were analyzed. The dissolved oxygen concentration (DO) and the biochemical oxygen demand (BOD) were used as indicators of environmental pollution. A coupled hydrodynamic and water dispersion model implemented in QUAL2kw software was used to simulate the distribution of these parameters along the river. The simulation results are consistent with field observations and demonstrate that the model has been correctly calibrated

The second part of our work is the mapping of vulnerability across the Agueda watershed. The DRASTIC Pesticide index was used. The DRASTIC is a parametric method (developed by US EPA) for evaluating the intrinsic vulnerability of groundwater systems on a regional scale. It takes into account the inherent geological, hydrological and hydrogeological characteristics of an area, but is independent of the nature of human activities. The parameters included in the method are depth to water (D); net recharge (R), aquifer media (A), soil material (S), topography (T), impact of vadose zone (I) and hydraulic conductivity (C) of the aquifer. Higher DRASTIC scores implies higher likelihood of contamination. The DRASTIC method includes two versions: the generic DRASTIC and the pesticides DRASTIC where the seven parameters' weights are reassigned in order to reflect the relevance of anthropic activities.

A Geographical Information System (GIS) was built to overlap the maps of vulnerability classes and surface water quality's parameters. The joint visualization allows the identification of regions of, high-high, High-low, low-high and low-low, vulnerability-risk.

The high-high areas are located mainly in the central zone which is the tertiary aquifer and the largest urban area. Feasibility studies of different treatment schemes and the development of specific monitoring activities must be addressed in future work.

Keywords: Watershed, DRASTIC Pesticide, QUAL2kw simulation, risk regions

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-P01 Room:Convention Hall Time:May 20 18:15-19:30

Development of soil pollution evaluation method using luminous bacteria -Class II Specified Chemical Substances-

Hajime Sugita[1*], Takeshi Komai[1], Yukari Imoto[1]

[1]National Institute of Advanced Industrial Science and Technology (AIST)

Recently, a lot of soil pollutions with heavy metals or volatile organic compounds have been found in many parts of the world. The soil pollution survey and the countermeasure are required socially. The bioassay with luminous bacteria is becoming the center of attention as a simplified detection technique or an acute toxicity evaluation method on pollutants.

In Japan, 9 heavy metals (Cd, Pb, Hg, Se, Cr6+, As, F, B, CN) have been regulated as Class II Specified Chemical Substances by Soil Contamination Countermeasures Act.

In this study, the bioassay tests using the luminescent bacteria were carried out on these nine substances, and the results are reported.

Keywords: bioassay, luminous bacteria, Soil Contamination Countermeasures Act, Class II Specified Chemical Substances, heavy metals

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-P02 Room:Convention Hall Time:May 20 18:15-19:30

On the experimental study of waves passing over a muddy bottom from a viewpoint of energy

Chi-Min Liu[1*], Wen-Yang Hsu[2], Ray-Yeng Yang[2], Hwung-Hweng Hwung[2]

[1]Chienkuo Technology University, [2]National Cheng Kung University

Recently the issue of how to protect the coastal region from being damaged by incoming waves has attracted a great deal of attention. One of the wave damping mechanisms is the muddy sea bottom. The mud has been found to be efficient to damping the incoming waves. Herein an series of experiments for surface waves propagating over a muddy bottom is performed to analysis the damping mechanism from a viewpoint of energy. As very few observations and discussions on the energy transfer and dissipation were presented in past studies, the focus of present paper is the transfer and dissipation of wave energy. The wave energy is partly dissipated by the viscosity of muddy bottom which results in the damping of surface waves. At the same time, part of wave energy is transferred to the lower layer which is responsible for the interfacial wave motion. The experimental data show that the energy transferring from surface waves to the mud layer is less than 1% of total wave energy during each wave cycle. In addition, the transferred energy will accumulate with the increasing propagation distance, and finally becomes notable at the far-end side.

Keywords: Fluid-mud interaction, wave damping, energy viewpoint

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-P03 Room:Convention Hall Time:May 20 18:15-19:30

Stepwise Approximation of Hydraulic Tomography Surveys for Field-Scale Heterogeneous Aquifers

Yi Ju Huang[1*], Chuen-Fa Ni[1]

