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Development of a technically defensible soil gas sampling strategy for vapour intrusion assessments

Tai T. Wong and John G. Agar

Abstract: Soil vapour intrusion is now commonly evaluated as part of human health risk assessments at contaminated sites where buildings or other structures are located in close proximity to volatile organic chemicals (VOCs) in subsurface soils and groundwater. Investigation of the vapour intrusion pathway often requires that VOC concentrations in the soil gas adjacent to buildings and structures be characterized as part of the risk assessment process. This paper presents the design of a new soil gas monitoring well and a sampling procedure that effectively eliminates concerns about soil gas sample dilution due to short-circuiting of atmospheric air and help to ensure the collection of representative soil gas samples. The results of a parametric numerical modelling study that was applied to address the air short-circuiting issue and the technical rationale for the new soil gas monitoring well (SGMW) design are presented in this paper along with recommended soil gas sampling procedures in various soil conditions. The SGMW design rationale and methodology outlined in this paper considered the effects of soil moisture content and permeability, the depth to the sampling screen interval, and the soil gas sample extraction rate.



Key words: advection, diffusion, environmental site assessment, sampling, soil gas, vapour intrusion.

Résumé : L'intrusion de vapeur dans le sol est maintenant couramment évaluée dans l'évaluation des risques sur la santé humaine pour des sites contaminés où des bâtiments ou autres structures se situent à proximité de composés organiques volatiles « COV » dans les sols et la nappe phréatique. Les investigations de la trajectoire de l'intrusion de la vapeur requièrent souvent que les COV dans le gaz des sols adjacents aux structures et bâtiments soient caractérisés à l'intérieur du processus d'analyse de risques. Cet article présente la conception d'un nouveau puits de surveillance des gaz du sol et une procédure d'échantillonnage qui élimine les préoccupations reliées à la dilution des échantillons par court-circuitage de l'air atmosphérique et qui assure la représentativité des échantillons recueillis. Les résultats d'une étude paramétrique par modélisation numérique qui visait les problèmes de court-circuitage de l'air et la justification de la conception du nouveau puits de surveillance des gaz du sol « SGMW » sont présentés, ainsi que les procédures d'échantillonnage des gaz du sol dans différentes conditions de sol. La conception et la méthodologie du SGMW présentées dans cet article sont discutées en fonction des paramètres suivants : humidité du sol et perméabilité, l'intervalle de profondeur jusqu'au tamis d'échantillonnage, et la vitesse d'extraction de l'échantillon de gaz.

Mots-clés : advection, diffusion, évaluation environnementale de sites, échantillonnage, gaz du sol, intrusion de vapeur.

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References

- AENV. 2001. Alberta soil and water quality guidelines for hydrocarbons at upstream oil and gas facilities. Vol. 1. Protocol. Alberta Environment (AENV), Edmonton, Alta.
- API. 2005. Collecting and interpreting soil gas samples from the vadose zone: A practical strategy for assessing the subsurface vapor-to-indoor air migration pathway at petroleum hydrocarbon sites. API Publication 4741. American Petroleum Institute, Washington, D.C.
- Baehr, A.L., and Hult, M.F. 1991. Evaluation of unsaturated zone air permeability through pneumatic tests. *Water Resources Research*, 27(10): 2605–2617.

- California Environmental Protection Agency. 2005. Guidance for the evaluation and mitigation of subsurface vapor intrusion to indoor air, interim final report [online]. Department of Toxic Substance Control, California Environmental Protection Agency, Sacramento, Calif. Available from www.dtsc.ca.gov/assessingrisk/upload/herd_pol_eval_subsurface_vapor_intrusion_interim_final.pdf [accessed 10 July 2008].
- Cho, J.S., and DiGiulio, D.C. 1992. Pneumatic pumping test for soil vacuum extraction. *Environment and Progress*, 11(3): 228–233.

