KEYNOTE ADDRESS

THE EMERGING ROLE OF GEOENVIRONMENTAL ENGINEERING: APPROPRIATE TECHNOLOGIES FOR ENVIRONMENTAL POLLUTION CONTROL AND INFRASTRUCTURE DEVELOPMENT

By

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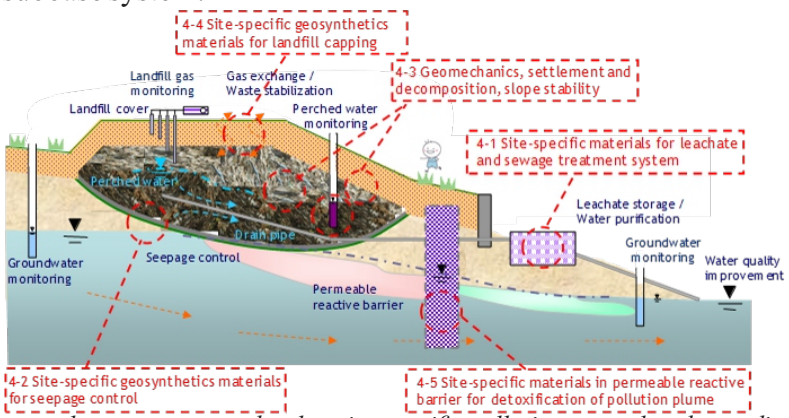
Open dumping of waste is the most common way of disposing municipal solid waste in developing countries due to the lower cost over the other waste management techniques. In the case of Sri Lanka, most of waste landfills are operated as unmanaged and uncontrolled open dumpsites as a result of lack of engineered technologies and capacities of operation and maintenance. Due to rapid urbanization and increase in population, amount of solid waste generation is expected to increase rapidly in upcoming years and environmentally sound waste landfilling is highly required in Sri Lanka. Open dumping of solid waste under unsanitary conditions causes various kinds of problems: 1) Damage to human health surrounding the dumping sites (water-born infectious diseases), 2) Environmental pollution (water, air, soil, and sea), 3) Disaster (landslide, explosion), 4) Global warming (emission of greenhouse gases), and so on. In order to avoid and prevent those problems, appropriate techniques for pollution control and environmental restoration should be adopted.

On the other hand, with rapid urbanization on all fronts, much construction is conducted everywhere in developing countries, especially in big cities. All these activities, new construction, renovation, and demolition of buildings and structures, generate huge amounts of waste, called construction and demolition waste (CDW). In Vietnam, for example, the total municipal solid waste generation was about 60 thousand tons/day on average, of which the CDW waste accounts for 10–12% of total solid waste according to the State of the Environment report of 2011 on solid waste management issued by Ministry of Natural Resources and Environment. In order to maximize the potential positive impacts but at the same time to minimize the negative effects of modernization and industrialization, it is necessary 1) to take immediate measures to protect the environment, 2) to promote recycling of CDW, and 3) to reduce the use of natural resources for environmentally-sustainable infrastructure development.

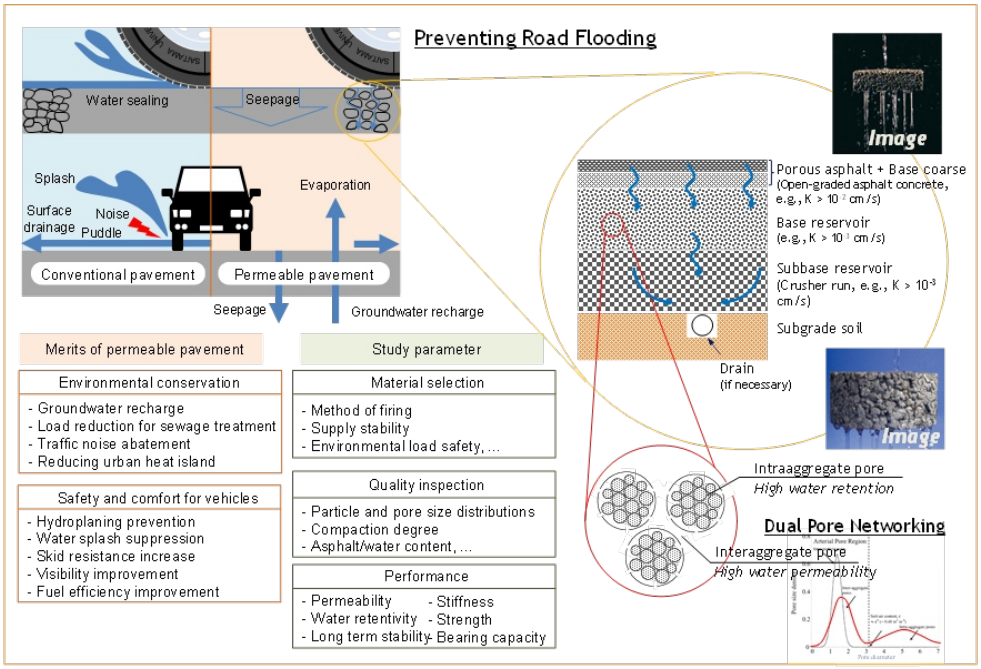
Based on the agreement between Sri Lanka and Japan, the JST-JICA SATREPS (Science and Technology Research Partnership for Sustainable Development) project entitled "Development of pollution control and environmental restoration technologies of waste landfill sites taking into account geographical characteristics in Sri Lanka" has been carried out from 2011 to 2016.