[1]Graduate Institute of Applied Geology, National Central University, Taiwan

Hydraulic tomography surveys (HTS) integrate information of direct measurements and pumping test data to estimate spatial distributions of hydraulic conductivity with higher resolution. To conduct HTS requires a series of cross-well hydraulic tests. Practical applications of HTS are expensive because many packers and pressure transducers are usually used to simultaneously obtain multilevel and isolated head observations for numerical inversions. This study aims to develop a stepwise approximation to estimate multilevel hydraulic test data and apply the approach to a field-scale problem in a confined aquifer located at the campus of the Fooyin University in south Taiwan. The hydraulic stepwise test in field would use least set of packers to separate the well into an interval and obtain the multilevel observations by changing different depths of packers in a pumping stress. This study first conducted numerical investigations that a variety of cases including different variations of hydraulic conductivity (K) such as variance value and correlation length in x direction of K. To assess how and to what degrees the accuracy of the proposed stepwise approximation would compare with original HTS for estimations of aquifer parameters in synthetic heterogeneous aquifers. Base on the stepwise approach this study is then applied to hydraulic tests at well field in the Fooyin University. The numerical assessments show that the higher variance of aquifer properties the lower accuracy. The results of numerical experiments indicate that two types of head observations could yield similar estimations of hydraulic properties in magnitude and patterns. Due to limited packers and pressure transducers, the full version of HTS was not conducted at the well field for comparisons. The results based on stepwise observations from three wells in Fooying University show that the inversion of field test data agrees well with the identification of soil material types from borehole loggings. Additionally, the mean value of the estimated hydraulic conductivity closed to the one from depth?averaged two-dimensional HTS and inversions.

Keywords: hydraulic conductivity, hydraulic tomography, inverse model, stepwise approximation

Japan Geoscience Union Meeting 2013
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The Effect of Artificial Macropores on the Amount of Organic Matters in Soils and Plant Biomass.

Tetsuya Yamamoto[2], Yasushi Mori[1*], Atsushi Suetsugu[1]

[1]Okayama University, [2]Shimane University

Artificial macropores with fibrous material were installed in degraded red yellow soils to enhance vertical infiltration along with organic matter and nutrients. They enhanced vertical infiltration without cultivation which could cause small particle loss from the surface soils. Macropore and no macropore plots were prepared and total carbon in 10, 30, 50 cm depth were measured each half year. Infiltrated soil water was sampled through wick sampler to measure total organic carbon and ion concentration. Results showed that total carbon in macropore plot increased in spring while it decreased in fall, which would be caused by infiltrated soil water. Actually total carbon concentration in soil water was always higher in macropore plot. Nitrate nitrogen concentration was also higher in macropore plot, which was decomposed by biological activity. Resulted vegetation was significantly higher in macropore plot than no macropore plot. This vegetation would be possible organic matter source for future soils. This technique enhanced vertical infiltration, provided organic matter in soils, and restored the vegetation in degraded land.

Keywords: Macropore, Infiltration, Carbon sequestration

Japan Geoscience Union Meeting 2013
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AGE04-P05 Room:Convention Hall Time:May 20 18:15-19:30

Artificial macropore installation effect on plant biomass amount at a degraded land.

Yasushi Mori[1*], Atsushi Suetsugu[1], Tetsuya Yamamoto[2]

[1]Okayama University, [2]Shimane University

At ill-drained lands, heavy rain would cause erosion which enhances degradation process much faster. According to our previous study, artificial macropore successfully enhanced vertical infiltration and increased organic matter contents. However, there was a concern that infiltrated fresh soil water transported nutrient and oxygen at the same time, resulting decomposition of the organic matter. We installed artificial macropores to degraded clayey soils to evaluate how they affected vertical infiltration, organic matter contents and vegetation. Four repetitive plots were prepared for macropore, no macropore, macropore with nutrients and no macropore with nutrients treatment, respectively. Nutrients would be delivered to soil body by macropores, which would stimulate biological activity. After 6 month, results showed that total carbon was slightly larger than no macropore treatment. At the same, it could be said that macropore treatment would not negatively stimulate the decomposition of organic matter. Dry weight of plants was significantly larger in macropore treatment, which would be caused by better infiltration.

Keywords: Macropore, Infiltration, Carbon sequestration

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

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Using Complementary Approaches to Characterizing Pore Structure of Natural Rock

Qinhong Hu[1], Shoichiro Hamamoto[2*]

[1]The University of Texas at Arlington, [2]Saitama University

Microscopic characteristics of porous media ? pore shape, pore-size distribution, and pore connectivity ? control fluid flow and chemical transport, and are important in hydrogeological studies of rock formations in the context of energy, environmental, and water resources management. For example, the effect will influence the mass transfer in a fracture-matrix system, such as gas production from tight shale after hydraulic stimulation or long-term performance of geological repository. This presentation discusses various approaches to investigating pore structure of a range of rocks. These approaches include imbibition, tracer gas/liquid diffusion, porosimetry (mercury injection porosimetry, water vapor transport and capillary condensation), and imaging micro-tomography, Woods metal impregnation). Consistently across approaches, we found well-connected pores for Berea sandstone, intermediately-connected pores in welded tuff and dolomite, and a sparsely-connected pore system for Indiana sandstone, metagraywacke, and Barnett shale.

