JWARP> Vol.4 No.8, August 2012

OPEN ACCESS

Aquifer Vulnerability Assessment and Wellhead Protection Areas to Prevent Groundwater Contamination in Agricultural Areas: An Integrated Approach

PDF (Size:1784KB) PP. 674-685 DOI: 10.4236/jwarp.2012.48078

Author(s)
Stefano Lo Russo, Glenda Taddia

ABSTRACT
To implement successful policies for the protection of groundwater and curtail the possibility of water supply contamination, an early evaluation of aquifer vulnerability is needed. Rather than implementing broad restrictions to land use and effluent discharge, it is more cost-effective and economically favourable to approach protection in a stepwise manner by first assessing the intrinsic vulnerability of the aquifer when defining the level of land use control that is needed to protect groundwater quality. Following aquifer vulnerability evaluation, specific land uses and restrictions should be defined locally for each water supply within the wellhead protection areas (WHPAs), which are identified by means of the groundwater time of travel (TOT). The WHPA should be established for each individual situation, considering the level of vulnerability of the exploited aquifer. We applied our findings to a specific test site in the Piemonte region of NW Italy, following the current local procedure for individuating the WHPAs. Using data gathered from this site-specific exercise, we identified that the procedure allows methods that consider only aquifer parameters to evaluate vulnerability and discourages the use of techniques that already compartmentalize soil parameters in the vulnerability assessment.

KEYWORDS
Groundwater Protection Zones; WHPA; Vulnerability; FEFLOW; Piemonte; Italy

Cite this paper
S. Lo Russo and G. Taddia, "Aquifer Vulnerability Assessment and Wellhead Protection Areas to Prevent Groundwater Contamination in Agricultural Areas: An Integrated Approach," *Journal of Water Resource and Protection*, Vol. 4 No. 8, 2012, pp. 674-685. doi: 10.4236/jwarp.2012.48078.

References

[1] A. A. Fadlelmawla and M. A. Dawoud, "An Approach for Delineating Drinking Water Wellhead Protection Areas at the Nile Delta, Egypt," Journal of Environmental Mana- gement, Vol. 79, No. 2, 2006, pp. 140-149. doi:10.1016/j.jenvman.2005.06.001

[2] S. Y. Feng, Z. L. Huo, S. Z. Kang, Z. J. Tang and F. X. Wang, "Groundwater Simulation Using a Numerical Mo- del under Different Water Resources Management Sce- narios in an Arid Region of China," Environmental Earth Sciences, Vol. 62, No. 5, 2011, pp. 961-971.

[3] S. Foster, J. Chilton, M. Moench, F. Cardy and M. Schiffler, "Groundwater in Rural Development: Facing the Challenges of Supply and Resource Sustainability," World Bank Technical Paper 463, Washington DC, 2000.

[4] S. Foster, R. Hirata, D. Gomes, M. D'Elia and M. Paris, "Groundwater Quality Protection," World Bank, Washington DC, 2002, 103 p. doi:10.1596/0-8213-4951-1

[5] X. H. Wang, "Conceptual Design of a System for Selecting Appropriate Groundwater Models in Ground-water Protection Programs," Environmental Management, Vol. 21, No. 4, 1997, pp. 607-615. doi:10.1007/s002679900053

[6] W. Zhou, B. F. Beck, A. J. Pettit and B. J. Stephenson, "A Groundwater Tracing Investigation as an

• Open Special Issues
• Published Special Issues
• Special Issues Guideline

JWARP Subscription

Most popular papers in JWARP

About JWARP News

Frequently Asked Questions

Recommend to Peers

Recommend to Library

Contact Us

Aid of Locating Groundwater Monitoring Stations on the Mitchell Plain of Southern Indiana," Environmental Geology, Vol. 41, No. 7, 2002, pp. 842-851.

[7] M. Albinet and J. Margat, "Cartographie de la Vulnerabilitè a la Pollution des Nappes d'eau Souterraine," Bulletin BRGM 2nd Series, Vol. 3, No. 4, 1970, pp. 13-22.

[8] A. Haertle, "Method of Working and Employment of EDP during the Preparation of Groundwater Vulnearbility Maps," International Association of Hydrogeological Sci- ences, 142, 1983, pp. 1073-1085.

[9] L. Aller, T. Bennett, J. H. Lehr, R. J. Petty and G. Hackett, "DRASTIC: A Standardized System for Evaluating Ground- water Pollution Potential Using Hydrogeologic Settings," Environmental Protection Agency Report 600/2-87-035, Washington DC, 1987.

