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

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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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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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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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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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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