Keywords: rock, pore structure, mass transfer

Japan Geoscience Union Meeting 2013
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Numerical simulation of CO2 natural convection in heterogeneous porous formations

Chi-Ping Lin[1*], Chuen- Fa Ni[1]

[1]National Central University. Graduate Institute of Applied Geology

Geologic storage of carbon dioxide (CO2) could be a solution to the problem of global climate change. Geologic sequestration of CO2 is the direct injection of carbon dioxide in the compatible deep saline aquifers for long term storage. Before site scale investigations are conducted, numerical simulations play important roles to evaluate the capability of geologic disposal of CO2. This study employed TOUGHREACT simulator with an equation of state package, called ECO2N, to simulate the migration of dissolved CO2 plume in heterogeneous saline formations. The ECO2N module is calculated to handle two-phase (liquid, gas), three-component (water, salt and CO2) system in the pressure- temperature regime above the critical point of CO2. The density of dissolved supercritical CO2 is larger than that of saline water and will lead to the migration of liquid phase CO2 downward due to the gravitation-driven force. On the early stage of a CO2 injection, the speed of natural convection is typically faster than diffusion of CO2 molecules so that the convection may control the liquid CO2 migration and then enhance the dissolution rate. This work presents a preliminary study for modeling the natural convection of CO2 sequestration in heterogeneous saline formation in a finite two-dimensional domain. The objective of this study is to evaluate the effect of different degrees of geologic variability on the natural convection. With a minor modification of TOUGHREACT model, we can incorporate the random field generator with ECO2N module and evaluate the uncertainty influenced by the formation variability. The simulation results show that during the simulation time period, due to the heterogeneity, the liquid CO2 was more easily pass through highly permeable region, but to be up in lower permeable region which have more carbon dioxide dissolution in this part. The convection in the heterogeneous case is sooner than in a homogeneous case with the same effective permeability for dissolved CO2. The dissolution rate of carbon dioxide in heterogeneous media was larger and sooner than in homogeneous media, and the structure of permeability filed has different way to strongly dominate the convective effect for low, moderate and large heterogeneity, respectively. To understand the natural convection behavior of carbon dioxide, the effect of permeability is the leading condition to familiar with it.

Keywords: geologic storage, carbon dioxide, CO2, heterogeneity, natural convection

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(May 19-24 2013 at Makuhari, Chiba, Japan)

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Estimation of the parameters of CTRW model by means of LAT-PIV pore-velocity measurement

Itsuki Araya[1*], Shuhei Tajima[1], Yuko Hatano[1]

[1]Graduate School of Systems and Information Engineering,University of Tsukuba

Recently, the CTRW (Continuous-Time Random Walk) model has been acknowledged that it can reproduce the behavior of substances in the groundwater. This model can describe the anomalous diffusion and includes the ADE (Advection-Dispersion Equation) as a special case. However, in the CTRW model, it is one of the most difficult problems that the parameters in the model cannot be fixed a priori.

In the present study, we propose a method that can estimate the most crucial parameter, alpha, in the CTRW model with the aid of LAT-PIV (Laser-Aided Tomography and Particle-Image Velocimetory) method.

With the LAT-PIV method, we can visualize the internal structure of porous media, and tracks down tracers in the pore fluids. We packed the glass beads of diameter 2 mm ~ 5 mm into a rectangular acrylic-resin container (400 mm x 100 mm x 100 mm) and filled the container with silicone oil, tracer particles dispersed.

Silicone oil is discharged in the box with a peristaltic pump with a specific flow rate.

Laser-sheet light is projected in the box from the side, parallel to the front face of the container in order to glow the tracers.

With a CCD camera, we obtain successive images of the tracers. Then a histogram of velocities is generated.

We repeat the same procedure for another porous medium, consisted of sphere particles of 7 mm in diameter.

We improved the PIV procedure in two ways. One is that we re-edited the images in order to make glass particles invisible.

Secondly, we revised the computer program of the velocimetory part. These revisions are in order to eliminate unwanted effects due to the existence of solid particles. After these revisions, we confirmed that the mean flow velocity, estimated by the pump rate, actually agrees very well with that obtained by the PIV velocimetry.

To estimate the model parameter of CTRW, we have to convert the pore-velocity histograms into the waiting-time distribution.

The waiting-time distribution is the essential element of the CTRW model, so this is important.

We converted them in the following method.

First, after a study by Borgne et al. (2011), we conducted a Monte Carlo simulations; we choose values of the pore velocity randomly within the range of measurement. Then we sum up these values until the total displacement reaches at the pore length. The numbers summed up can be regarded as the waiting time. We repeat this 1,000,000 times and obtained the distribution of the waiting time.