[10] S. Foster and R. Hirata, "Groundwater Pollution Risk Assessment: A Methodology Using Available Data," WHO- PAHO/HPE-CEPIS Technical Manual, Lima, 1988.

[11] NRC (National Research Council), "Groundwater Vulner- ability Assessment: Contamination Potential under Con- ditions of Uncertainty," National Academy Press, Washington DC, 1993.

[12] J. Vrba and A. Zaporozec, "Guidebook on Mapping Groundwater Vulnerability," H. Heise, Hannover, 1994.

[13] M. Civita, "Le carte della vulnerabilità degli acquiferi all'inquinamento," Teoria & Pratica, Bologna, 1994.

[14] S. Foster and C. Skinner, "Groundwater Protection: The Science and Practice of Land Surface Zoning," International Association of Hydrogeological Sciences, Vol. 225, 1995, pp. 471-482.

[15] T. G. Fritch, C. L. McKnight and J. C. Yelderman, "An Aquifer Vulnerability Assessment of the Paluxy Aquifer, Central Texas, USA, Using GIS and a Modified DRASTIC Approach," Environmental Management, Vol. 25, No. 3, 2000, pp. 337-345. doi:10.1007/s002679910026

[16] J. P. Dash, A. Sarangi and D. K. Singh, "Spatial Variability of Groundwater Depth and Quality Parameters in the National Capital Territory of Delhi," Environmental Management, Vol. 45, No. 3, 2010, pp. 640-650. doi:10.1007/s00267-010-9436-z

[17] M. V. Civita, "The Combined Approach When Assessing and Mapping Groundwater Vulnerability to Contamina- tion," Journal of Water Resource and Protection, Vol. 2, No. 1, 2010, pp. 14-28. doi:10.4236/jwarp.2010.21003

[18] D. Ducci, "Aquifer Vulnerability Assessment Methods: The Non-Independence of Parameters Problem," Journal of Water Resource and Protection, Vol. 2, No. 4, 2010, pp. 298-308. doi:10.4236/jwarp.2010.24034

[19] M. Lourdes Lima, K. Zelaya, H. Massone, "Groundwater Vulnerability Assessment Combining the Drastic and Dyna-Clue Model in the Argentine Pampas," Environ- mental Management, Vol. 47, No. 5, 2011, pp. 828-839. doi:10.1007/s00267-011-9652-1

[20] M. Alraggad, S. Al-Saleh, H. Al-Amoush, A. Jasem and D. Isied, "Vulnerability of Groundwater System in Cen- tral Jordan Valley/Pollution Indicators and Decontamination Process," Journal of Water Resource and Protection, Vol. 4, No. 3, 2012, pp. 133-139. doi:10.4236/jwarp.2012.43016

[21] N. Doerfliger and F. Zwahlen, "EPIK: A New Method for Outlining of Protection Areas: A Water Vulnerability As- sessment in Karst Environment," Proceedings of 5th International Symposium on Karst Waters and Environmental Impacts, Antalya, 10-20 September 1995, pp. 117- 123

[22] M. Civita and M. De Maio, "SINTACS R5 a New Parametric System for the Assessment and Automatic Mapping of Groundwater Vulnerability to Contamination," Pitagora Editrice, Bologna, 2000.

[23] F. Barry, D. Ophori, J. Hoffman and R. Canace, "Ground- water Flow and Capture Zone Analysis of the Central Passaic River Basin," Environmental Geology, Vol. 56, No. 8, 2009, pp. 1593-1603.

[24] J. Y. S. Hodgson, J. R. Stoll and R. C. Stoll, "Evaluating the Effectiveness of a Fixed Wellhead Protection Area Delineation: Regional Case Study," Journal of the American Water Resources Association, Vol. 42, No. 2, 2006, pp. 409-423. doi:10.1111/j.1752-1688.2006.tb03847.x

[25] L. Galleani, B. Vigna, C. Banzato and S. Lo Russo, "Validation of a Vulnerability Estimator for Spring Protection Areas: The VESPA index," Journal of Hydrology, Vol. 396, No. 3-4, 2011, pp. 233-245. doi:10.1016/j.jhydrol.2010.11.012

[26] S. Lo Russo and G. Taddia, "Groundwater in the Urban Environment: Management Needs and Planning Strategies," American Journal of Environmental Sciences, Vol. 5, No. 4, 2009, pp. 494-500. doi:10.3844/ajessp.2009.494.500

[27] W. A. Harman, C. J. Allan and R. D. Forsythe, "Assessment of Potential Groundwater Contamination Sources in a Wellhead Protection Area," Journal of Environmental Management, Vol. 62, No. 3, 2001, pp. 271-282. doi:10.1006/jema.2001.0436

[28] M. S. Miller, P. Chudek and S. Babcock, "A Comparison of Wellhead Protection Area Delineation Methods for Public Drinking Water Systems in Whatcom County, Washington," Journal of Environmental Health, Vol. 66, No. 2, 2003, pp. 17-24.

