Using Two Wells Pumping Test to Estimate the Spatial Distribution of Hydraulic Properties

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Many researches have been proved that tomography can be successfully applied to single well pumping tests at the field site. However, how to apply the technique to large-scale problems would be a challenge. If we could pumping two wells simultaneously, it would make more interference range. For now, two wells pumping test has not been investigated in the field site. Therefore, the two wells pumping test is conducted in this study. The transient observed drawdowns were used to estimate transmissivity (T) and storage coefficient (S). The estimated T and S would be validated, to test whether two wells pumping test makes the better result and decrease cost at times.
Field two wells pumping were conducted in National Yunlin University of science and Technology (NYUST) campus. The analysis method using Hydraulic Tomography (HT) applied to estimate T and S by VSAFT2 (Variably saturated flow and transport in 2-dimensions) software.
Results show that pumping tests have more stimuli and more information will be obtained. The advantages of two wells pumping tests can be used to estimate the heterogeneous spatial distribution of hydraulic properties by using fewer pumping tests than single well pumping tests. Therefore, the results of inversion will converge quickly and efficiently.

Keywords: Two Wells Pumping test, Hydraulic Tomography, Heterogeneity

Permeability Degradation of Permeable Pavement Material Due To Clogging

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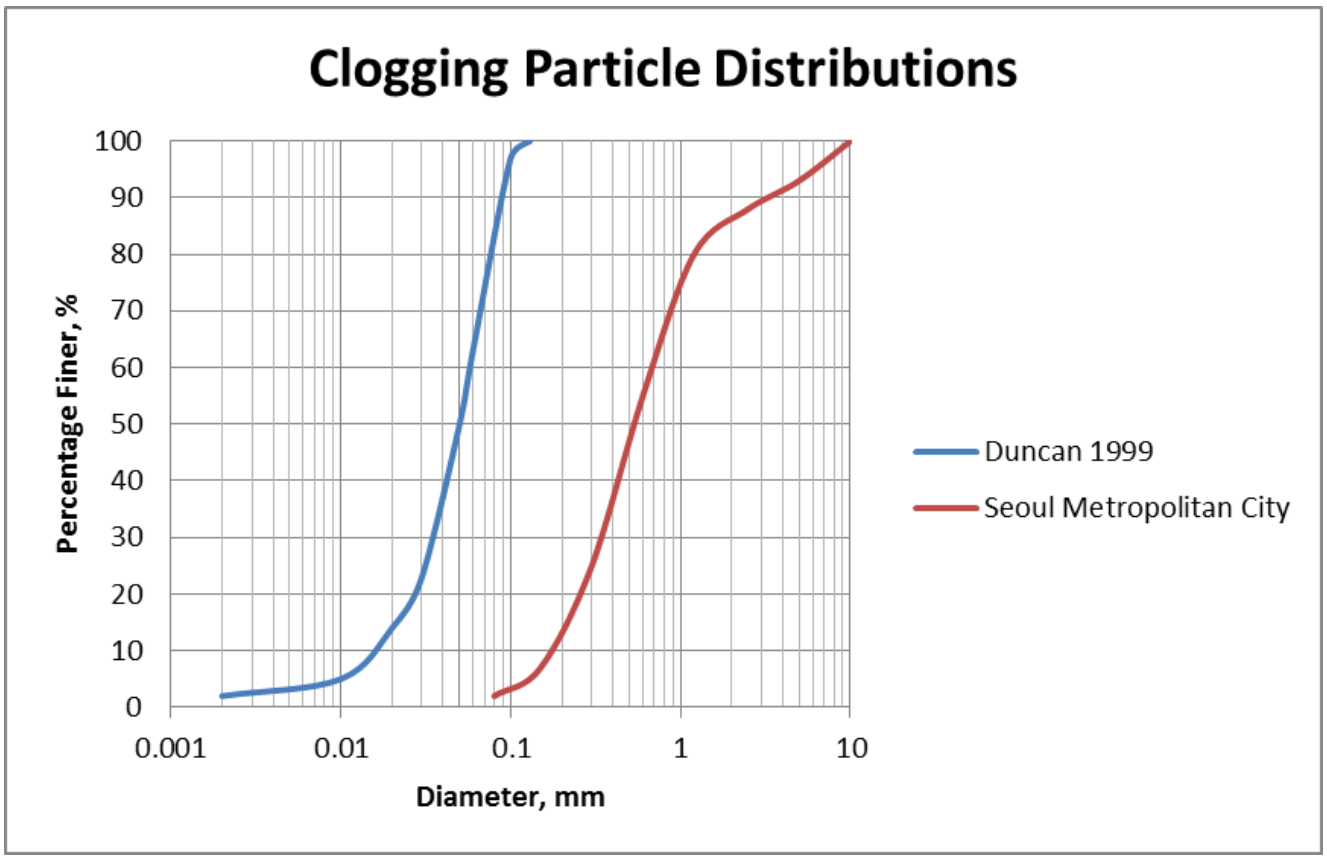
Clogging is one of major determinants in the lifespan of permeable pavements; the permeability and infiltration capacity of pavements can degrade much with physical clogging of pores in pavements. A series of laboratory experiments were conducted to understand and quantify the physical clogging and threshold value for particles governing physical clogging. Two different clogging particle distributions, reported by Seoul Metropolitan City and Duncan (1999), were prepared and used for clogging. The clogging particles were spread on the permeable pavement material under a constant head set up. For the specimens with area of 300x300 mm, and porosity of 0.20, the clogging particles of about 200 g, made the samples clogged reaching the terminal permeability. Both clogging particles reduced the coefficient of permeability by about 85%. Further efforts are needed to standardize the test procedure and investigate other specimens.