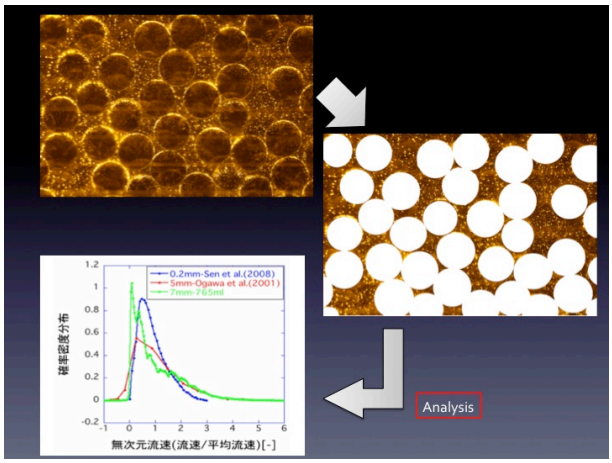
Second, we estimate the value of parameter alpha. We make a log-log plot of the waiting-time distribution and the slope of the graph corresponds to the value of alpha.

As a result, we found that the waiting-time distribution follows the power law that is assumed in the CTRW model.

We obtained values of alpha of the model, which are in the range of 1.6 ~ 2.4. We also found that the anomaly of the diffusion is stronger in a medium packed with irregular particles than a sphere-packed medium.

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

AGE04-P08 Room:Convention Hall Time:May 20 18:15-19:30



Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-P09 Room:Convention Hall Time:May 20 18:15-19:30

Impact of landfill leachate from municipal solid waste dumpsites on environmental pollution

Nadeeka Sewwandi Badabadde Gamage[1*], Koide Takahiro[2], Ken Kawamoto[1], Shoichiro Hamamoto[1], Shingo Asamoto[1], Hiroyasu Sato[3]

[1]Graduate School of Science and Engineering, Saitama University, [2]Institute of Environmental science and Technology, Saitama University, [3]Graduate School of Frontier Sciences, University of Tokyo

Landfill leachate contains different types of pollutants, organic, inorganic pollutants and heavy metals. A research was conducted to study the impact of landfill leachate on environment from municipal solid waste dumpsites in Sri Lanka. The objective of the study was to study the impact of landfill leachate on environmental pollution by quantifying different pollutant concentrations. Leachate samples were collected from five landfills from different areas of Sri Lanka. Collected samples were analyzed for pH, EC, DO, TDS, Cl-, BOD5, COD, TN, TP and heavy metals. Concentration of pollutants in landfill leachate was compared with the standards level of pollutants to be discharged into inland surface waters. Further, BOD5/COD ratio for organic pollutants and quality rating scale (QRS) values for heavy metals were used. Results show that all the leachate has a very low DO concentration. Leachate from Kolonnawa and Rathnapura show an acidic pH and pH of the other sites are basic. The ratio of BOD5/COD is highest, 0.6 from Kolonnawa leachate followed by Rathnapura leachate (0.27). Quality rating scale values of all the samples exceed the 100% except for the Cr concentration in Hambantota leachate sample. Chromium concentration in leachate from Hambantota sample was 80%. From the results of the study, it can be concluded that the soil and water nearby the open dumpsites are prone to be polluted by heavy metals present in the leachate. Further, the inorganic and organic pollutants can cause environmental imbalance in receiving bodies.

Keywords: heavy metals, quality rating scale, pollution, BOD5/COD

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(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-P10 Room:Convention Hall Time:May 20 18:15-19:30

Application of Coconut Fiber Biofilm Treatment System to Wastewater Treatment: Development of Synthetic Leachate

Nirmala Kumuduni Dharmarathne[1*], Ken Kawamoto[1], Koide Takahiro[2], Naofumi Sato[1], Hiroyasu Sato[4], Shoichiro Hamamoto[1]

[1]Graduate School of Science and Engineering, Saitama University, Japan, [2]Institute of Environmental science and Technology, Saitama University, Japan, [3]Kokusai Kogyo Co., Ltd, [4]Graduate School of Frontier Sciences, University of Tokyo, Japan

