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

AGE003-01 Room:202 Time:May 27 14:15-14:45

Data Source, Data Quality and Error Propagation Effects on Simulated Flow in a Deep Unsaturated Zone

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Simulating flow and transport in the deep vadose zone requires accurate estimation of three-dimensional hydraulic parameter fields based on often limited field and/or laboratory data. Based on an extensive research program at the Maricopa Agriculture Center (MAC) in Arizona that was started in the mid-nineties we will compare several methods that can be used to generate the hydraulic parameter fields, while accounting for the effects of error propagation that are inherent to each method. The methods are evaluated on infiltration (28 day) event, followed by a 300-day drainage phase. Water content dynamics were measured at 400 locations (nine wells, increments of 25 cm, down to 14.5 m). Directly measured hydraulic properties are sparse: only 21 cores were retrieved for laboratory measurements, while field retention curves can only be established at four depths. However, abundant secondary information is available with regard to particle size distributions (429 samples) and bulk density (224) and it is therefore attractive to use estimation methods (pedotransfer functions) to generate hydraulic properties. Several approaches are available. For example, existing general pedotransfer functions (PTF, e.g. Schaap et al., 2001) can be used, or the existing site data can be used to develop site-specific models as well as Bayesian approaches which merge site-data with existing models. Each set of hydraulic parameter estimates (approx 22,000 locations in a 50x50x14.5 meter domain) is used to simulate numerically space-time variations in water content for the infiltration-drainage experiments (328 days). Parameter estimates are then further conditioned on measured water contents through inverse simulation. Results indicate that PTFs calibrated against site data provide hydraulic parameter estimates with significantly lesser bias and uncertainty than estimates with a general PTF, resulting in much improved reproduction of observed moisture content dynamics (methods of moments). Preliminary conclusions indicate that collection of hydraulic site data is needed and that some form of model inversion leads to superior results. Analysis of error propagation is still ongoing.

Keywords: unsaturared flow, soil, hydraulic properties, pedotransfer functions, simulation, error propagation

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AGE003-02 Room:202 Time:May 27 14:45-15:00

A Single-well push-pull test for flow and mass transfer properties with the depth of 100m at a coastal area

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Hydrogeological Investigations are conducted at the coastal area of Horonobe to realize a long-term deep groundwater flow, especially focusing a movement of saltwater/freshwater interface. The understanding of the groundwater system is crucial for questions that have to be solved, e.g. assumed groundwater velocities at depths of about 1,000 m below ground surface; the ”age” of groundwater; and the evolution of these systems depending on different sea levels, etc. Horonobe is located at the north-western coast of the northern Japanese main island, Hokkaido, and is a part of a sedimentary coastal basin, which is composed of poorly compacted sand-, silt- and mudrocks of Quaternary. In our project, the hydraulic and hydrochemical properties of an aquifer in about 1,000 m depth should be investigated. The final goal of the project is to establish a numerical model to predict the long-term behaviour of groundwater flow and transport. In the first phase a Single-well (”push-pull”) test was conducted as a preliminary study in the 100 m deep well. First a tracer-groundwater mix was pumped into the aquifer (”push-phase”), and afterwards the resulting plume was pumped back (”pull-phase”). The retardation of several different ions and their recoveries in relation to conservative tracers were used to characterize the transport characteristics of dissolved substances within a potential sedimentary host rock.

Keywords: geological disposal, saltwater/freshwater interface, groundwater environment, tracer, adsorption, retardation

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AGE003-03 Room:202 Time:May 27 15:00-15:15

Relationship between water saturation and hydraulic conductivity of a sandstone

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Evaluation of hydraulic conductivity in the earth surface environment is important for considering the transport of dissolved matters and groundwater balance. Because the rock above water table is unsaturated, it is necessary to consider not only saturated hydraulic conductivity but also the relationship between water saturation and unsaturated hydraulic conductivity. In order to construct a model that can predict the unsaturated hydraulic conductivity of a rock, we measured the hydraulic conductivities of sandstone under various water saturations. It was found that the hydraulic conductivity (K) exponentially decreased with decreasing water saturation (S), and a proportional relationship between K and S^{3-4} was observed. In addition to the permeability test, we measured the size distribution of water-bearing pores by a water expulsion porosimetry, in which the water contents in each size of pore are determined by expelling pore water under various gas pressures. Based on the experimental results, we evaluated the applicability of Katz and Thompson model (K-T model), which has been often used for predicting a saturated hydraulic conductivity of sedimentary rock, to the prediction of unsaturated hydraulic conductivity. In the K-T model, the saturated hydraulic conductivity of a rock can be calculated by using the pore size distribution measured by the mercury intrusion porosimetry, without using fitting parameters. Although the original K-T model has been derived based on the data of mercury intrusion porosimetry, we can estimate unsaturated hydraulic conductivities under various water saturations if we use the size distribution of water-bearing pores measured by the water expulsion porosimetry. However, for calculating an unsaturated hydraulic conductivity, both the effect of the decrease of the volume of water flow paths and the effect of the decrease of connectivity of water flow paths need to be considered. In the present study, we attempt to formulate the unsaturated hydraulic conductivity by incorporating the above effects into the K-T model with the use of the percolation theory.

Keywords: unsaturated hydraulic conductivity, water saturation, vadose zone, sandstone

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AGE003-04 Room:202 Time:May 27 15:15-15:30

Enhancing Infiltration and Carbon Storage in Soils by Artificial Macropore Systems

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Soil is largest carbon storage body in all terrestrial medium such as vegetation and the atmosphere. However, these days, soils could not show its function as water storage layer or culture medium for plant, because of climate change or rough management. In this study, artificial macropores are introduced in soils, then, effective solute transports in soils are performed by controlling convection and dispersion of solutes. Organic matters at surface soils are effectively introduced into the soil body, which would enhance carbon storage in soils and remediate soil environment.

Keywords: soil, macropore, infiltration, carbon storage

Japan Geoscience Union Meeting 2011
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AGE003-05 Room:202 Time:May 27 15:30-15:45

Gas Transport Parameters for Landfill Cover Soil: Dry bulk density based models for gas diffusivity and air permeability

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Mitigation and emission of greenhouse gases such as carbon dioxide, methane as well as other environmental impact gases from terrestrial environments to the atmosphere gives increasing concerns for climatic, human and ecosystem health. Landfill sites, have been one of the largest sources of anthropogenic CH{sub}4{sub} emission over the last few decades. Gas exchange through compacted earthen final covers at landfill sites plays a vital role on emission of greenhouse gases, fate and transport of toxic landfill gases. Numerous studies have been dome for the hydraulic performance of landfill final cover soil but studies on gas transport parameters and their dependence have adequately not addressed.