Keywords: Low Impact Development, Permeable Pavements, Porosity, Particle Distribution



Microbially induced calcium carbonate precipitation: A bioremediation technology for heavy metal immobilization

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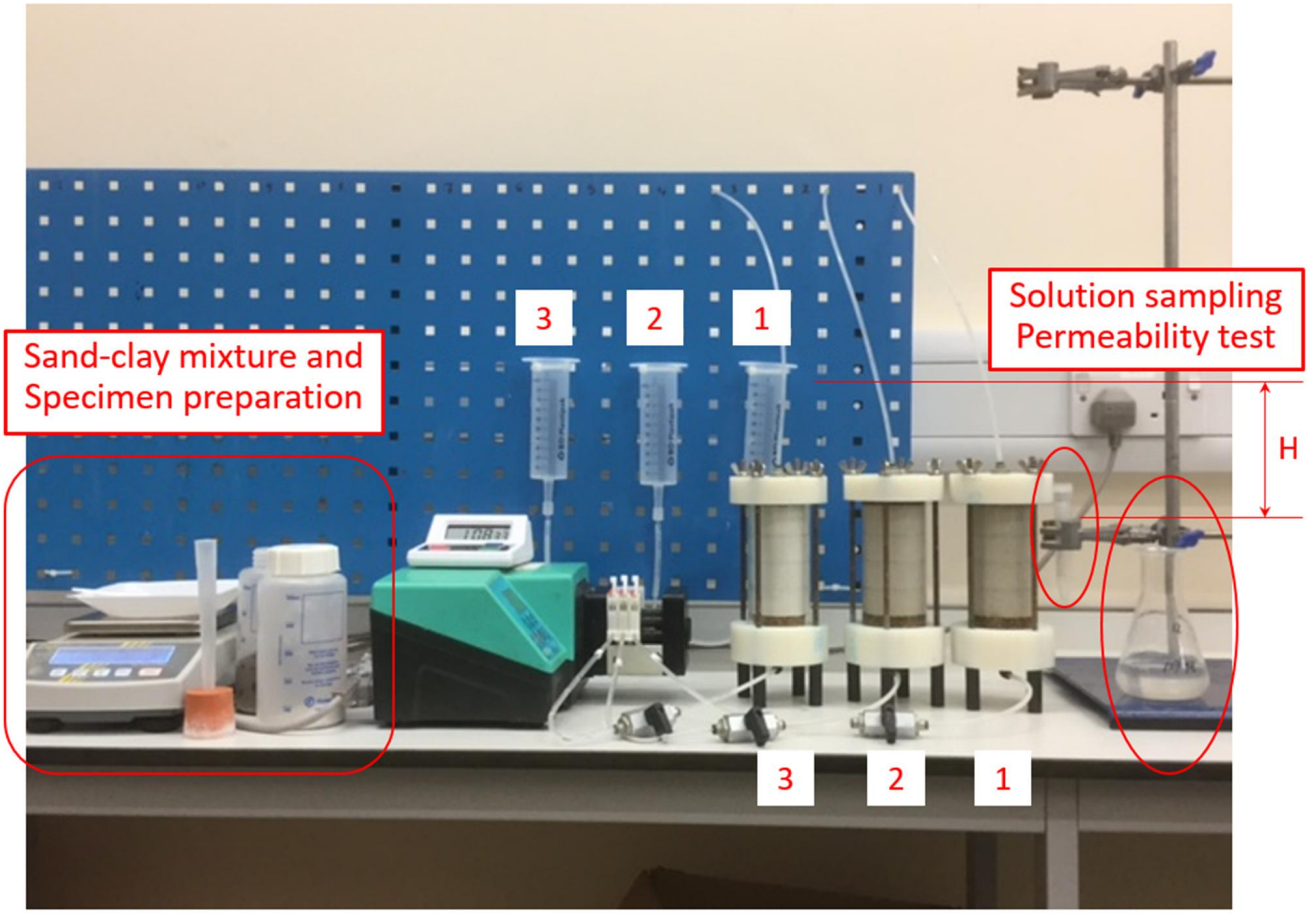
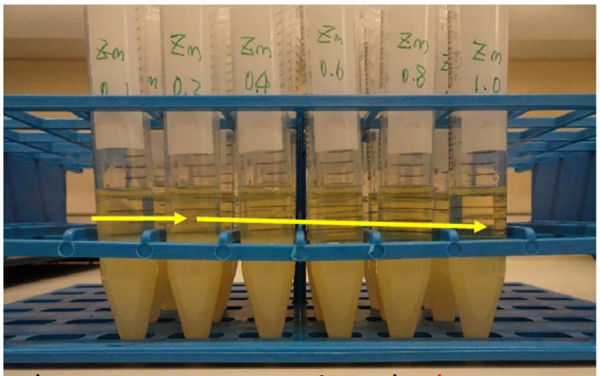
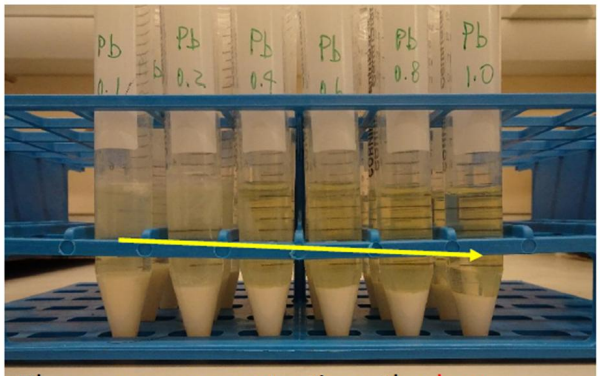
Microbially induced calcium carbonate precipitation (MICP), a bacteria-induced bio-mineralization process, has been investigated extensively in civil, environmental and infrastructure engineering applications. The urea hydrolysis by indigenous or exotic urease-producing bacteria is one of the most common pathways for bio-mediated calcium carbonate precipitation. The MICP process via ureolysis involves several stages: synthesis of enzyme through bacteria metabolic activities; catalysis of ureolytic reactions by enzyme and massive production of ammonia and dissolved inorganic carbon; alkalinity accumulation at the proximity of bacteria cells and formation of calcium carbonate precipitation on nucleation sites (i.e., bacteria cell surfaces) in the presence of available calcium source. Among these processes, production of ammonia and dissolved inorganic carbon can raise the pH of soil pore fluid. Precipitated calcium carbonate can provide extra specific surface area, which improves absorption capacity of soil. Calcium and carbonate may also entrap other metal ions in soil pore fluid to form co-precipitation. These features of MICP are in favor of heavy metal immobilization in contaminated soils.
In this study, firstly, a series of rigid-wall column leaching test was conducted to investigate the immobilization effect of MICP treatment on several heavy metal species (Pb, Zn, Ni, and Cu). Base soil was composed of sand and kaolin clay at a ratio of 9:1 (w/w). Binary mixture was prepared in rigid-wall columns using the dry tamping method to maintain uniformity. After saturated by