One of the main causes of water pollution is the leachate from waste disposal sites with an improper operation. The objective of this study is to assess the utilization of local-available biomass resources for wastewater treatment and to study the adaptability of the developed wastewater treatment system for the present circumstances in Sri Lanka. The experiment container is designed as 0.012m3 in volume. Pile of strings of coconut fibers from Sri Lanka will be used as a biofilm agent. Experiment will be carried out synthetic leachate at a rate of 0.057m/day (0.012m3/7days) with one-week retention time and 0.029m/day (0.006 m3 /14day) with two-week retention time with different fiber density. Using synthetic leachate, provides a relatively constant influent source concentration of leachate constituents to the microcosm system. The two type of synthetic leachate was prepared to meet the following objectives:1) to be more representative of real leachate in Sri Lanka, 2) the medium should be stable during the operation of experiment (2 week), 3)low BOD/COD ratio. Prepared Synthetic leachates were tested for biodegradability. Variation of Dissolved oxygen (DO), pH, and ORP (Oxidation Reduction Potential) profiles are almost constant with time. Chemical oxygen demand (COD) of leachate 1 is 2.09x104 mg/l and leachate 2 is 1.92x104 mg/l. In the case of leachate 1 and leachate 2, COD values were not significantly change up to 21 days and 34 days respectively. After that, COD value is significantly changed. It could be assumed that hardly degradable complexes may be formed with increasing time. In order to measure BOD values in a synthetic leachate 0.01g of landfill capping soil was added, as a seeding material.BOD value of both type of leachate is decreases as the time increases. This indicated that microorganism would depredate readily degradable organic and inorganic compounds. Total Organic Carbon (TOC), Inorganic Carbon (IC) and TC (Total carbon) values are almost constant with time. BOD/COD ratio is decreases with the time. It could be assumed that the biodegradability of leachate is decreases with time.

Keywords: Synthetic Leachate, Biodegradability, Coir Fiber, Wastewater Treatment

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-P11 Room:Convention Hall Time:May 20 18:15-19:30

Determining Diffusive Properties of Acetate and Dissolved Hydrogen in Soils

Miho Yoshikawa[1*], Mio Takeuchi[2], Ming Zhang[2], Takeshi Komai[2]

[1]Chemical Grouting Co., LTD, [2]AIST

Remediating polluted groundwater and soil is one of the essential environmental issues in industrialized countries. More than 100,000 sites polluted by Volatile Organic Compounds (VOCs) such as tetrachloroethene (PCE), trichloroethene (TCE) and their intermediate decomposition products like cis-dichloroethene (cis-DCE) are potentially existing throughout Japan. These pollutants are biologically decomposable, and bioremediation is considered as a practically applicable, low cost remediation technology. A special type of microbes, specifically *Dehalococcoides* having the ability to completely decompose PCE and TCE to ethylene, has been used to remediate polluted sites. For stimulating the activity and decomposability of the microbes, an organic matter slowly releasing hydrogen is frequently injected into the sites. Dissolved hydrogen and acetate released from the organic matter are considered to be an electron donor and carbon source for *Dehalococcoides*, respectively. For an effective remediation, especially when remediating an aquitard, delivery of hydrogen and acetate to microbes is required.

To evaluate the transport properties of acetate in soils, diffusion tests on clay soils were performed. In-diffusion test was applied to analyze effective diffusion coefficient of acetate, and a commercially-available kaolin clay was used for preparing the test specimens. The results were discussed and compared with the data previously tested for the dissolved hydrogen by the authors. The diffusivity of acetate is lower compared to that of dissolved hydrogen having smallest molecular size, and a technique to accelerate the delivery of organic matter in aquitards is necessary when performing an in situ remediation.

Keywords: VOCs, Bioremediation, diffusion test, acetate, dissolved hydrogen

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-P12 Room:Convention Hall Time:May 20 18:15-19:30

Carbon dioxide flux from Andisol in relation to soil physical properties as affected by tillage systems

Linlin Guo[1*], Taku Nishimura[1], Tsuyoshi Miyazaki[1], Hiromi Imoto[1]

[1]Graduate School of Agricultural and Life Sciences, University of Tokyo

Annual CO2 emission has grown between 1970 and 2004 by about 80%. Pedologic carbon pool is one of the major pools to store a large amount of carbon. Carbon cycle in agricultural ecosystem is one of the resources to emit CO2 from soil to the atmosphere. Since negative environmental impacts of global warming were realized, carbon sequestration by agricultural managements became hot topics recently. Tillage operation changes soil structure and thus soil physical properties, which may affect production and transport of CO2. The relationship between soil physical porosities and carbon dynamics was so complex and the studies focused on Andisol were not enough.

In this study we measured soil physical properties of Andisol under no tillage and tillage treatments. We also measured soil CO2 flux from Andisol under no tillage and tillage treatments by a 150-days incubation experiment using soil columns of 15 cm in diameter.

The results show that, compared with no tillage, tillage significantly reduced soil dry bulk density, and destructed soil aggregates, especially macroaggregates. Relationship between soil air filled porosity and gas diffusivity was well described by a soil-water-characteristic based model for the two treatments. Soil air filled porosity and gas diffusivity under no tillage treatment was higher than that of tillage treatment in tilled layer. Changes in these physical properties following tillage practice were considered as key factors of soil carbon dynamics. Soil CO2 flux under tillage treatment was higher than that under tillage treatment. No tillage may contribute to less carbon decomposition and CO2 emission in soil.