The gas exchange through the final cover soils is controlled basically by advective and diffusive gas transport. Air permeability (k{sub}a{sub}) governs the advective gas transport while the soil-gas diffusion coefficient (D{sub}p{sub}) governs diffusive gas transport. In this study, the effects of compaction level (different dry bulk density) size fractions (finer and coarser) on k{sub}a{sub} and D{sub}p{sub} for landfill final cover soil were investigated. The disturbed soil samples were taken from landfill final covers at Saitama prefecture in Japan. Compaction tests were performed for the soil samples with two different size fractions ($<$ 35.0 mm and $<$ 2.0 mm). In the compaction tests at field water content , the soil samples were repacked into soil cores (i.d. 15-cm, height 12-cm) at two different compaction levels (2700 kN/m{sup}2{sup} and 600 kN/m{sup}2{sup}) correspondent to the modified and standard proctor compaction tests. Having completed the compaction tests, two 100-cm{sup}3{sup} intact core samples (i.d. 5.1 cm, height 4.1 cm) were taken each mold which 2 mm fraction soil were compacted at 9.0 and 10.0% moisture content. After the compaction tests, k{sub}a{sub} and D{sub}p{sub} were measured and then samples were saturated and subsequently drained at different soil-water matric potential of 1.5, 2.0, 3.0, 4.1, and with air-dried (pF 6.0) and oven-dried (pF 6.9) conditions. Further hand compaction was done at relatively low dry bulk densities (i.e., 1.40, 1.55 and 1.70 g cm{sup}-3{sup}) at different water contents ranging from 0.0 to 17.5 %.

Based on the normalized relationships between measured gas transport parameters [D{sub}p{sub}/D{sub}f{sub}, ratio of measured D{sub}p{sub} to D{sub}p{sub} at total porosity (f), and k{sub}a{sub}/k{sub}a,pF4.1{sub}, ratio of measured k{sub}a{sub} to k{sub}a{sub} at 1235 kPa suction (= pF 4.1)] and air-saturation, predictive D{sub}p{sub} and k{sub}a{sub} models in an exponential form with a single parameter (M for D{sub}p{sub} model and P for k{sub}a{sub} model) were developed. The model parameters, M and P, were correlated linearly to dry bulk density values, and the effects of compaction on D{sub}p{sub} and k{sub}a{sub} well-expressed graphically for both coarser and finer fractions.

Keywords: Gas transport, Dry bulk density, Landfill final cover

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AGE003-06 Room:202 Time:May 27 15:45-16:00

Assessment of water repellency indices: Contact angle for hydrophobized sands

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Alternative soil-based covers are commonly recognized as useful and interesting technical-solutions for landfill final cover systems. However, the material used for constructing of these capping layers is expensive and not affordable by developing countries. The capping system can vary from a simple soil layer to multiple layers. Capillary barriers consisting of inclined fine over coarse soil layers recognized as another cover system. In developing the concept of hydrophobic capillary barriers, development of possible technique to enhance the impermeable properties of capillary barriers, which consists of turning the coarse grain surface of subsoil water repellent by mixing it with low-cost and locally available hydrophobic material were discussed. Soil water repellency is the common phenomenon that reduces water infiltration; enhance surface runoff and erosion, and forming of preferential flow pattern in the soil. The soil water repellency is affected by composition and content of the organic matter. The relationship between the composition of organic matter and soil physical properties like water repellency is largely unknown. Soil water repellency is an important soil property varying with soil water contact time. In the present study, the effects of hydrophobic organic matter contents on the water repellency of the hydrophobized sands were investigated. Secondly, the time dependency of the sessile drop contact angle was determined. Lastly, the effect of wetting and drying process on contact angle were evaluated.

The degrees of water repellency of hydrophobized sands were assessed using the water drop penetration time test (WDPT), the molarity of ethanol droplet test (MED) and the sessile drop method (SDM). Water repellency category of the hydrophobized sands showed strong repellency at an oleic acid content of 0.25 g kg-1 to 5 g kg-1. Directly measured contact angles using the SDM were in good agreement with indirectly obtained contact angles using the MED test. The contact angle decreased exponentially and almost reached apparent equilibrium after 25 minutes of the soil-water contact time. The wetting and drying of hydrophobized sand were performed by hanging water column system. The contact angle measured before and after wetting and drying process showed the good agreement. The contact angle measured after wetting and drying process decreased exponentially and almost reached apparent equilibrium after 20 minutes of the soil-water contact time.

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AGE003-07 Room:202 Time:May 27 16:00-16:15

Uncertainty assessment in water transport models in semiarid Inner Mongolia steppe

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A challenge of soil water transport modeling is the assessment of various uncertainties resulting from parameterization of soil hydraulic characteristics, from boundary condition applied and estimation of source/sink terms like plant water uptake. The objective of this paper is, adopting three contrasting and widely used parameterization methods for the defined error source (including the parameters and input data), to assess the model uncertainty in predicting plot-scaled soil moisture. HYDRUS, a physically-based hydrologic model was used to incorporate these uncertainties, and the model outputs were compared with measured water content collected in semiarid Inner Mongolia steppe, China. Soil hydraulic characteristics (expressed by van Genuchten model) were parameterized by two direct methods (water retention data and evaporation method), and an indirect method (pedotransfer function), respectively. While each hydraulic parameter approach generally simulated well the trend of soil moisture, the evaporation method showed the perfect agreements. This suggested that the measurement in unsaturated hydraulic conductivity be necessary or even critical to ensure reasonable simulation of soil-water patterns, especially in a semiarid area where soil is mostly under an extreme dry (unsaturated) situation. Based on this best validated hydraulic parameters, we further showed the dependence of simulated soil moisture on the inputted boundary data, i.e. reference FAO evapotranspiration (ET) was partitioned by i) soil fraction cover, ii) leaf area index, and iii) crop height. The results showed the partitioning via soil fraction cover reflected the better simulation. Moreover, the uncertainty of a root constant model with root water uptake parameters referenced to i) grass and ii) pasture, and iii) a root growth model (only referenced to grass) in prediction were also compared, and no significant difference was found. Compared with three sources of uncertainty in predicting soil moisture, we conclude that the input parameter (e.g. soil hydraulic characteristics) is more sensitive than input data (e.g. ET partitioning or root quantification).