[29] T. W. Raynes, K. R. Bradbury and M. A. Muldoon, "Delineation of Capture Zones for Municipal Wells in Fractured Dolomite, Sturgeon Bay, Wisconsin, USA," Hydrogeology Journal, Vol. 9, No. 5, 2001, pp. 432-450. doi:10.1007/s100400100154

[30] U. S. EPA, "Delineation of Wellhead Protection Areas in Fractured Rocks," US Environmental Protection Agency, Office of Water, Washington DC, 1991.

[31] D. Paradis, R. Martel, G. Karanta, R. Lefebvre, Y. Michaud, R. Therrien and M. Nastev, "Comparative Study of Me- thods for WHPA Delineation," Ground Water, Vol. 45, No. 2, 2007, pp. 158-167. doi:10.1111/j.1745-6584.2006.00271.x

[32] S. P. Esling, J. E. Keller and K. J. Miller, "Reducing Capture Zone Uncertainty with a Systematic Sensitivity Analysis," Ground Water, Vol. 46, No. 4, 2008, pp. 570- 578. doi:10.1111/j.1745-6584.2008.00438.x

[33] Y. Mogheir and G. Tarazi, "Comparative Identification of Wellhead Protection Areas for Municipal Supply Wells in Gaza," Journal of Water Resource and Protection, Vol. 2, No. 2, 2010, pp. 105-114. doi:10.4236/jwarp.2010.22012

[34] S. Lo Russo, A. Fiorucci and B. Vigna, "Groundwater Dynamics and Quality Assessment in an Agricultural Area," American Journal of Environmental Sciences, Vol. 7, No. 4, 2011, pp. 354-361. doi:10.3844/ajessp.2011.354.361

[35] EU, "Council Directive 80/778/EEC of 15 July 1980 Relating to the Quality of Water Intended for Human Consumption," 1980. http://eur-lex.europa.eu/LexUriServ/site/en/consleg/1980/L/01980L0778-19950101-en.pdf

[36] Repubblica Italiana, "Attuazione Della Direttiva No. 80/ 778/CEE Concernente la Qualità Delle Acque Destinate al Consumo Umano ai Sensi Dell ' Art. 15 Della Legge 16 Aprile 1987, No. 183. Gazzetta Ufficiale No. 152 del 30 Giugno 1988—Supplemento Ordinario," 1988. http://www.atobrenta.it/pdf/DPR_236_88.pdf

[37] EU, "Council Directive 91/271/EEC of 21 May 1991 Concerning Urban Waste-Water Treatment," 1991. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31991L0271:EN:HTML

[38] EU, "Council Directive 91/676/EEC of 12 December 1991 Concerning the Protection of Waters against Pollution Caused by Nitrates from Agricultural Sources," 1991.

[39] EU, "Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 Establishing a Framework for Community Action in the Field of Water Policy, 2000. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:327:0001:0072:EN:PDF

[40] EU, "Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the Protection of Groundwater against Pollution and Deterioration, 2006. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:372:0019:0031:EN:PDF

[41] Repubblica Italiana, "Disposizioni Sulla Tutela Delle Acque Dall ' Inquinamento e Recepimento Della Direttiva 91/271/CEE Concernente il Trattamento Delle Acque Reflue Urbane e Della Direttiva 91/676/CEE Relativa Alla Protezione Delle Acque Dall ' Inquinamento Provocato dai Nitrati Provenienti da Fonti Agricole," 1999. http://www.camera.it/parlam/leggi/deleghe/99152dl.htm

[42] Repubblica Italiana, "Norme in Materia Ambientale," 2006. http://www.parlamento.it/leggi/deleghe/06152dl.htm

[43] Repubblica Italiana, "Attuazione Della Direttiva 2006/ 118/CE, Relativa Alla Protezione Elle Acque Sotterranee Dall ' Inquinamento e dal Deterioramento," 2009. http://www.camera.it/parlam/leggi/deleghe/testi/09030dl.htm. (in Italian).