de-aired water, nitrate solution of heavy metals was injected into the column specimen at a rate of 1.0 PV/h (pore volume per hour) for a total volume of 1.5 PV. Soil samples were left alone for 24 hours, before bacteria (*Sporosarcina pasteurii*) solution and urea-$CaCl_2$ solution were injected in sequence to trigger calcium carbonate precipitation. In some cases, urea-$CaCl_2$ solution was injected several times to improve precipitation content. After final injection, MICP treated heavy metal contaminated soil samples were held for 20 hours, which allowed calcium carbonate precipitation to grow and form sufficient cementations in soil matrix. As a comparison, control samples without MICP treatment were prepared as well. Finally, the column leaching test was conducted by percolating distilled water downwards. Hydraulic conductivity of soil and pH, EC and heavy metal concentrations of the leachate were measured during the leaching procedure. Results have demonstrated that MICP contributes to better immobilization of most heavy metals investigated in this study. There were only marginal discrepancies in hydraulic conductivity between untreated and MICP treated samples.
In order to understand the interactions between the bacteria solution and heavy metals, a follow-up laboratory batch test was conducted. The interactions were examined under aqueous condition by mixing nitrate solution of heavy metals and the bacteria solution. It was found that the interactions between the bacteria solution and heavy metals were predominantly pH-dependent. In the cases of Zn, Pb and Cu, ionized heavy metals were directly precipitated when mixed with the bacteria solution.
In addition, the efficacy of MICP for heavy metal immobilization was further examined via chemical equilibrium simulation using MINTEQ. It was found that the aqueous condition in favor of calcium carbonate precipitation also facilitate heavy metal immobilization, mainly through precipitation.