And, based on the agreement between Vietnam and Japan, the JST-JICA SATREPS project entitled "Establishment of Environmentally Sound Management of Construction and Demolition Waste and Its Wise Utilization for Environmental Pollution Control and for New Recycled Construction Materials in Vietnam" has begun from 2018 and will continue until 2022. One of main activities in the both SATREPS project is to develop pollution control and environmental restoration techniques with site-specific, low cost, sustainable, environmentally friendly, and engineered/easy-construction. In this keynote address, some of developed and developing techniques with the use of locally available geo- and bio-materials and industrial by-products are introduced, and it is emphasized the emerging role of Geoenvironmental Engineering for developing those techniques.

For the pollution control and environmental restoration techniques for waste landfill sites, the Sri Lankan SATREPS project mainly targets five components which are necessary for upgrading open waste dumpsites into engineered and sanitary waste landfills; 1) Leachate treatment, 2) Surface lining and seepage control, 3) Geomechanics and slope stability, 4) Landfill capping, and 5) Permeable reactive barrier (PRB) for in-situ contaminant treatment of groundwater. In the project, locally-available geo- and bio-materials are encouraged to use for proposing applicable and durable techniques in Sri Lanka. Effectiveness and performance of developed appropriate techniques have been evaluated not only by laboratory tests but also by field experiments. Besides, part of newly developed techniques have been adopted in the follow-up JICA technical cooperation project in Sri Lanka; 1) PRB and leachate treatment techniques at Kurunegala waste landfill site and 2) bottom liner and leachate treatment techniques at newly-constructed semi-engineered waste landfill site in Kataragama, Sri Lanka. On the other hand, in order to develop new techniques utilizing recycled materials produced from CDW and industrial by-products, the Vietnam SATREPS project targets 1) Treatment technique for heavy metal-contaminated/oil-polluted water, and 2) Permeable road pavement technique with the high water-retentive road base/subbase system.



Five research components to develop site-specific pollution control and remediation techniques at municipal solid waste landfills (adopted from "Guide for Sustainable Planning, Management and Pollution Control of Waste Landfills in Sri Lanka 2011-2016. SATREPS Project, May 2018)



Concept on the development of new permeable road pavement system utilizing recycled CDW and industrial by-product in Vietnam (Adopted from JICA Application form for Japan's Technical Cooperation. July 2015)

See more details scientific evidence and backup for newly-developed techniques and role of Geo-environmental Engineering in academic publications:

1. Wickramarachchi, P., K. Ranasinghe, S. Hamamoto, K. Kawamoto, U.P. Nawagamuwa, P. Moldrup, and T. Komatsu. 2011. Gas transport parameters for compacted reddish brown soil in Sri Lankan landfill final cover. *J. Hazardous, Toxic and Radioactive Waste* 15: 285-295, DOI: 10.1061/(ASCE)HZ.1944-8376.0000078.
2. Hamamoto, S., P. Moldrup, K. Kawamoto, P. Wickramarachchi, M. Nagamori, and T. Komatsu. 2011. Extreme compaction effects on gas transport parameters and estimated climate gas exchange for a landfill final cover soil. *J. Geotech. Geoenviron. Engrg*. 137; DOI: 10.1061/(ASCE)GT.1943-5606.0000459.
3. Wickramarachchi, P., K. Kawamoto, S. Hamamoto, M. Nagamori, P. Moldrup, and T. Komatsu. 2011. Effects of dry bulk density and particle size fraction on gas transport parameters in variably saturated landfill cover soil. *Waste Management* 31, 2462-2472, DOI: 10.1016/j.wasman.2011.07.008.
4. Subedi, S., K. Kawamoto, and T. Komatsu, L. Jayarathna, and M. Vithanage, P. Moldrup, and L.W. de Jonge. 2012. Characterizing time-dependent contact angles for sands hydrophobized with oleic and stearic acids. *Vadose Zone J.* 11(1): doi:10.2136/vzj2011.0055.
5. Subedi, S., K. Kawamoto, A.K. Karunarathna, P. Moldrup, L.W. de Jonge, and T. Komatsu. 2013. Mini tensiometer-time domain reflectometry coil probe for measuring soil water retention properties. *Soil Sci. Soc. Am. J.*, doi:10.2136/sssaj2012.0106.
6. Subedi, S., K. Kawamoto, P. Moldrup, L.W. de Jonge, K. Müller, B.E. Clothier, and T. Komatsu. 2013. Contact angles of water-repellent porous media inferred by Tensiometer- TDR probe measurement under controlled wetting and drying cycles. *Soil Sci. Soc. Am. J.*, doi:10.2136/sssaj2013.05.0203.