Keywords: Uncertainty analysis, Soil water simulation, Unsaturated conductivity, Evapotranspiration, Root water uptake

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AGE003-08 Room:202 Time:May 27 16:30-17:00

Experimental and numerical study of colloid transport in a fractured rock sample

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In fractured rocks with low matrix permeability, fluid flow and transport are dominated by flow paths that occupy discrete fracture networks. In these systems fractures act as the main channels for the distribution of fluids and for the migration of pollutants, solid particles (colloids), and microorganisms. An accurate understanding of how fluid flows through fractures is fundamental to protecting groundwater against contamination, assessing the safety of long-term hazardous waste sites, and determining remediation strategies for contaminated sites. In this paper we explore the influence of the geometry and distribution of surface roughness on the directional anisotropy of fluid flow and transport properties of natural fractures. For this study, a Phoenix v|tome|x s 240 micro X-ray Computed Tomography (CT) system is used to obtain high-resolution 3D geometry of a fractured sample. The geometry of the fractures and their aperture spatial distribution was input into directly coupled numerical model of fluid flow and transport. We simulated the transport of particles through the fracture and, as suggested data collected during laboratory flow tests, found significant sensitivity of the particle breakthrough to flow direction of the fracture. Particles were observed to be trapped in low velocity and recirculation zones (named as trapping areas) on the lee side of fracture walls. These observations have significant implications for quantifying the transport of dissolved and solid phase materials through fractured rock. The results also show a promising venue for the use of micro-CT technique for obtaining the real geometry of fractured samples and the use of these data as input for numerical modeling. Moreover, micro-CT data allow to map the real micro-structure of the fracture surface, allowing for more in depth study on the effect of mineral composition on the growth of biofilm colonies.

Keywords: lattice Boltzman, micro CT, colloid transport, roughness, fracture

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AGE003-09 Room:202 Time:May 27 17:00-17:15

Variably-charged soil colloids: characterization and transport in saturated sand columns

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Characterization of natural colloids and knowledge of their transport and deposition behavior in the subsurface and at extreme environmental conditions is required to effectively manage and remediate soil and groundwater pollution caused by colloid associated contaminant transport. In the present study, suspended soil-colloids with diameter less than 1 micrometer, extracted from a volcanic ash-soil (VAS colloids) from Nishi-Tokyo, Japan and a red-yellow soil (RYS colloids) from Okinawa, Japan were characterized in terms of their surface charge and stability and their transport and deposition in saturated sand columns was investigated. The extracted soil colloids, characterized as variably-charged colloids, were applied to 10-cm long saturated sand columns repacked with either Narita sand (mean dia. = 0.64 mm) or Toyoura sand (mean dia. = 0.21 mm) at different flow rates and pH conditions. NaBr (0.01M) was used as conservative tracer and pH was adjusted using 0.01M HCl. Colloid transport and deposition were studied by analyzing colloid effluent concentration breakthrough curves and deposition profiles. Based on zeta potential measurement, VAS colloids were characterized as pH-dependent surface charge dominant colloids whereas, RYS colloids were categorized as less pH-dependent or permanent surface charge dominant colloids. The results of column studies indicated that higher deposition was observed for decreasing flow rate, decreasing pH and for soil-colloids dominated by pH-dependent surface charge (VAS colloids). At natural pH and high flow rate, higher elution and less deposition was observed for RYS colloids as compared to VAS colloids and the deposition of both colloids was mainly due to attachment. At low pH, the deposition was mainly controlled by depth-dependent straining for VAS colloids in both Narita and Toyoura sands, and for RYS colloids in Toyoura sand. Due to pH-dependent surface charge characteristics of VAS colloids, charge neutralization of colloids occurred and hence the deposition was enhanced leading to ripening with decreasing pH. The transport and deposition of variably-charged colloid was highly influenced by the surface charge characteristics of colloids coupled with solution chemistry and receiving medium surface properties.

Keywords: Variably-charged colloids, zeta potential, colloid transport, deposition profile

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AGE003-10 Room:202 Time:May 27 17:15-17:30

A HYSTERESIS MODEL OF SOIL WATER RETENTION CURVES BASED ON BOUNDING SURFACE CONCEPT

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In 2004, Mid Niigata Prefecture had faced an earthquake that caused more than 3,000 slope failures. Before the earthquake, heavy rainfalls had occurred and the water content of the soil surface on slopes was high. These slope failures may be attributed to the combined earthquake and rainfalls effects, defined as cyclic loadings. In fact, little information is known about the cyclic loads effects. The investigation of such problems should introduce saturated-unsaturated consolidation analysis method or saturated-unsaturated seepage analysis methods which deal, in certain way, with such dynamic factors.

This presentation introduces a hysteresis model of soil water retention curve based on bounded surface concept. In the bounding surface concept, the plastic modulus is defined as a function of the distance between a current stress point and the conjugated stress point on the bounding surface. We have adopted the similar idea that the slope c of the soil water retention curves are defined as a function of the normalized distance between a current stress point and the conjugated points on main curves (main drying and wetting curves). The experimental process used to establish a soil water retention characteristics model consisted of those related to saturated-unsaturated consolidation analysis methods.

The modeling of main curves was conducted by the tangential model proposed by the author. Usually, in the modeling of water retention characteristics, the positive suction values were mostly taken into account. But the tangential model considers both of the effects of positive and negative suction values; and in another hand, it insures the continuity of the slopes of the soil water retention curves.

In order to verify the model, soil water retention curves of three samples, with cycles (drying and wetting) were simulated. The samples were: (1) white silica sand, (2) glass beads consisting of uniform glass spheres of about 180 micrometers in diameter and (3) smaller glass beads lightly sintered into aggregates, roughly 200 micrometers in diameter.

The simulation results were conclusive. Three main conclusions can be retained from the results: (i) the normalized distance was expressed by a variable r and only two parameters (hd and hw: material parameters) were required to describe the scanning curves; (ii) the tangential model may trace the retention curves as if pore water pressures are both positive and negative; and (iii) only three points are selected and the degree of saturation Sr, the suction s and the slope c at those points may be input.

Keywords: constitutive equation, degree of saturation, hysteresis, numerical analysis, soil water retention curve, suction (IGC: D4E7)

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AGE003-11 Room:202 Time:May 27 17:30-17:45

Thermal properties of differently-decomposed and variably-saturated peat soils in Japan

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Soil-temperature is one of the important factors to control the emissions of the greenhouse gases, especially methane, from the wetlands because methane formed by anaerobic bacteria activity which is highly affected by soil-temperature. Unique physical characteristics of peat soils such as high total porosity, high organic matter contents, and shrinkage characteristics may influence heat transport properties of peat soils. In this study, the thermal properties for differently-decomposed and variably-saturated peat soils were measured to investigate the effects of decomposition level and volume shrinkage on heat transport.

The study site was Bibai marsh, Hokkaido in Japan. Undisturbed peat samples were taken from three different sites in Hokkaido Bibai marsh at different depths using 100cm3 cylindrical cores. Peat 1 samples were sampled inside the marsh area, while Peat 2 samples were sampled from the area nearby a drainage ditch surrounding the marsh. Peat 3 samples were obtained from forested area located outside the wetland. Fiber contents showed that Peat 3 samples were the most decomposed followed by Peat 2 and Peat 1 samples.

The peat samples were initially saturated and subsequently drained using two different methods corresponding to the matric suction ranges. The thermal properties of the samples at different soil moisture suction levels were measured by using Decagon KD2-Pro probe.