Keywords: Microbially induced calcium carbonate precipitation, Heavy metal immobilization

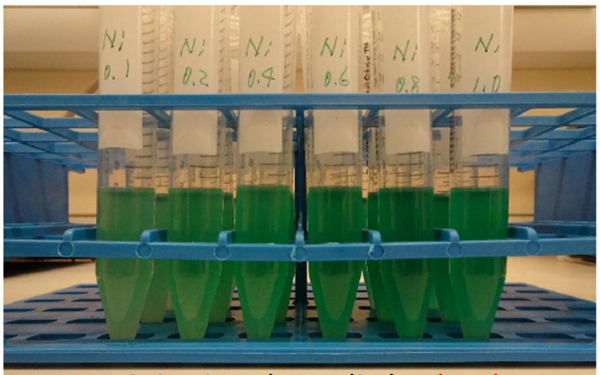




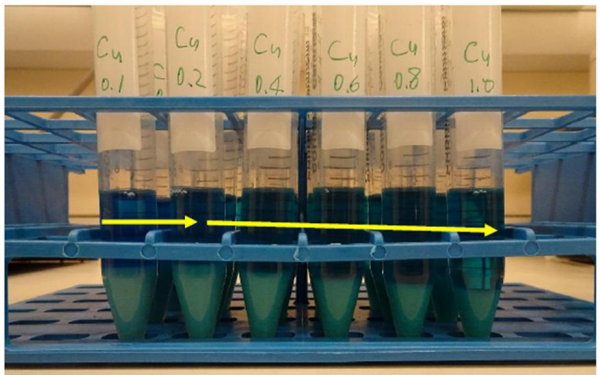
The more concentration, the less precipitation (C > 0.2).



The more concentration, the less precipitation.



No precipitation, but a little cloudy.



The more concentration, the less precipitation (C > 0.2).

Comparison of the Redundant and the Non-Redundant Verification for the Hydraulic Tomography Analysis