Keywords: carbon dioxide flux, tillage systems, soil physical properties, Andisol

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-P13 Room:Convention Hall Time:May 20 18:15-19:30

Fukushima-derived radiocesium in coniferous forest floor

Teramage Mengistu[1*], Yuichi Onda[1]

[1]University of Tsukuba

We are investigating the time-dependent evolution of Fukushima-derived radiocesium in coniferous forest floor in Tochigi prefecture at Karasawa yama. In our study, we classified the forest floor in to three major components: undergrowth vegetation (UG), litter layer (Ol) and fermented layer (Of). The samples are carefully separated and collected inside a rectangular frame (30 ∗15 cm) at a stable site in Japanese cypress forest at different season of a year. Radiocesium activities in the soil and litter samples were determined by gamma ray spectrometry. Results revealed that highest fluctuation of radiocesium content were observed in the UG components. Relatively, a slight variation was observed in Ol-layers but showed a general decrease whereas Of-horizon demonstrated a steady increase over time. The swinging of radiocesium content in UG components can be explained by the difference in the dynamic and the growth stage of the herbaceous plants in response to climatic-derived seasonal changes that creates an interface of active exchange. The slight fluctuation and a general decrease in Ol-layer can be partly due to microbial and mechanical decomposition of the litter components and partly due to less contaminated litters tends to fall from canopy in the later period of time. Hence, Ol-layer tends to temporary store radiocesium and feeds Of-horizon in the course of the process. The steady increasing of radiocesium in Of-layer indicates that radiocesium leaves this layer at very slow rate which implying radiocesium tends to stay longer and could be bioavailabe to plant roots exploring the horizon. Such kind of study helps to understand the dynamic of radiocesium and assist to design a precaution measures to reduce the risk associated to radiation exposure.

Keywords: Radiocesium, Undergrowth, Ol-layer, Of-layer

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-P14 Room:Convention Hall Time:May 20 18:15-19:30

Predicting nitrate leaching from cropped soils under different fertilization treatments using the modified LEACHM model

Kei Asada[1*], Sadao Eguchi[1], Ayumi Tsunekawa[2], Masaki Tsuji[2]

[1]National Institute for Agro-Environmental Sciences, [2]Aichi Agricultural Research Center

Nitrogen (N) management strategies for reducing the ground water contamination around agricultural fields require precise prediction of N leaching using a process-based model. We modified LEACHM model for use in Andosols, which are characterized by slow soil organic carbon mineralization and nitrate adsorption. The modified model was able to improve the prediction of N leaching loss from Andosol with relative improvements 63.5% over the original model. In this study, further validation of the modified model was carried out using field data from a long-term N leaching experiment conducted on sandy-loam soil amended with N chemical fertilizer, cattle and swine manure. The modified model provided relatively accurate predictions of the measured N loss below the crop root zone as well as the measured inorganic N content in surface soils under different fertilization treatments.

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-P15 Room:Convention Hall Time:May 20 18:15-19:30

Estimation of water film thickness in pores under the presence of trapped gas

Naoki Nishiyama[1*], Tadashi Yokoyama[1]

[1]Department of Earth and Space Science, Osaka University

When water infiltrates into a dry or partially saturated geological medium, the capillary trapping of gas as discontinuous clusters occurs. The trapped (residual) gas is known to influence the hydraulic conductivity of geological media (e.g., *Nishiyama et al.*, 2012, *Water Resour. Res.*), and is considered as an effective mechanism in the storage of carbon dioxide in aquifers. Previous experimental observation using a sand column has implied the presence of wetting film between trapped non-wetting phase and grain surfaces (*Conrad et al.*, 1992, *Water Resour. Res.*). Other study has shown that the dissolution and precipitation of minerals occur as long as a water film of a thickness of a few nanometers covers mineral surfaces (*Stipp et al.*, 1996, *Am. Mineral.*). It is inferred from these results that to consider the presence of water film on pore walls is essential for quantifying the dissolution and precipitation and the mass transport in geological media under the occurrence of gas trapping. Because the rate of mass transport is expected to be affected by the thickness of water film, the estimation of film thickness is important. Thus, we constructed a theoretical model predicting the thickness of water film under the condition that gas is trapped in pores.