- Conway, M.F., and Boutwell, S.H. 1987. The use of risk assessment to define a corrective action plan for leaking underground storage tanks. *In* Proceedings of the NWWA/API Conference on Petroleum Hydrocarbons and Organic Chemicals in Groundwater — Prevention, Detection, and Remediation Conference, Houston, Tex., 17–19 November 1987. National Water Well Association (NWWA), Dublin, Ohio. pp. 19–40.
- Crank, J. 1975. *The mathematics of diffusion*. 2nd ed. Oxford University Press, Oxford, UK.
- Dixon, K.L., and Nichols, R.L. 2006. Soil vapor extraction system design: a case study comparing vacuum and pore-gas velocity cutoff criteria. *Remediation Journal*, 17(1): 55–67. doi: 10.1002.rem.
- Hartman, B. 2002. How to collect reliable soil gas data for risk-based applications. Part 1: Active soil gas method. *LUSTLine Bulletin* 42.
- Hartman, B. 2006. How to collect reliable soil gas data for risk-based applications – specifically vapor intrusion. Part 4: Updates on soil gas collection and analytical procedures. *LUSTLine Bulletin* 53.
- Hers, I. 2005. Canadian vapour intrusion guidance and empirical attenuation factors. *In* Proceedings of the 15th Annual West Coast Conference on Soils, Sediments and Water, San Diego, Calif., 14–17 March 2005. RTI International, Research Triangle Park, N.C. Available from iavi.rti.org/attachments/Resources/Hers_-_Canadian_Vapor_Intrusion_Guidance_and_Empirical_Factors_.pdf [accessed 15 July 2008].
- Hers, I., and Southwood, J. 2006. Guidance on site characterization for evaluation of soil vapour intrusion into buildings [online]. Golder Associates Ltd., Burnaby, B.C. Available from www.sabcs.chem.uvic.ca/GUIDANCE%20ON%20SITE%20CHARACTERIZATION%20FOR%20EVALUATION%20OF%20SOIL%20VAPOUR%20INTRUSION%20INTO%20BUILDINGS.pdf [accessed 10 July 2008].
- Hers, I., Zapf-Gilje, R., Li, L., and Atwater, J. 2000a. Validation of models used to predict indoor air quality from soil and groundwater contamination. *In* Proceedings of the 2000 Petroleum Hydrocarbons and Organic Chemicals in Groundwater, Prevention, Detection, and

