Arsenic contents and physicochemical properties of agricultural soils from the Red River Delta, Vietnam

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Abstract: To evaluate arsenic (As) levels in agricultural soils of the Red River Delta in northern Vietnam, surface (0-5 cm) and subsurface (20-25 cm) soil samples were collected from 18 paddy and six upland fields on both sides of the river. As a reference, forest soils were also sampled at two sites of the upper river basin. The total As contents of approximately 80% of the surface paddy and upland soils exceeded the maximum allowable limit for Vietnamese agricultural soils (12 mg kg^{-1}). Arsenic contents higher than 35 mg kg^{-1} were found in soils from the Hungyen and Hanam provinces, where high As levels in the groundwater have also been reported. Sequential fractionation of As in these soils indicated that the amounts of As in the phosphate-extractable and residual fractions were higher than those in the forest soils. Elevated total As contents were also detected in the surface soil of a paddy field near a fertilizer factory in Hanoi (site P10). The amount of HCl-extractable As in the surface soil at P10 corresponded to 84% of the total As, while the proportion never exceeded 40% at other locations. In the surface soil at P10, most of the As was part of the phosphate-extractable fraction. Significant correlations between the total As contents of the upland soils and their non-crystalline Fe oxide contents (r = 0.652, P ?? 0.05) and between As levels of paddy soils and their crystalline Fe oxide contents (r = 0.544, P ?? 0.01) were observed. Overall, the present study indicated that although serious As pollution was not found in the studied area, there were some point pollutions caused by industrial activities, in addition to some non-point pollutions resulting from high As concentrations in the groundwater. In addition, Fe oxides in the soils are important factors affecting the As contents of agricultural soils in the Red River Delta. ?? 2008 Japanese Society of Soil Science and Plant Nutrition.

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References:

1. Adriano, D.C., Arsenic (2001) Trace Elements in Terrestrial Environments: Biogeochemistry, Bioavailability, and Risks of Metals., pp. 229-250. , In. Ed. Adriano D.C., pp. Springer-Verlag, New York
2. Agusa, T., Inoue, S., Kunito, T., Widely-distributed arsenic pollution in ground water in Red River Delta, Vietnam (2005) Biomed. Res. Trace Elem., 16 (4), pp. 296-298
3. Agusa, T., Kunito, T., Fujihara, J., Contamination by arsenic and other trace elements in tube-well water and its risk assessment to humans in Hanoi, Vietnam (2006) Environ. Pollut., 139, pp. 95-106
4. Berg, M., Stengel, C., Pham, T.K.T., Magnitude of arsenic pollution in the Mekong and Red River Deltas - Cambodia and Vietnam (2007) Sci. Total Environ., 372, pp. 413-425
5. Berg, M., Tran, H.C., Nguyen, T.C., Pham, H.V., Schertenleib, R., Giger, W., Arsenic contamination of ground water and drinking water in Vietnam: A human health threat (2001) Environ. Sci. Technol., 35 (13), pp. 2621-2626
6. Bowen, H.J.M., Elements in the geosphere and the biosphere (1979) Environmental Chemistry of the Elements., pp. 237-273. , In. Ed. Bowen H.J.M., pp. Academic Press, London
7. Chander, B., Nguyen, T.P.T., Nguyen, Q.H., (2004) Random Survey of Arsenic Contamination in Tube-well Water of 12 Provinces in Vietnam and Initially Human Health Arsenic Risk Assessment Through Food Chain, pp. 16-24. , Workshop of Science and Technology Relating to Arsenic Contamination. 16 November 2004, Hanoi, Vietnam, pp
8. Gee, G.W., Bauder, J.W., Particle-size analysis (1986) Methods of Soil Analysis: Part 1-Physical and Mineralogical Methods., pp. 383-411. , In. Ed. Klute A., pp. American Society of Agronomy, Soil Science Society of America, Madison
9. Goldberg, S., Competitive adsorption arsenate and arsenite on oxides and clay minerals (2002) Soil Sci. Soc. Am. J., 66, pp. 413-421
10. Goldberg, S., Johnston, C.T., Mechanisms of arsenic adsorption on amorphous oxides evaluated using macroscopic measurements, vibrational spectroscopy, and surface complexation modeling (2001) J. Colloid Interf. Sci., 234, pp. 204-216
11. Haruyama, S., Dinh, H.T., Le, V.T., Problem soils of the paddy fields in the eastern coastal plain of the Red River Delta, Vietnam (2006) J. Geogr., 115 (6), pp. 737-749
12. Ho, T.L.T., Nguyen, D.M., Do, N.H., Egashira, K., Pollution of water and agricultural soils in Tu Liem and Thanh Tri Districts of Hanoi City, Vietnam-A report (1998) J. Fac. Agr., Kyushu Univ., 42 (34), pp. 509-521