All Peat samples gradually shrank with increasing pF, showing 50% to 85% of shrinkage during very dry conditions. Peat 1 at 20 cm depth and Peat 2 at 50 cm depth showed high volume shrinkage at pF 4 condition, while the volume shrinkage for Peat 1 at 10 cm was not significant as compared to that for other soils likely because a surface layer in Peat 1 is mainly composed of fresh Sphagnum mosses. In general, the thermal conductivity (TC) and heat capacity (HC) for all peat samples linearly increased with increasing volumetric water content (?). However, changes in the slope of the TC with ? under dry conditions, indicated shrinkage effects on the TC, giving the enhancement of TC due to the increased solid contents. The TC and HC of the deeper layers of Peat 3 samples were higher than surface layers and other Peat 1 and 2 samples. Since the Peat 3 samples, especially deeper samples, are more decomposed, higher solid contents and the difference in solid constituent might affect the TC and HC behaviors for deeper layers of Peat 3.

In perspective, with accumulations of TC and HC data for Peat soils including more decomposed deeper layers, micro-scale observations of pore structure e.g., using X-ray CT scanner and the effects of solid matter content on thermal properties should be further investigated and accurate predictive TC and HC models available for peat soils will be developed.

Keywords: Wetlands, Peat soil, Thermal Properties, solid content, Total Porosity, Volume Shrinkage

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AGE003-12 Room:202 Time:May 27 17:45-18:00

Sorption-desorption behavior of 2,4-Dichlorophenoxyacetic Acid in Volcanic Ash Soil and Kaolinite

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Pesticide desorption process controls release rate of adsorbed pesticide and its subsequent movement towards groundwater resource. Understanding of hysteretic characteristic, which is typically observed in desorption of pesticide from soils is very important. Although the sorption of 2,4-dichlorophenoxyacetic acid (2,4-D) herbicide onto various soils has been widely reported, the study of 2,4-D desorption from the soils especially volcanic ash soils having variable pH-dependent charged characteristic is still very scarce. In this study, sorption-desorption behavior of 2,4-D from a volcanic ash soil sampled from Nishi-Tokyo, Japan was investigated under different pH conditions. In addition, kaolinite (pure clay mineral) obtained from Clay Science Society of Japan (CSSJ) was also used as a comparison of volcanic ash soil.

Consecutive desorption experiments were conducted after batch adsorption experiments with three concentrations of 2,4-D (2.5, 5, and 10 mg/L) in triplicate under three pH conditions (natural pH, 5.0, 4.0). The 2,4-D solutions were prepared in artificial rain water (ARW= 0.085 mM NaCl + 0.015 mM CaCl2) for volcanic ash soil and in deionized water for kaolinite. The sample solutions were prepared by adding 10 mL of 2,4-D solution into either 1 g of the soil for volcanic ash soil or 0.5 g of kaolinite. Under a specified pH condition, consecutive desorption experiment was repeated three times after one batch adsorption experiment to obtain a desorption isotherm with three desorption steps.

All sorption and desorption isotherms followed well with the Freundlich isotherm model. The adsorption of 2,4-D increased significantly for volcanic ash soil and slightly for kaolinite with decreasing pH. Moreover, volcanic ash soil has higher adsorption capacity of 2,4-D than kaolinite under the same pH because volcanic ash soil has higher organic matter content and different clay minerals including kaolinite. The desorption of 2,4-D from both volcanic ash soil and kaolinite exhibited hysteresis at each concentration under each pH condition. Hysteretic behavior in volcanic ash soil was markedly affected by pH and concentration of 2,4-D. The higher hysteretic index showing lesser desorption was obtained at lower pH and lower 2,4-D concentration. This observation related to hysteresis indicated that the adsorption of 2,4-D in volcanic ash soil under lower pH was mainly controlled by strong adsorption mechanisms. In addition, the association of 2,4-D to the soil at lower 2,4-D concentration was probably occurred at higher energy binding sites of the soil resulting in less desorption. For kaolinite, the effect of pH and 2,4-D concentration on hysteresis was very less as compared to volcanic ash soil likely due to the simple clay mineral characteristic of kaolinite.

Keywords: sorption-desorption, 2,4-Dichlorophenoxyacetic acid, volcanic ash soil, kaolinite, pH

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AGE003-13 Room:202 Time:May 27 18:00-18:15

Evaluation of ecological risk assessment of nursery box applied insecticide via uncertainty inputs in rice paddy

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Rice paddy fields share about 55% of total farm land in Japan. Nearly 40% of total domestic pesticides such as herbicide and insecticide have been applied for stable productivity and labor saving in paddy fields. In the process of paddy rice cultivation, application of insecticide to nursery box plays an important role on preventing young rice seedling from being damaged by insects. Meanwhile, its toxic mode of action of insecticide can also affect other species living in rice paddy environment. The objective of this study was therefore to assess the environmental risk of insecticide application using process-based model under the various uncertainty condition of insecticide fate and transport processes through stochastic approach.

PCPF-1 model (Pesticide Concentration in Paddy Field type-1), which predicts pesticide concentrations in paddy water and top 1 cm surface paddy soil compartments, was used. Fipronil was chosen as the target insecticide. Input parameters of deterministic simulation of fipronil were calibrated by the results of field and laboratory experiments. Considering various responses in fipronil fate and transport processes, uncertainty analysis incorporating Monte Carlo techniques was carried out by characterizing input parameters using probability density functions for both physicochemical parameters and water management parameters with different practices and regions. Simulation results were rearranged as exposure concentration distribution (ECD) expressed as exceedance function for both paddy water and surface paddy soil. Next, species sensitivity to the toxicity of fipronil was described by species sensitivity distribution (SSD) using literature values of median effective concentration (EC50) and median lethal concentration (LC50). Since lognormal distribution is widely used to express the SSD, literature values were fitted into lognormal distribution using goodness of fitting test. Effect of fipronil exposure on aquatic biota was evaluated by overlapping ECD and SSD. Ecological risk of fipronil was estimated as probability of failure which indicates the proportion of species.

This study showed that aforementioned evaluation method was applicable for ecological risk assessment of nursery box applied insecticide. Furthermore, by coupling other models, ecological risk assessment can be extended for vadose zone and ground water in both on-farm plot and regional scale.

Keywords: Rice paddy, insecticide, process-based model, ecological risk, species sensitivity distribution, uncertainty analysis

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AGE003-P01 Room:Convention Hall Time:May 27 10:30-13:00

Effects of soil and pH on leaching behavior of lead from cathode ray tube glass

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In Japan, the television broadcast system will complete the transition from analog to digital broadcasting on July in 2011. It is expected that a large amount of CRT (cathode ray tube) based television will be disposed when it happens. Since the major component of the CRT glass is lead glass, there is concern that the landfill disposal of CRT glass is possible to lead to contaminations of the surrounding soil and ground water. Potential solvents which encounter the storage or disposal CRT glass are from acid (e.g. acid rain) to alkaline (e.g. leachate from cement).Also, CRT glass may be affected by soil coexisted (e.g. adsorption on soil). In this study, the leaching tests for CRT glass with some kind of soil and solvent of pH4 to 12 carried out. The effects of soil and solvent pH on leaching behavior of lead from CRT glass were experimentally examined.