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In the groundwater study, it estimated the heterogeneous spatial distribution of hydraulic properties, there were many scholars use to hydraulic tomography (HT) from field site pumping tests to estimate inverse of heterogeneous spatial distribution of hydraulic properties, to prove the most of most field site aquifer was heterogeneous hydrogeological parameters spatial distribution field. Many scholars had proposed a method of hydraulic tomography to estimate heterogeneous spatial distribution of hydraulic properties of aquifer, the Huang et al. [2011] was used the non-redundant verification analysis of pumping wells changed, observation wells fixed on the inverse and the forward, to reflect the feasibility of the heterogeneous spatial distribution of hydraulic properties of field site aquifer of the non-redundant verification analysis on steady-state model.
From past literature, finding only in steady state, non-redundant verification analysis of pumping well changed location and observation wells fixed location for inverse and forward. But the studies had not yet pumping wells fixed or changed location, and observation wells fixed location for redundant verification or observation wells change location for non-redundant verification of the various combinations may to explore of influences of hydraulic tomography method. In this study, it carried out redundant verification method and non-redundant verification method for forward to influences of hydraulic tomography method in transient. And it discuss above mentioned in NYUST campus sites the actual case, to prove the effectiveness of hydraulic tomography methods, and confirmed the feasibility on inverse and forward analysis from analysis results.

Keywords: Hydraulic Tomography, Redundant Verification, Heterogeneity, Inverse, Forward

A constitutive model for gas hydrate-bearing soils with considering hydrate occurrence habits

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To exploit the resource of methane hydrate, it is crucial to understand the mechanical behavior of hydrate-bearing sediments. Here an elastoplastic constitutive model is developed for describing the mechanical behavior of gas hydrate-bearing soils (GHBS). To address the effect of the hydrate occurrence habits, the concept of the effective degree of saturation of the gas hydrate is introduced, and the effective stress stresses are redefined for describing the mechanical response of the GHBS. Within this context, a yield or loading function is developed with considering the bonding effect of gas hydrate, so that the yield function can expand or shrink as gas hydrate forms or dissociates. To describe more realistically the mechanical behavior of the GHBS, a non-associative flow rule is proposed by assuming the dilatancy to be a function of bonding stresses, suction stress and stress ratio. The proposed model are applied to analyze the mechanical responses of the GHBS with different hydrate occurrence habits under different environmental loadings. It is demonstrated that the proposed model can capture well the main features of the mechanical behavior of GHBS, including the hydrate-induced enhancements of stiffness, strength and dilatancy, the unsaturation-related characteristics and the hydrate occurrence habits dependency, showing that the proposed model is capable of describing the mechanical behavior of GHBS due to hydrate dissociation or under other environmental loadings.

Factors affecting the leaching behaviors of magnesium phosphate cement-stabilized/solidified Pb-contaminated soil, Part II: Dosage and curing age

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Magnesium phosphate cement (MPC) is frequently used to dispose synthetically spiked Pb contaminated soils by means of stabilization/solidification (S/S) technology. Leaching behaviors of heavy metal represent the most important parameters for MPC-treated metal-contaminated soil. Little information is available for the effectiveness evaluation and leaching mechanism investigation of MPC treatment. Moreover, various factors in the S/S process would affect its effectiveness, especially leaching behaviors. Part I presented the effect of original Pb concentration in soil and water-to-cement ratio on leaching behaviors of MPC treated synthetically spiked Pb contaminated soil , and this part investigated the effect of dosage and curing age on leaching behaviors of MPC treated waste. Leaching behaviors were investigated via Toxicity Characteristic Leaching Procedure (TCLP) and semi-dynamic leaching test about different MPC dosage and curing age. Results showed that both the MPC dosage and curing age would change the leaching behaviors of MPC treated synthetically spiked Pb contaminated soil . The TCLP leaching concentration of Pb decreased with the increasing MPC dosage and curing age. The calculated effective diffusion coefficients and leachability index indicated that the MPC treated Pb contaminated soil could be used for utilization after S/S treatment. The controlling leaching mechanism of Pb appeared to be diffusion for S/S products with different MPC dosage and curing age.

Keywords: Stabilization/solidification, Leaching, Water-to-Solid ratio, Magnesium phosphate cement

Multi-scale Evaluation of the Solidification/Stabilization Technology for the Remediation of Zinc/Chlorine-Contaminated Soil