7. Sewwandi, B.G.N., M. Vithanage, S.S.R.M.D.H.R. Wijesekara, M.I.M. Mowjood, S. Hamamoto, and K. Kawamoto. 2014. Adsorption of Cd(II) and Pb(II) humic acid treated coconut (*Cocos nucifera*) husk. *J. Hazardous, Toxic and Radioactive Waste, ASCE*, DOI: 10.1061/(ASCE)HZ.2153-5515.0000196.
8. Wijewardana, Y.N.S., K. Kawamoto, P. Moldrup, T. Komatsu, L.C. Kurukulasuriya, N.H. Priyankara. 2015. Characterization of water repellency for hydrophobized grains with different geometries and sizes. *Environ. Earth Sci.*, 74: 5525-5539, DOI 10.1007/s12665-015-4565-6.
9. Dilrukshi, E.A.A., K. Kawamoto, T. Saito, I. Sakaguchi, P. Moldrup, and T. Komatsu. 2015. Gas diffusivity and thermal properties of compost-mixed soils under variable water saturation. *GSTF International Journal of Geological Sciences* (JGES), 2(1), DOI: 10.5176/2335-6774_2.1.23.
10. Paranavithana, G.N., K. Kawamoto, Y. Inoue, T. Saito, M.Vithanage, C.S. Kalpage, and G. B. B. Herath. 2016. Adsorption of Cd^{2+} and Pb^{2+} onto coconut shell biochar and biochar-mixed soil. *Environ. Earth Sci.* 75:484. DOI 10.1007/s12665-015-5167-z.
11. Sato, N., W.N.K. Dharmarathne, T. Saito, H. Sato, N. Tanaka, and K. Kawamoto. 2017. Microcosm experiments on a coconut-fibre biofilm treatment system to evaluate wastewater treatment efficiencies. Int. J. GEOMATE, 12(33): 160-166. DOI: http://dx.doi.org/10.21660/2017.33.2754.
12. Rashid, H.M.A., J. A. D. K. Wanigarathna, L. C. Kurukulasuriya, N. H. Priyankara, A. M. N. Alagiyawanna, T. Saito, and K. Kawamoto. 2017. Characterization of locally available soil as a liner material for solid waste landfills in Sri Lanka. *Environ. Earth Sci.* 76:396. DOI 10.1007/s12665-017-6717-3.
13. Sato, N., T. Saito, H. Satoh, N. Tanaka, and K. Kawamoto. 2017. Coconut-fibre biofilm wastewater treatment system in Sri Lanka: Microcosm experiments for evaluating wastewater treatment efficiencies and oxygen consumption. *International Journal of Environmental Science and Development* (IJESD), 8(10): 691-695. ISSN: 2010-0264. doi: 10.18178/ijesd.2017.8.10.1040.
14. Kumarasinghe, U., Y. Sakamoto, T. Saito, M. Nagamori, C.S. Kalpage, G.B. Herath, M.I.M. Mowjood, and K. Kawamoto. 2018. Effectiveness of permeable reactive barrier (PRB) on heavy metal trap in aquifer at solid waste dumpsite: A simulation study. *Int. J. GEOMATE*, 15(51): 225-232. DOI: http://dx.doi.org/10.21660/2018.51.7179.
15. Kumarasinghe, U., K. Kawamoto, T. Saito, Y. Sakamoto, and M.I.M. Mowjood. 2018. Evaluation of applicability of filling materials in Permeable Reactive Barrier (PRB) system to remediate groundwater contaminated with Cd and Pb at open solid waste dump sites. *Process Safety and Environmental Protection*, 120: 118-127. DOI: https://doi.org/10.1016/j.psep.2018.09.003.
16. Iqbal, M.R., K. Hashimoto, S. Tachibana, and K. Kawamoto. 2019. Geotechnical properties of sludge blended with crushed concrete and incineration ash. *Int. J. GEOMATE*, 16(57): 116-123. DOI: https://doi.org/10.21660/2019.57.8130.
17. Kumara, G.M.P., T. Saito, S. Hamamoto, S. Asamoto, and K. Kawamoto. 2018. Evaluation of Autoclaved Aerated Concrete (AAC) fines for Removal of Cd(II) and Pb(II) from Wastewater. J. Environ. Engineering, ASCE (in press).