Keywords: CRT, lead glass, leaching test, pH, soil adsorption

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AGE003-P02 Room:Convention Hall Time:May 27 10:30-13:00

Chemical Characterization of Sewage Sludge Ash Disposed in Four Cities in Northeastern Japan

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The amount of disposal sewage sludge ash in Japan is increasing every year and the percentage of sewage sludge waste was 18 percent of the total industrial waste in 2004. In Japan, landfill site is hardly available now and it is difficult to ensure the new landfill site. Therefore, approximately 71 percent of sewage sludge is incinerated to reduce its mass and weight. Because of the limited availability for landfill site, many studies have been undertaken to develop reuse technologies for application to agricultural soil, asphalt roads, construction materials and bricks. On the other hand, hazardous elements such as heavy metals could be concentrated in sewage sludge ash even after it is incinerated. Determination of chemical composition of sewage sludge ash is definitely necessary to evaluate the environmental risk of the ash. Only after we know the chemical composition of the sewage sludge ash, we can decide how to use it. The purpose of this study is to characterize the chemical composition of sewage sludge ash disposed in four cities in Tohoku region, Japan, and to discuss the origin of chemical elements in sewage sludge ash.

In this study, the sewage sludge ashes from the four sewage-processing plants were analyzed for thirteen major elements (Na, Mg, Al, Si, P, S, K, Ca, Ti, Mn, Fe, Zn, Ba) and five trace elements (Cu, As, Sr, Ag, Pb). They were analyzed by XRF milling sample-briquette technique. Surface observation, element mapping, mineral observation were performed by SEM, EDS and polarizing microscope.

The sewage sludge ash in four cities showed almost same pattern of chemical composition: SiO2 component has maximum weight percentage (30wt%), then P2O5 (20wt%), Al2O3 (15wt%), CaO (5 to 10wt%) in order. Chemical composition of sewage sludge ash is not similar to natural rocks or to essential elements of living matter. As sewage sludge is from human sewage; from excreta, kitchen, laundry and bath, they should have random composition among the cities. The highest abundance may possibly be P or Ca. However, Si and P and Al are dominant components of the sewage sludge ash composition in all cities and they all share the same characteristics. We compared the chemical compositions of the sewage sludge ashes of our results with those of the major cities in the world. The differences of the compositions, however, cannot be easily accounted for. The origins of major chemical elements are discussed in this study.

The results of minor elements are as follows: Cu amount was high amount such as 2000 to 4000 ppm, Sr resulted in about 500 ppm, Pb resulted in ca. 200 ppm, As and Ag were both 50 to 100 ppm. All trace elements are concentrated in sewage sludge ash compare to the elements in the crust. Especially, this study reveals that the amount of Ag was 1000 times higher than that of crustal abundance.

Keywords: Sewage sludge ash, XRF milling sample-briquette technique

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Leaching of dissolved organic matter and chemical components with vinasse application to a calcareous soil

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Bio-ethanol is at present demonstratively produced from biomass material (Sugarcane molasses, wheat straw, rice straw, etc.) all over Japan. Up to 20 litters of stillage may be generated for each litter of ethanol produced, and disposal and utilization of the stillage have been important problems for sustainable bio-ethanol production. In southeast region of Japan, demonstration studies have been conducted to produce bio-ethanol from sugarcane-molasses generated at sugar factories, where stillage (called "Vinasse") is generated during distillation process. Because the vinasse contains fertilizer ingredients, application to agricultural land as the fertilizer water is a hopeful utilization method. However, vinasse contains very large amounts (60,000 mg/L) of dissolved organic carbon (DOC), and its application to agricultural land raises concerns about ground water pollution. In addition, DOC can influence mobility of heavy metals in soils because heavy metals form complexes with DOC. Furthermore, vinasse contains a lot of Fe (44. 5 mg/L), Mn (9.58 mg/L) and Zn (4.80 mg/L). Thus, leaching of dissolved organic carbon and chemical components, including heavy metals, with application of sugarcane-molasses ethanol vinasse to a calcareous soil was evaluated by the soil column studies.

After vinasse of 100 m^3/ha was added to soil surface in calcareous soil columns (7 cm internal diameter; 15 cm height), deionized water was supplied to the soil surface by a peristaltic pump at fast (7.0 cm/d) and slow (1.7 cm/d) infiltration rates. The column effluent was collected by a fraction collector. At a cumulative water discharge of 20 cm, DOC cumulative discharges were 636 mg and 315 mg at the fast infiltration rate and the slow infiltration rate, respectively; DOC cumulative discharge for slow infiltration rate was clearly less than for the fast infiltration rate. The results suggested that residence time in the soil column would influence DOC leaching. Retention and transport properties of chemical components, including heavy metals, in the soil column are currently under investigation.

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Unsaturated hydraulic conductivity reduction of an Andisol during vinasse application

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As a result of increasing production of bio-ethanol, the disposal and utilization of vinasse, which is distillery wastewater, are of increasing importance worldwide because up to 20 liters of vinasse may be generated for each liter of bio-ethanol produced. Since vinasse contains ingredients that can be used as fertilizer, one approach would be to directly apply vinasse to land as irrigation water and fertilizer. To establish a sustainable recycling system including the land application of vinasse, more detailed information on the effects of applying vinasse to soil and environmental issues is required. The objective of this study was to examine the impact of vinasse on unsaturated hydraulic conductivity. Column experiments were conducted to determine the temporal change of unsaturated hydraulic conductivity with continuous loading of vinasse. The value of unsaturated hydraulic conductivity near the soil surface (2.5-7.5 cm) decreased rapidly within the initial 2 days, then remained almost constant for the following 3-5 days. The magnitude of unsaturated hydraulic conductivity reduction was one to two orders, which depended on the initial volumetric water content when the vinasse started to be applied to the soil columns. The value of unsaturated hydraulic conductivity of the deeper soil layers (7.5-12.5 cm, and 12.5-17.5 cm) decreased slightly. Rapid reductions in unsaturated hydraulic conductivity are associated with biological clogging near the soil surface of the columns. Since vinasse contains easily decomposable organic matter that allows microorganisms to reproduce, the application of vinasse caused biological clogging of unsaturated soils and the reduction in unsaturated hydraulic conductivity in the soils.