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Solidification/Stabilization methods are routinely used in the remediation of contaminated land. Laboratory scale environmental remediation of contaminated land and groundwater has previously been studied by many researchers. However, there are not any studies on larger scale experiments involving applications in the field. Moreover, the immobilization mechanisms of pollutants are not described in multi-scale to give more detailed interpretation.
This study presents a systematically multi-scale investigation of the immobilization effects of two binders (GM and KMP) on zinc and chlorine contaminated soil from an abandoned galvanizing mill in Jiangsu province, China. The physical-chemical properties including dry density, soil pH, dynamic cone penetrometer, unconfined compression strength and toxicity leaching properties were tested on the treated soil at 1-28 days of curing after in-situ application of solidification and stabilization. Furthermore, laboratory tests, such as the modified BCR sequential extraction procedure, X-ray diffraction, scanning electron microscope and energy dispersive spectroscopy tests, were also conducted to investigate the immobilization mechanism of Zn or/and Cl in both the GM and KMP binders treated soils.
The results demonstrate that the dry density of stabilized soil has a significant increase of 10.68%-12.21% after 28 days of curing. Corresponding with the dry density, the strength of stabilized soil is about 5-7 times higher than that of the untreated soil treated after 28 days of curing. With the addition of binders, the pH of treated soils increases to 6.75-6.96 from 4.23 after 28 days of curing. Moreover, the two binders have different immobilization effects on zinc and chlorine in the contaminants soils, as KMP is better on immobiling zinc, while GM has a stronger ability on immobilization of chlorine.
In addition, the production of $Zn_3(PO_4)_2$, $Zn(OH)_2$, $CaZn_2(PO_4)_2$, $CaZn_2(OH)_6{\cdot}2H_2O$, $Mg_2Cl(OH)_3{\cdot}4H_2O$, $CaCl(OH)$, $Ca_5(PO_4)_3Cl$ and $Zn_5(OH)_8Cl_2$ are the most probable mechanisms in the KMP tread soil contaminated with Zn and Cl. However, in the GM tread soil, the production of $Zn(OH)_2$, $Ca(CO_3)_2(OH)_{17}Cl$, $Mg_2(OH)_3Cl{\cdot}4H_2O$, $CaCl(OH)$ and $Ca_8ZnSi_4O_{16}Cl_2$ are the most probable immobilization mechanisms for Zn and Cl. Furthermore, these results are interpreted based on the changes in chemical speciation of Zn and/or Cl in the treated soils.
Overall, this study demonstrates that the zinc and chlorine in soil can be effectively stabilized by both the two binders, and the leached toxicity of treated soil can meet the requirements for soil remediation. The outcomes of this research are significant from engineering, environmental and economic perspectives.

Keywords: zinc and chlorine contaminated soil, solidification/stabilization, bearing capacity, toxicity characteristic leaching characteristics, soil pH, immobilization mechanism

Chemical Characteristic and Utilization of Coal Bed Methane Produced Water in Qinshui Basin, China

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Approximate 1/10 of coal bed methane resource reserves deposited in Qinshui Basin of Shanxi province, China. In 2015, the national ground extraction was 4.4 billion m^3, of which 3 billion m^3 was produced from Qinshui Basin. Qianshui Basin has become one of China's most important coal bed methane development bases. The management of produced water(PW) associated with CBM production is a major environmental challenge of CBM industrialization. According to the statistics, the PW volume of CBM wells in Qinshui Basin ranges from 2.8~20.6m^3d^{-1} in a single well, and the total volume was over 3 ×$10^4m^3d^{-1}$ by the end of 2015. Based on the water quality monitoring data the PW of coal bed gas field is divided into five categories :(1) PW with suspended solid(coal powder, rock powder and other suspended solids);(2) the flow back of fracturing fluid (suspended solids , high COD, complex organic matters); (3) PW with high salinity (high salinity , low level of Ca^{2+} and Mg^{2+},but high level of Na^{+}); (4) the PW with high fluoride; (5) PW with high iron and manganese .The chemical characteristics of PW in coal bed gas fields vary widely in different stages. The hydrochemical type of fracturing fluid flow back with total salinity of 4125.4-4965.1mgL^{-1}, is mainly characterized by Cl-Na type, high level of organic matter and COD (768.9-2003.2mgL^{-1}). The total salinity of thePW from the coal gas field in the normal production stage is 678.1-1621.7mgL^{-1}; the water quality is dominated by HCO_3-Na; and the organic matter is low with COD of 2.1-92.7 mgL^{-1}. According to the chemical type differences among different production stages, a coal bed methane production water treatment process and demonstration project was conducted. (1) Treatment of PW from recovery stage with fracturing fluid: multiple oxidation method involving iron micro-electrolysis-Fenton combined can be used, and effluent could meet water discharge requirement. In addition, effluent can be deeply treated for a production and living usage. (2) Treatment of PW during normal production stage: The flocculation-precipitation technology was applied and effluent was discharged when it met the standard. Additionally, reverse osmosis technology can be used for drinking purpose.