- Remediation Conference, Anaheim, Calif., 15–17 November 2000. National Ground Water Association, Westerville, Ohio. p. 213. Important Notices
- Date modified: 2009-01-22
- Hers, I., Zapf-Gilje, R., Li, L., and Zapf-Gilje, R. 2000b. Evaluation of vadose zone biodegradation of BTX vapors. *Journal of Contaminant Hydrology*, **46**(3–4): 233–264. CrossRef
- Hers, I., Zapf-Gilje, R., Johnson, P.C., and Li, L. 2003. Evaluation of the Johnson and Ettinger model for prediction of indoor air quality. *Ground Water Monitoring and Remediation*, **23**(2): 119–133. CrossRef
- Johnson, P.C., and Ettinger, R.A. 1991. Heuristic model for predicting the intrusion rate of contaminant vapors into buildings. *Environmental Science & Technology*, **25**: 1445–1452. CrossRef
- Johnson, P.C., Ettinger, R.A., Kurtz, J., Bryan, R., and Kester, J.E. 2002. Migration of soil gas vapors to indoor air: determining vapor attenuation factors using a screening-level model and field data from the CDOT-MTL. API Soil and Groundwater Research Bulletin 16. American Petroleum Institute, Washington, D.C.
- Kindziarski, W.B. 1997. Influence of soil gas entry, outdoor and indoor sources on indoor VOCs at petroleum contaminated settings. *In* Proceedings of the 90th Annual Air and Waste Management Conference, Toronto, Ont., 9–13 June 1997. Air and Waste Management Association, Toronto, Ont. Paper 97-TP54.01.
- Kramer, W.H. 1998. Evaluation of subsurface utilities and indoor air environments as migration pathways and points of exposure in a RBCA site assessment. *In* Proceedings of the 1998 Petroleum Hydrocarbons and Organic Chemicals in Groundwater: Prevention, Detection, and Remediation Conference, Houston, Tex., 12–14 November 1998. National Ground Water Association, Westerville, Ohio. pp. 267–298.
- McHugh, T.E., Connor, J.A., Ahmad, F., and Newell, C.J. 2003. A groundwater mass flux model for groundwater-to-indoor air vapor intrusion. *In* Proceedings of the 7th International In Situ and On-Site Bioremediation Symposium, Orlando, Fla., June 2003. Battelle Press, Columbus, Ohio. Paper H-09.
- McHugh, T.E., Connor, J.A., and Ahmad, F. 2004. An empirical analysis of the groundwater-to-indoor air exposure pathway: the role of background concentrations in indoor air. *Environmental Forensics*, **5**(1): 33–44. CrossRef
- McHugh, T.E., Deblanc, P.C., and Pokluda, R.J. 2006. Indoor air as a source of VOC contamination in shallow soils below buildings. *Soil & Sediment Contamination, an International Journal*, **15**(1): 103–122.
- O'Connor, M.J., Agar, J.G., and King, R.D. 1984. Practical experience in the management of hydrocarbon vapours in the subsurface. *In* Proceedings of the NWWA/API Conference on Petroleum Hydrocarbons and Organic Chemicals in Groundwater — Prevention, Detection, and Remediation Conference, Houston, Tex., 12–14 November 1984. National Water Well Association (NWWA), Dublin, Ohio. pp. 519–533.
- Parker, J.C. 2003. Physical processes affecting natural depletion of volatile chemicals in soil and groundwater. *Vadose Zone Journal*, **2**: 222–230.
- Ririe, G.T., Sweeney, R.E., and Daugherty, S.J. 2002. A comparison of hydrocarbon vapor attenuation in the field with predictions from vapor diffusion models. *Soil & Sediment Contamination, an International Journal*, **11**(4): 529–544. CrossRef
- Roggemans, S., Bruce, C.L., Johnson, P.C., and Johnson, R.L. 2001. Vadose zone natural attenuation of hydrocarbon vapors: an empirical assessment of soil gas vertical profile data. Technical Task Force Bulletin 15, American Petroleum Institute, Washington, D.C.
- Shah, J.J., and Singh, H.B. 1988. Distribution of volatile organic chemicals in outdoor and indoor air: a national VOCs database. *Environmental Science & Technology*, **22**(12): 1381–1388. CrossRef
- USEPA. 1996. Soil gas sampling. SOP 2042, Environmental Response Team, US Environmental Protection Agency (USEPA), Cincinnati, Ohio.
- USEPA. 1999a. Determination of volatile organic compounds in ambient air using active sampling onto sorbent tubes (Compendium Method TO-17). *In* Compendium of methods for the determination of toxic organic compounds in ambient air. 2nd ed. Office of Research and Development, US Environmental Protection Agency (USEPA), Cincinnati, Ohio.
- USEPA. 1999b. Determination of volatile organic compounds (VOCs) in ambient air using specially prepared canisters with subsequent analysis by gas chromatography (Compendium Method TO-14A). *In* Compendium of methods for the determination of toxic organic compounds in ambient air. 2nd ed. Office of Research and Development, US Environmental Protection Agency (USEPA), Cincinnati, Ohio.
- USEPA. 1999c. Determination of volatile organic compounds (VOCs) in air using specially prepared canisters and analyzed by gas chromatography/mass spectrometry (GC/MS) (Compendium Method TO-15). *In* Compendium of methods for the determination of toxic organic compounds in ambient air. 2nd ed. Office of Research and Development, US Environmental Protection Agency (USEPA), Cincinnati, Ohio.
- USEPA. 2002. OSWER draft guidance for evaluating the vapor intrusion to indoor air pathway from groundwater and soils (subsurface vapor intrusion guidance). Office of Solid Waste and Emergency Response, US Environmental Protection Agency (USEPA), Cincinnati, Ohio.
- USEPA. 2006. Assessment of vapor intrusion in homes near the Raymark superfund site using basement and sub-slab air samples. Office of Research and Development, US Environmental Protection Agency (USEPA), Cincinnati, Ohio.
- Wallace, L.A. 1989. Major sources of benzene exposure. *Environmental Health Perspectives*, **82**: 165–169. CrossRef
- Wang, Y., Raihala, S., Jackman, A.P., and St. John, R. 1996. Use of Tedlar[®] bags in VOC testing and storage: evidence of significant VOC losses. *Environmental Science & Technology*, **30**: 3115–3117. CrossRef
- Williams, P.J., and Gold, L.W. 1976. Ground temperatures. Canadian Building Digest 180, Institute for Research in Construction, National Research Council of Canada, Ottawa, Ont.
- W.L. Gore & Associates, Inc. 2008. GORE™ modules for passive soil gas collection [online]. W.L. Gore & Associates, Inc., Newark, Del. Available from www.gore.com/en_xx/products/geochemical/petroleum/surveys_petroleum_modules.html [accessed 17 July 2008].