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Keywords: Bio-ethanol, Vinasse, Hydraulic Conductivity, Andisol

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Causes of shallow ground water fluctuation at Songnen plain Northeast China

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Songnen Plain is located northeastern China, and covers around $17.0*10^6$ ha. Soil alkalization in the Songnen plain has been a serious problem for the last two decades in the areas overlain shallow ground water. Ground water level in the plain has seasonal changes and affects water circulation and thus extent of soil alkalization. In this study, soil temperature, moisture, ground water level as well as climatic data of salt accumulated and vegetated fields were monitored for one year. The processes causing the fluctuation of shallow ground water are discussed. It is worth noting the low temperature and less precipitation of this region. During winter, air temperature drops to be lower than -20?C and seasonal soil freezing occurs around 1m in depth. Rainstorm happens mostly from May until September, and annual precipitation in 2005-2006 was 336 mm. Ground water level started to decrease in November and showed the lowest level of -3 m below the ground surface at early April. Then, it showed slight increase until early June. Ground water level showed two distinct rises during the summer of 2006, mid-June and late-July. During the mid-June, the rise in temperature enhanced evapo-transpiration and thus decreased the soil moisture at shallow depth. During rainfall event of this period, most of rainwater was captured by the dry shallow soil layer and could not affect ground water level. This interpretation is supported by the fact that during early July when the region had several rainfall events falling on a dry surface soil, ground water level decreased though there were large rain storms. Soil temperature profile suggests seasonal frozen soil had melted early June. It is expected liquid water accumulated low permeable frozen soil then flowed into aquifer and caused a rise in ground water level after the melt of frozen subsoil. Latter half of July, surface soil moisture was always almost saturated and rainfall in this period caused large rise in ground water level. The rise was more than 10 times greater than rainfall depth. The mid-June rise in ground water level was also more than 10 times greater than the rainfall depth of the same period. However, the process of the rise in ground water level was different to that of the July rise. Large rise of shallow ground water level in response to rainfall event has been reported by several researchers. Small input of water into nearly saturated soil is a key mechanism of the phenomenon. In Songnen plain very interesting rise of shallow ground water level was observed. In early summer, when surface soil is significantly dry due to evapotranspiration and frozen and low permeable subsurface soil has just melted, accumulated water on frozen subsoil may be a key addition of water to rise shallow ground water. while in mid-summer, i.e. late July, when frequent precipitation is observed, rainfall event onto nearly saturated surface soil stimulates rise in shallow ground water level. Both processes could rise shallow ground water level around 1.0 m and as a result, totally, 2.5m of ground water level rise had happened under 336mm precipitation during the summer of 2006.

Keywords: Salt accumulation, seasonally frozen soil, shallow ground water, rainfall, soil moisture

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Bioremediation of Heavy Metals Contaminated Sites ? Case Histories in Korea

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Metal-microbe interactions includes generally four processes such as bioleaching, biosorption, biomineralization and enzyme-catalyzed transformations (e.g. bioreduction). This paper introduces each case history of the four processes which was carried out quite recently in author's lab. The first case is on the bioleaching of As in contaminated soils under the anaerobic condition by indigenous bacteria and schwanella sp. The second case is concerned on the removal of toxic metals by biosorption and biofilm formation of indigenous bacteria in soil, and the third case on the in-situ precipitation (mineralization) of As and heavy metals in soils by microbiological sulfate reduction. The last case history is on the Cr(Vi) reduction by rhodococcus erythropolis in Cr-contaminated sediment with industrial waste. The removal efficieccy of As and heavy metals in contaminated soils and sediments collected from the industrial and mining and smelting sites in Korea was investigated in lab scale and the practical applicability of the above experimental results to the contaminated fields was discussed in this study.

Keywords: bioremediation, As and heavy metals, contaminated soils and sediments, mine and smelter and industrial sites, removal efficiency of metals, metal-microbe interactions

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Application of Electrokinetics to Enhance the Degradation of VOCs in Low Permeability Geological Formations

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Remediation of groundwater and soils polluted by VOCs, like PCE and TCE, with low cost and low energy remains a big challenge in the field of environmental engineering science. Although many kinds of technologies that are available, in principle, for treating VOCs, in situ remediation of them in low permeability geological formations, like clay and slit, is very difficult and generally suffers from incomplete remediation due to the complexity of hydro-geological conditions, the lack of effective microbes that can contribute to biodegradation, and/or low bioavailability of contaminants to microbes.

In this presentation, we compare and discuss the major technologies that are applicable to degradation or remediation of VOCs, summarize the difficulties and limitations associated with remediation of contaminants in low permeability geological formations and finally discuss the potentialities of using electrokinetics to enhance the degradation of VOCs in low permeability geological formations.

Potential application of electrokinetics to enhance the degradation of VOCs includes sequential reduction and oxidation reactions by using electro-activated water or electro-chemically activated water solution; spreading chemical solutions throughout a polluted formation by electro-osmosis flow for direct redox reactions; spreading nutrients and/or electron donors throughout a polluted formation by electro-osmosis flow for accelerating bioremediation; and combination of electro-osmosis flow with reactive barriers or pumping and treat approach. Some typical examples are collected and discussed to illustrate the efficiency of using the electrokinetic technology for accelerating in situ remediation of VOCs in low permeability geological formations.

Keywords: VOCs, Remediation, Degradation, Electrokinetics, Enhancement

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A method about setting CTRW model parameters for the prediction of the behavior of adsorptive substance

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Recently the problem of ground water pollution attracts more attention. The continuous time random walk (CTRW) model, which is one of the methods to evaluate contamination, has been noticed because it can describe the complex behavior of substances in heterogeneous porous media. However, implicating the CTRW model to real problems, values of the model parameters cannot be fixed *a priori*.

Now when we use the CTRW model, we determined the values of model parameters by trial and error. This method takes labors due to the lack of criteria for deciding parameters. Meanwhile, the Advection Dispersion Equation (ADE model) is conventional method for describing the behavior of substances in groundwater. However, it is reported that the ADE model cannot describe the behavior of substances in heterogeneous porous media. On the other hand, the ADE model is relatively easy to be used because it consists of measurable parameters. Therefore, in the present study, we concentrate on studying the relationship between the ADE model parameters and the CTRW model parameters and finding the method of determining the CTRW parameters from measurable experimental parameters.

In the ADE model, the model parameters are threefold; the velocity v (m/s), the dispersion coefficient D (m^2/s) and the retardation factor R. These values can be solved from experimental values. On the other hand, in the CTRW model needs following three parameters; coefficient a, the fine distance dx(m) and the fine time dt (s). In the CTRW model, we regard the migration of the substances as the jump of particles and describe the heterogeneity of porous media by giving distribution of waiting time t between each jumps. The waiting time describes how long staying at a site before a particle jumps. In this study, we use the probability density function P(t) proportional to t^{-a}.

The value of a has a deep relationship with the behavior of relevant system. The dx describes how far the particle moves in each jump and the dt describes how long it takes in each jump.We concentrated on the parameters mentioned above and conducted the numerical experiment between the ADE model and the CTRW model. As a result, we found that the relationship of two can be described in following equations.