The water film on a mineral surface is subject to van der Waals and electric double layer forces perpendicular to the plane of the film. The relationship between the film thickness and the pressure (disjoining pressure) associated with the forces acting in the film can be described on the basis of Derjaguin-Landau-Verwey-Overbeek theory. Because the disjoining pressure can be converted to relative humidity in the surrounding gas, we first obtained the relationship between film thickness and relative humidity. When we consider the pore space where gas is confined by pore water, the relationship between relative humidity and pore diameter can be determined on the basis of the Kelvin equation. Combining these relationships, we finally obtained the expression describing the film thickness-pore diameter relation. The expression shows that the water film thickness changes depending on the pore diameter, mineral type, electric potential at the water-gas and water-mineral interfaces, and pore solution composition. Especially for the system in which the ion concentration in pore solution is low ($<10^{?4}$ M) and the mineral has a high electric potential (e.g., quartz in contact with dilute pore solution), pore diameter is the most important factor controlling the water film thickness. In this case, the thicker film exists in pores having larger diameter. The broader the pore size distribution of a given geological medium, the broader the range of the film thickness. The expression presented in this study will be useful in modeling the reaction and mass transport in the water film in geological media under the occurrence of gas trapping.

Keywords: water film, capillary trapping, residual gas, disjoining pressure

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-P16 Room:Convention Hall Time:May 20 18:15-19:30

Determination of the Tangential Model Parameters for different soil types using the Unsaturated Soil Database (UNSODA).

Magatt Thiam[1*], Anzu Shigeoka[2], Hirotaka Saito[3], Yuji Kohgo[4]

[1]PhD Student, United Graduate School of Agriculture, Tokyo University of Agriculture and Technology, [2]Undergraduate Student, Tokyo University of Agriculture and Technology, [3]Department of Ecoregion Science, Tokyo University of Agriculture and Technology, [4]Professor, Graduate School of Agriculture, Tokyo University of Agriculture and Technology

The use of Tangential Model proposed by Kohgo (1995) in Soil Water Retention Curves (SWRCs) fitting requires to know some parameters related to: (i) the soil air entry value, (ii) its maximum specific moisture capacity, (iii) its critical suction and degree of saturation; and (iv) the slopes of the curve. In this study, an attempt is made to determine these parameters for different soil types. For that, the Unsaturated Soil Hydraulic Database, UNSODA, is used as a data source. Two methods were used to fit SWRCs data, from UNSODA, to Tangential Model. SWRCs data chosen in this study, from UNSODA, were those of sand, clay, silty clay, and sandy loam.

First approach is that of M. Brown (2000) which uses SOLVER, a built-in Microsoft Excel function, with Tangential Model equation as a user defined function. For this method, good accuracy was not always guaranteed and the smoothness of curves at lower and higher suction ranges remained difficult to satisfy. However it does permit a fast and approximate fitting. It was noticed that parameters obtained by this method depend highly on the initial input values (initial parameter input).

Determining the parameters graphically on the curves obtained from the experimental results was the method that gave the best fit with Tangential Model. Results showed a relative good agreement between experimental data points and fitted curve in the case of sand (same bulk density), silty clay and clay (close bulk density value); while they remained less accurate in the case of sandy loam. From the obtained results, the parameters determined for the different sands were very close. However, in the case of clays and silty clays, some differences were observed especially for the lower and higher suction ranges. The results put in perspective possible correlation between Tangential Model Parameters and/or the bulk density which is to be investigated further.

Keywords: soil water retention curves, degree of saturation, suction, fitting, UNSODA, parametric model

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-P17 Room:Convention Hall Time:May 20 18:15-19:30

Characterization of Compaction and Gas Transport Properties for Solid Waste Samples

Damith Nandika Hiniduma Liyanage[1], Ken Kawamoto[1*], Shoichiro Hamamoto[1], Takahiro Koide[2], Kazuto Endo[3]

[1]Graduate School of Science and Engineering, Saitama University, Japan, [2]Institute for Environmental Science and Technology, Saitama University, Japan, [3]Center for Material Cycles and Waste Management Research, NIES, Japan

Compaction of waste at a landfill is the main factor that controls short-term density, hence, landfill space requirement. Conversely, it can lead to deteriorate the gas transport and hydraulic characteristics of waste due to change of pore structure and eventually, resulting on long time required for stabilization. The change of Initial moisture content of waste may control its dry density during compaction similar to soil. Hence, in this study, compaction characteristics of different waste materials were studied. Then, effect of different compaction level owing to alteration of initial water content during compaction on gas transport and hydraulic properties such as gas diffusivity (Dp/D0), air permeability (ka), and saturated hydraulic conductivity (ks) were studied. The result suggested that compaction characteristics of landfill waste fully mixed with soil is similar to soil and the variations of hydraulic conductivity of waste materials are similar to granular material. However, landfill waste exhibits higher water blockage effect and tortuous pore network compared to soil giving less gas transport parameters.

