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

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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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

Kaoru Inaba[1*], Hirotaka Saito[2], Ken Kawamoto[3], Toshiko Komatsu[4]

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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