$dx = D/(v*k*<t>)$

$dt = D/(v^2*k*<t>)$

The term k is a coefficient approximated by each a and can be found experimentally. The term <t> describes the mean of waiting time and can be solved in each a.

In addition, we conducted a series of column test to obtain diffusion behavior in a laboratory scale. Toyoura sand was filled in the equipment as porous media, and Zn and Pb was used adsorptive tracer. We observed how the concentration of tracer changed from the difference of adsorption strength and compared the data between Zn and Pb using by the equation mentioned above. In consequence, we found that the most suitable a to experiment data can be estimated from the retardation factor R.

Keywords: soil pollution, anomalous transport, continuous time random walk, adsorption, heterogeneity, heavy metal

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Effects of water control on flux of greenhouse gases at rice paddy field

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Global warming is one of the important issues because that impact on human life is very severe. Japan set out 25% reduction of greenhouse gases (GHG) emission below 1990 levels by 2020 at the Summit on Climate Change in 2009. Global warming potentials (GWP) in a 100-yr time horizon were calculated by taking conversion factors that 1 mg methane (CH_4) and nitrous oxide (N_2O) are equivalent to 23 and 296 mg carbon dioxide (CO_2), respectively (IPCC, 2001). All GWP results were expressed as mg CO_2 equivalent per kg soil (air dry) per hour. Rice paddies are considered to be a major source of anthropogenic methane emission (Jacobson, 2005). Especially, there exist a big proportion of the paddy field throughout Asian region include Japan. We should control GHG emission from paddy field. Yu and Patrick (2004) reported that there exist suitable oxidation-reduction potential (ORP) range that makes the minimum emission of CO_2 and CH_4 and N_2O. Water management of paddy field would be one of the most important tools that can control the emission of GHG from paddy field. In this study, we investigated the effect of water management on the GHG flux in paddy field.

We used six 2∗2∗2 m size lysimeters installed in Ikuta Campus of Meiji University to observe the GHG flux in paddy field. We set 3 types of water management practices (1) continuous flooding, (2) mid-season drainage, (3) low water level. We set water level 20 cm under the surface to study the effect of low water level on GHG flux from the rice field. We plant one japonica rice cultivar Kinuhikari per hill and set the 20 cm of interplanting. As GHG, we had observed the CH_4, CO_2, N_2O gas flux (mg m^{-2} h^{-1}) once a week during rice growing season (June 11st /2010 to September 17th /2010) using the closed chamber method. Each GHG flux was measured at rice glowing area with 30∗60∗106 cm chamber and at bare area with 25.6 cm i.d. 50cm hight cylindrical chamber. When the flux at rice glowing area was measured, we set six Kinuhikari into the chamber. The concentration of GHG was analyzed with GC-FID and GC-ECD. ORP was measured with putting reference electrode and platinum electrode into the soil.

As a result, high GHG flux was observed at rice glowing area and there were a very low GHGs flux at bare area. High emission of CH_4 was observed from constant flooding paddy fields by contrast of the low water level sites as for rice glowing area. CO_2 greatly sank into rice glowing area regardless of the difference of water management at rice glowing area. NO_2 flux is small compared to other GHG and both of the emission and sink had been observed at rice growing area. At bare area, observed GHG flux value was very small, but CH_4 was seemed to sink into the field, CO_2 and NO_2 tended to emit from the field.

The reason why the emission of CH_4 from low level water site was smaller than from constant flooding paddy fields would be that anaerobic methane producing bacteria's activity was inert in aerobic low level water sites. Hou et al. (2000) reported methane is produced in the strict anaerobic environment by obligate anaerobic microorganisms either through CO_2 reduction or transmethylation of acetic acid. Observed CH_4 emission and sink of CO2 in this study support their results. Almost all GHG flux was observed at rice glowing area might conclude that aerenchyma worked as an important GHG passage root. The photosynthesis of rice would be thought a major reason of large CO_2 sink because our flux measurement made in the daytime. ORP value at low water level site was minus through this test time. It might be caused by the pore water around electrodes. ORP at continuous flooding and mid-season drainage sites were observed under -200 mV through almost of this test time and could not be set the suitable range (+180 to -150 mV) proposed by Yu and Patrick (2004). We will try to observe the annual GHG flux change with set the suitable ORP level.

Keywords: water management, paddy field, global warming, greenhouse gases, gas flux

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Accounting for surrounding agricultural dithces in hydrological and thermal monitoring and coupling modeling of groundwa

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Functions and values of wetlands (marshes, swamps, peat bogs, and etc.), in particular theri rich natural resources and biological diversity, have come to be recognized as significant elements int natural environments (Ramsar convention, 1971). Among developed countries, their functions such as water storage, flood control, and water filtration/purification with srrounding watershed and environment. On the other hand, among developong countries, the wetlands including surrounding areas are important landfill and infrastructure development sites for cultivated and residential lands. Thus, there is growth of the demands for applicable management and wise-use of wetlands. In spite of this, due to lack of information, scientific evidences, etc., measures or engineering tools have not been sufficiently taken for evaluation ongoing methods/techniques for wetland conservation and restoration.

Our study aims to characterize mass movement and circulation systems in wetlands combining with geoengineering properties such as consolidation and strength. Based on such scientific/engineering knowledge, our final goal of the study is to develop an integrated tool which predicts water flow and transport of greenhouse gases, energy, and nutrients simulaneously in marshes by taking geoengineering properties and behaviors of wetland soils into account, and to evaluate conservation and restoration methos at natural and constructed wetlands in pursuit of site-specific management and wise-use of wetlands.

The study site is Bibai marshland in Hokkaido, Japan. An intensive field monitoring has been conducted at the marsh: methane emission has been monitored since 2003, methane content distributions have been measured since 2006, and groundwater levels and soil temperatures have been monitored since 2008,. At the same time, we have developed and improved integrated flow simulation codes to model movement of water and heat in geospheres from the field scale to the regional scale.

A hydro-thermal coupling modeling and simulation of the water-circulation at Bibai marsh surrounded by agricultural dithes (area of about 1km x 1.5km) have been excuted. The model can simulate changes in water flow, evapotranspiration, and the depth of snow cover. The model verification and update using the ovserved data collected from the Bibai site have been investigated. And as a result of this, it showed that the distribution of the water content, the direction of the groundwater flow, the distribution of evapotranspiration at surface, and the distribution of temperature at surface and subsurface on this site will be adequately calculated. These monitoring and simulation will be continued into the future.

Keywords: hydro-circulation, thermal circulation, evaptranspiration, snow cover and snow melt, hydro-thermal coupling model, marsh

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Gas Dispersion in Variably Saturated and Differently Textured Porous Media

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Measurements of Gas Dispersion in Variably Saturated and differentially Textured Porous Media
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The transport, fate and emission of gases in the soil are governed by gas advection, diffusion and dispersion phenomena. Among three gas transport phenomenas, gas dispersion is the least understood. Therefore the main focus of this study is to investigate the effect of porous media on gas dispersion both at air dry and at variably saturated conditions. The aim is to characterize the effect of particle size distribution, particle shape and water enhanced effect on gas dispersion as well as the relationship between gas diffusion coefficient and gas dispersion coefficient.