Keywords: Coal bed methane produced water, Water chemical type, Wastewater treatment

A transient numerical model for multi-component gas transport in landfill cover soils

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The landfill gas consists of methane, carbon dioxide, hydrogen sulfide, ammonia and numerous volatile organic compounds. The transport and interact between multicomponent gas in the soil cover layer of the landfills are of great importance. Based on DGM (dust-gas-model) and mass balance equation, a one-dimensional transient multi-component gas transport model in landfill cover soils was developed for the first time. The methane oxidation in the soils is considered in the model. The numerical model was solved by the finite element method based program COMSOL Multiphysics V5.0. The numerical result consists well with the laboratory soil column experiments, which was conducted to simulate four-component (CH_4, CO_2, O_2 and N_2) gas transport in landfill cover system. The parameter analysis shows that, ordinary diffusion plays an important role in transport process. For methane and carbon dioxide, ordinary diffusion contributes 97% of the total transport flux at the top soil. The effect of ordinary diffusion decreases with the increase of depth. The ordinary diffusion contributes 50%-60% of the flux at the bottom. The influence of advection becomes more important when the depth increases. Advection contributes 37% to the flux at the bottom of the cover soil. On the contrary, the effect of Knudsen diffusion is relatively week. It contributes 0.5%-12% to the total flux. This is due to the relatively large gas permeability of the cover soils. Advection becomes important when gas permeability increase. The effect of advection is comparable to diffusion when the gas permeability increases up to 3e-13m^2. Methane oxidation rate is found to increases by 5 times when gas permeability increase from 3.5e-12m^2 to 3.5e-11m^2. The numerical solution can be used for multi-component landfill gas transport in the soils and can also be used for the design of landfill cover system with respect to gas pollution control.

Keywords: landfill, multi-componennt gas transport, methane oxidation, numerical model, column test

The Geothermal Opportunity in Taiwan

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Currently, the installed capacity and gross electricity productions of power structures in Taiwan are 40.79 GW and 219.2 billion kWh, respectively. Among them, the nuclear power plants occupy 12.61% and 18.61 % for installation and production, respectively. There are three nuclear power plants, named No. 1, 2 & 3, in operations and one (No. 4) is under construction, but is stopped and sealed now in Taiwan. Furthermore, the life-span of 40-year operation for those three power plants will be close-at hand and retire in 2018-2019, 2021-2023 and 2024-2025, respectively. Therefore, to find alternative energy sources, especially on the clean, renewable and sustainable ones for generating electricity are emergent and important for Taiwan’ s government in next few years. Among various energy sources, geothermal energy can be as base-load electricity and offers an opportunity for a country with naturally free-resource and less dependence on fossil fuel. However, development of geothermal energy has been stopped for more than 30 years, and currently no working geothermal power plant existed in Taiwan. To jump-start the geothermal exploitation rather than solely rely on knowledge, we also need to introduce the techniques from outside of this country. It provides you not only to know what the geothermal situation is, but also to find the collaborating and business opportunities in Taiwan.
Located in the west Pacific Rim of Fire, Taiwan possesses rich geothermal resources due to volcanic activities and rapid uplifting of plate collision. Based on available data prior to 1980, Taiwan may have about 1 GWe of potential shallow geothermal energy. A 3-MW pilot power plant, therefore, was constructed in 1981 and terminated in 1993 in the Chingshui geothermal field of Ilan, northeastern Taiwan. Recently, one of the National Science & Technology Program (NSTP) projects has been conducting research and reevaluating the island-wide deep geothermal energy. We found that the geothermal resource in Taiwan may be as high as 33.6 GWe of exploitable geothermal energy. There are no any commercial geothermal power plants until now in Taiwan, although the potential is great. However, geothermal energy has been listed as one of major tasks of National Energy Program, Phase II (NEP-II) in Taiwan. We will conduct more detailed geothermal energy surveys on some proposed hot sites in a few years.

Keywords: Taiwan, Geothermal potentials , Chingshui Geothermal Field