13. Hossain, M.F., Arsenic contamination in Bangladesh - An overview (2006) Agr. Ecosyst. Environ., 113, pp. 1-16
14. Huang, R.Q., Gao, S.F., Wang, W.L., Stuanton, S., Wang, G., Soil arsenic availability and the transfer of soil arsenic to crops in suburban areas in Fujian Province, Southeast China (2006) Sci. Total. Environ., 368 (23), pp. 531-541
15. Jackson, M.L., Lim, C.H., Zelazny, L.W., Oxides, hydroxides, and aluminosilicates (1986) Methods for Soil Analysis: Part 1-Physical and Mineralogical Methods., pp. 118-124. , In. Ed. Klute A., pp. American Society of Agronomy, Soil Science Society of America, Madison
16. Keon, N.E., Swartz, C.H., Brabander, D.J., Harvey, C., Hemond, H.F., Validation of an arsenic sequential extraction method for evaluating mobility in sediments (2001) Environ. Sci. Technol., 35, pp. 2778-2784
17. Kubicki, J.D., Comparision of As(III) and As(V) complexation onto Al- and Fe-hydroxides (2005) Advances in Arsenic Research., pp. 104-117. , In. Eds. O'day P.A., Vlassopoulos D., Meng X. Benning L.G., pp. Oxford University Press, Washington
18. Laurent, C., David, A.P., Arsenic in shallow, reducing ground water in Southern Asia: An environmental health disaster (2006) Elements, 2, pp. 91-96
19. Lenoble, V., Bouras, O., Deluchat, V., Serpaud, B., Bollinger, J.C., Arsenic adsorption onto pillared clays and iron oxides (2002) J. Colloid Interf. Sci., 255, pp. 52-58
20. Lim, T.T., Goh, K.H., Arsenic fractionation in a fine soil fraction and influence of various anions on its mobility in the subsurface environment (2005) Appl. Geochem., 20, pp. 229-239
21. Lombi, E., Wenzel, W.W., Sletten, R.S., Arsenic adsorption by soils and iron-oxide-coated sand: Kinetics and reversibility (1999) J. Plant Nutr. Soil Sci., 162, pp. 451-456
22. McKeague, J.A., Day, J.H., Dithionite- and oxalate-extractable Fe and Al as aids in differentiating various classes (1966) Can. J. Soil Sci., 46 (1), pp. 13-22
23. Meharg, A.A., Rahman, M.D.M., Arsenic contamination of Bangladesh paddy field soils: Implications for rice contribution to arsenic consumption (2003) Environ. Sci. Technol., 37, pp. 229-234
24. Mehra, O.P., Jackson, M.L., Iron oxide removal from soils and clays by a dithionite-citrate system buffered with sodium bicarbonate (1960) Clay Clay Min., 7, pp. 317-327
25. Norra, S., Berner, Z.A., Agarwala, P., Wagner, F., Chandrasekharam, D., Stuben, D., Impact of irrigation with As rich ground water on soils and crops: A geochemical case study in West Bengal Delta Plain, India (2005) Appl. Geochem., 20, pp. 1890-1906
26. O'Neill, P., Arsenic (1990) Heavy Metals in Soils., pp. 81-99. , In. Ed. Alloway B.J., pp. Wiley, New York
27. Pierce, M.L., Moore, C.B., Adsorption of arsenite on amorphous iron hydroxide from dilute aqueous solution (1980) Environ. Sci. Technol., 14 (2), pp. 214-216
28. Postma, D., Larsen, F., Nguyen, T.M.H., Arsenic in ground water of the Red River floodplain, Vietnam: Controlling geochemical processes and reactive transport modeling (2007) Geochim. Cosmochim. Acta, 71, pp. 5054-5071
29. Rhoades, J.D., Cation exchange capacity (1982) Methods of Soil Analysis: Part 2-Chemical and Microbiological Properties., pp. 149-165. , In. Eds. Pace A.L., Miller R.H. Keeney D.R., pp. American Society of Agronomy, Soil Science Society of America, Madison
30. Sakurai, K., Kawazu, H., Kono, Y., Impact of agricultural practices on slope land soil properties of the mountainous region of northern Vietnam: A case study in (2004) Tonan Ajia Kenkyu (Southeast Asian Studies), 41 (4), pp. 503-518. , Bac Ha district, Lao Cai province
31. (1988), http://www.nea.gov.vn/TCVNMT/ToanVan/TCVN%204402_1987.htm, TCVN 4402-87. Vietnamese Standard: Standard method of pH measurement, 1988. Vietnamese Ministry of Science and Technology. Available from URL: (in

Vietnamese)(2002), http://www.nea.gov.vn/TCVNMT/ToanVan/7209_02.pdf, TCVN 7209. Vietnamese Standard: Soil quality - Maximum allowable limits of heavy metals in the soil, 2002. Vietnamese Ministry of Science and Technology. Available from URL: (in Vietnamese)Terashima, S., [determination of arsenic and antimony in geological materials by automated hydride generation and electro-thermal atomic absorption spectrometry.] (1984) Bunseki Kagaku., 33, pp. 561-563. , (in Japanese with English summary)

32. Tran, K.T., Tran, K.K., Heavy metals and other elements in the main soil types in Viet Nam (2002) J. Vietnam Soil Sci., 16, pp. 13-22
33. Trinh, Q.H., Wada, S.I., Cadmium status of some soils and sewage sludge in Red River Delta of Vietnam (2004) J. Fac. Agr., Kyushu Univ., 49 (1), pp. 149-155
34. Tsutsumi, M., Arsenic pollution in Arable land (1981) Heavy Metal Pollution in Japanese Soils., pp. 181-192. , In. Eds. Kitagishi K. Yamane I., pp. Japan Scientific Societies Press, Tokyo