One dimensional laboratory column experiments, in an apparatus consisting of an acrylic column packed with porous medium and attached to inlet and outlet chambers (Hamamoto et al., SSAJ, 2009), were conducted. Various types of sands (Narita and Toyoura sand from Japan, and Granusils and Accusand from United States) with mean particle diameter (d50) ranging from 0.19 to 1.16 mm both at air dry and with variable moisture contents were used. Particle size distribution was characterized by sieve analysis whereas shape of the sand particles was characterized in terms of sphericity and roundness by using digital microscope and Youd (1973) method. The changes in the oxygen concentration along the porous medium column and in the inlet and outlet chambers were monitored. The measured oxygen breakthrough curves were fitted with the analytical solution to the advection-dispersion equation for the determination of the soil-gas dispersion coefficients. The measured soil-gas dispersion coefficient (DH) showed a linear increase with pore velocity (u0). Measured soil-gas dispersivity (DH/u0, where u0 is the average pore-air velocity) increased with decrease in air filled porosity.

The results showed that at air dry condition and at loosely and tightly packed state, gas dispersivity depends both on mean particle diameter (d50) and particle size distribution(s). Therefore gas dispersivity contour maps were developed between mean particle diameter and particle size distribution. In addition to this, two empirical exponential relationships between gas dispersivity and a porous media parameter (s/d50) have also been established both at loosely and tightly packed state. The effect of shape of sand particles both at air dry and at variable saturated conditions has been studied on granusils (angular) and accusand (rounded). It was found that there is a little effect of shape of sand particles on gas dispersivity.

Water enhanced effect on gas dispersivity has been studied by using various types of porous sands. Gas dispersivity varies from 0 to 3cm on reducing the air filled porosity from 0.51 to 0.28cm3/cm3. A predictive model was also developed as a function of gas dispersivity at air dry condition and normalized porosity (ratio of air filled porosity and total porosity), which fitted well the measured data.

Finally, a relationship has also been established between gas diffusion coefficient (Dp/D0) and gas dispersivity by using a pore characteristics parameter, gas phase tortuosity. Micro-focus X-ray CT Scanning analysis of sand samples at air dry and tightly packed conditions was carried out to obtain pore characteristics parameters directly for making a comparison with pore characteristics parameters obtained indirectly from gas transport parameters.

Keywords: Gas Dispersion, Dispersivity, Tortuosity

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Hysteretic Behavior in Gas Transport Parameters in Porous Media Using Unified Measurement System with Suction Control

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Gas movement of a porous media is controlled by pore structure characteristics of that medium. Pore geometric parameters including pore size distribution, total and air-filled porosities, pore tortuosity and connectivity strongly influence gas transport parameters (air permeability, ka, gas diffusion coefficient, Dp) in porous media. In this study, the gas transport parameters were measured for varying textured porous media under repeated drying and wetting cycles using a newly-developed measurement system, and the hysteretic behaviors of these gas transport parameters were investigated.

A unified measurement system with suction control (UMS_SC) was developed for measuring soil water characteristics curve (SWCC) and gas transport parameters sequentially under drying and wetting cycles. It consisted of a porous plate, diffusion chamber, sample ring (15 cm in inner diameter and 12 cm in height), tensiometer, soil moisture sensor, oxygen electrodes and air pressure gauges. Soil water characteristics curves and gas transport parameters for differently textured materials including fine sand, granulated molten slag (MS), and a mixture material of MS and volcanic ash soil were measured under repeated drying and wetting cycles. The measurement for each porous material was initiated from a full saturation and suction head was increased /decreased in steps in the drainage/wetting cycles. Moreover, independent measurements of Dp and ka were carried out for repacked samples using a cylindrical mold (15 cm in inner diameter and 12 cm in height) in order to obtain the Dp and ka values at a full dry condition.

The performance of the newly-developed UMS_SC was well for the applied suction head less than 50 cm of water with corresponding saturation of roughly 0.3-0.5. The gas transport parameters were well measured at each suction head level under repeated drying and wetting cycles, and the measured gas transport parameters including the independent measurements were verified by literature data as well as predicted values by existing models. For each material, the measured Dp values were mainly controlled by the air-filled porosities, indicating that the effects of drying and wetting paths on the gas diffusion coefficients were insignificant. On the other hand, considerable hysteretic behavior was observed in measured ka values for each material, and the ka values under the wetting processes were larger than those under the drying processes at the same air-filled porosities. This suggests that preferential pathways for gas advection could be easily created under wetting cycles. The results further show that entrapped air (air filled porosity below which no gas diffusion or air flow occurs) has no significant effect on drying and wetting processes for the used porous media.

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Non-destructive measurement of soil water content under sub-surface irrigation using ground penetrating radar

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In 2010, there are more than 6.9 billion people in the world. The world population has been quadrupling for the past 100 years. It is indispensable to increase foods product to this population increase. In arid regions where solar energy is abundant, the high production is expected if the water resource can be secured enough.

In the arid regions high-performance irrigation systems are necessary to reduce to amount of water used in agriculture. Among common irrigation systems, subsurface irrigation is known to increase the water use efficiency dramatically by decreasing the water loss from the ground surface. For effective design and management of these systems, non-destructive methods to observe changes in water contents in soils need to be developed. Ground penetrating radar (GPR), one of the geophysical methods for subsurface measurement, has been used to observe subsurface water contents non-destructively using electromagnetic waves.

The main objective of this study was to measure the soil water content distribution under subsurface irrigation using GPR. In this study, experiments were conducted using a lysimeter (1.2m x 0.6m x 0.8m) filled with river sands. An irrigation pipe was placed at a depth of 20 cm to supply water at a given head for one hour. A GPR system (1 GHz central frequency) used for subsurface environment measurement. GPR profiling data were collected a) every five minutes for an hour while irrigating and, b) 1, 2, 3, 4, and 23 hours after irrigation was ceased. For the ground truth, we measured water content using gravimetric sampling at before irrigation and 23 hours after irrigation.

As a result of the GPR measurement, before the irrigation, average water content was 0.018 to the depth of irrigation pipe and 0.013 to the bottom. After 23hours the irrigation, water content was 0.038 and 0.033 in the same zone respectively. Compared with sampling data, both were corresponding. Immediately after the irrigation, the electromagnetic wave velocity to the irrigation pipe was slower than other time. It is reflected that was higher water content. And after irrigation, GPR measurements were able to show the movement of water infiltration front by the change the position of reflected wave.

Keywords: ground penetrating radar, electromagnetic wave velocity, subsurface irrigation, unsaturated soil, volumetric water content