Keywords: Compaction characteristics, Gas diffusivity, Air permeability, Saturated hydraulic conductivity

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-P18 Room:Convention Hall Time:May 20 18:15-19:30

Thermal Properties of Sands and Aggregated Volcanic Ash Soils: Effects of Particle Size and Shape, and Soil Structure

Takahisa Kamoshida[1], Shoichiro Hamamoto[1*], Kawamoto Ken[1], Sakaki Toshihiro[2], Komatsu Toshiko[1]

[1]Saitama University, [2]National Cooperative for the Disposal of Radioactive Waste, Switzerland

Thermal properties including thermal conductivity and heat capacity are very important for understanding heat transport processes in landfill site cover soil to control the microbial processes in the cover soil.

Previous studies have shown effects of soil conditions such as moisture content and degree of compaction on the thermal properties for differently-textured soils. However, there are few studies on the relations between the thermal properties and micro-scale soil information such as particle size and shape although the size and shape of soil particles highly affect soil packing configuration. In addition, it is not fully understood that soil structure (i.e., aggregate structure) affects behaviors of thermal properties.

In this study, non-aggregated (sandy) and aggregated soils with different size fractions at variably-saturated conditions were used for measuring thermal properties. Micro-scale characterizations of soil-pore structure and soil particle configuration using a X-ray CT device were also performed for sandy soils. For sandy soils, the relation between measured thermal properties and mineral composition (i.e., quartz content), roundness/sphericity of soil particles, and particle size, and solid-phase tortuosity based on X-ray CT images, were investigated. For aggregated soils, the measured thermal conductivities at variably-saturated conditions were discussed based on the water retention characteristics and pore-size distribution in inter- and intra-aggregate pore regions.

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-P19 Room:Convention Hall Time:May 20 18:15-19:30

Effect of Hysteresis in the Soil-Water Retention on Gas and Heat Transport Parameters for Sandy Soils

Sasanuma Kumi[1], Shoichiro Hamamoto[1*], Kawamoto Ken[1], Sakaki Toshihiro[2], Komatsu Toshiko[1]

[1]Saitama University, [2]National Cooperative for the Disposal of Radioactive Waste, Switzerland

Gas and heat transport parameters such as soil-gas diffusion coefficient (Dp), air permeability (ka), and thermal conductivity (kT) are governing parameters for gas and heat transport behaviors in soils. Degree of water-saturation at different water potentials highly affects these gas and heat transport parameters. In this study, the effects of drying and wetting processes in the capillary water zone (water matric potential ranging from 0 to ? 100 cm H2O) on the Dp, ka, and kT were investigated using different sand size fractions at different particle shapes. Degree of soil compaction (i.e., bulk density) on water retention hysteresis, hereunder gas and heat transport parameters was also investigated. Based on the measured data, threshold air-filled porosities for Dp and ka, air-filled pore-tortuosiy, and effective pore diameter for gas transport under drying and wetting processes, and their relations with particles shape, particle size, and compaction levels were discussed.

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AGE04-P20 Room:Convention Hall Time:May 20 18:15-19:30

Modified TR model for soil water repellency characteristics curves for volcanic ash soils in Japan and New Zealand

Takuya Kuroda[1*], Shaphal Subedi[1], Ken Kawamoto[2], Karin Mueller[3], B.E. Clothier[4], Syuntaro Hiradate[5], Shoichiro Hamamoto[2], Toshiko Komatsu[2]

[1]Graduate Schol of Sience and Engineering, Saitama University, [2]Institute for Environmental Science and Technology, [3]Plant & Food Research Institute, Ruakura Research Centre, [4]Plant & Food Research Institute, Private Bag 11600, Palmerston North, [5]Biodiversity Division, National Institute for Agro-Environmental Sciences (NIAES)

Water repellency (WR) of soil can induce significant hydrological problems such as reduced water infiltration, enhanced surface runoff and erosion and the forming of preferential flow patterns in soils. Although WR has been reported in many countries including Japan and New Zealand, WR characteristics and its dependence of soil water content and soil organic carbon content (SOC) for volcanic ash soils are net fully understood. In this study, soil water repellency characteristics curves (SWRCCs; degree of WR as a function of soil water content or soil water potential) for volcanic ash soils with different SOC taken from several locations in Japan and New Zealand were determined by using various WR tests. WR parameters in the SWRCCs were correlated to either SOC per unit weight (kg kg-1) or SOC per unit specific surface area (kg m-2). Besides, a predictive model for SWCCs, Two-Regional Water Repellency (TRWR) model (Karunarathne et al., Vadose Zone J., 2010), was modified based on the newly obtained correlations between model parameters and SOC per unit specific surface area. The modified TRWR model performed better than the original model and well predicted the measured SWRCCs for volcanic ash soils.

Keywords: water repellency, volcanic ash soil, Two region model