JEP> Vol.3 No.10, October 2012

OPEN ACCESS

The Effects of Sample Matrices on Immunoassays to Detect Microcystin-LR in Water

PDF (Size:551KB) PP. 1275-1285 DOI: 10.4236/jep.2012.310145

Author(s)

Armah A. de la Cruz, Trevor J. Lynch, Dionysios D. Dionysiou

ABSTRACT

Immunoassays are widely used biochemical techniques to detect microcystins in environmental samples. The use of immunoassays for the detection of microcystins is vulnerable to matrix components and other interferents. This study is an evaluation of the effects of interfering substances commonly found in drinking and ambient water samples using commercially-available immunoassay kits for microcystin toxins. The microplate and strip test immunoassay formats were tested in the study. For the microplate ELISA, the following were found to inhibit microcystin-LR (MC-LR) detection: 250 µg/mL Ca^{2+} or Mg^{2+}, 0.01% ascorbic acid, 0.1% EDTA chelating agent, 0.05 M glycine-HCl, pH 3. The following exhibited no effect: sodium chloride (NaCl, 1% to 4%) and sodium thiosulfate (0.001% and 0.01%), 0.01 to 0.1 M phosphate buffers (PB), pH 7 and 0.067 M PB at pH 5, 6, 7 and 8. Overall, up to 50 µg/mL of standard and reference natural organic matter (NOM) from various sources did not interfere in the assay system (without MC-LR) but diminished the detection of MC-LR at varying degrees. This is the first study evaluating standard and reference humic and fulvic acids from various sources in immunoassays for microcystins. The strip test also showed variable effects on MC-LR detection in the presence of NOM. This assay format was also sensitive to varying pHs and ionic strengths. MC-LR binding was inhibited at low pH (0.05 M glycine-HCl, pH 3), whereas, 0.067 M PB with pH 6, 7 and 8 can yield false positive results. Lower ionic strength of 0.01 M PB, pH 7 showed no interference in MC-LR binding whereas higher ionic strengths can interfere with MC-LR detection. NaCl at 3% and 4% can interfere with the analysis giving false positive results. Mg2+ at 50 and 250 µg/mL showed no effect on the analysis while the same concentration of Ca2+ can yield false positive results. The performance in marine, brackish and hard waters should be tested given the potential sensitivity to salinity. Results of this study may assist in the further refinement of existing assays and the development of practical antibody-based methods to clean-up samples and detect cyanotoxins in water.

KEYWORDS

Microcystin; Immunoassay; Sample Matrix; Natural Organic Matter

Cite this paper

A. Cruz, T. Lynch and D. Dionysiou, "The Effects of Sample Matrices on Immunoassays to Detect Microcystin-LR in Water," *Journal of Environmental Protection*, Vol. 3 No. 10, 2012, pp. 1275-1285. doi: 10.4236/jep.2012.310145.

References

[1] M. G. Antoniou, A. A. de la Cruz and D. D. Dionysiou, "Cyanotoxins: A New Generation of Water Contaminants," Journal of Environmental Engineering, Vol. 131, No. 9, 2005, pp. 1239-1243. doi:10.1061/(ASCE)0733-9372(2005)131:9(1239)

[2] M. Welker and H. von D?hren, "Cyanobacterial Peptides—Na- ture's Own Combinatorial Biosynthesis," FEMS Microbio- logical Review, Vol. 30, No. 4, 2006, pp. 530-563. doi:10.1111/j.1574-6976.2006.00022.x

[3] J. L. Smith, G. L. Boyer and P.V. Zimba, "A Review of Cyanobacterial Odorous and Bioactive Metabolite: Impacts and Management Alternatives in Aquaculture," Aqua- culture, Vol. 280, No. 1-4, 2008, pp. 5-20. doi:10.1016/j.aquaculture.2008.05.007

- Open Special Issues
- Published Special Issues
- Special Issues Guideline

JEP Subscription

Most popular papers in JEP

About JEP News

Frequently Asked Questions

Recommend to Peers

Recommend to Library

Contact Us

[4] L. Zhou, D. Yu and H. Yiu, "Drinking Water Types, Microcystins and Colorectal Cancer," Zhonghua Yufang Yixue Zazhi, Vol. 34, No. 4, 2000, pp. 224-226.

[5] L. E. Fleming, C. Rivero, J. Burns, C. Williams, J. A. Bean, K. A. O'Shea and J. Stinn, "Blue Green Algal (Cya- nobacterial) Toxins, Surface Drinking Water, and Liver Cancer in Florida," Harmful Algae, Vol. 1, No. 2, 2002, pp. 157-168. doi:10.1016/S1568-9883(02)00026-4

[6] Z. Svircev, S. Krstic, M. Miladinov-Mikov, V. Baltic and M. Vidovic, "Freshwater Cyanobacterial Blooms and Pri- mary Liver Cancer Epidemiological Studies in Serbia," Journal of Environmental Science and Health C Environmental Carcinogen and Ecotoxicological Review, Vol. 27, No. 1, 2009, pp. 36-55.

[7] S. A. Wood, D. Mountfort, A. I. Selwood, P. T. Holland, J. S. C. Puddick and S. C. Cary, "Widespread Distribution and Identification of Eight Novel Microcystins in Antarctic Cyanobacterial Mats," Applied Environmental Microbiology, Vol. 74, No. 23, 2008, pp. 7243-7251. doi:10.1128/AEM.01243-08

[8] P. Babica, J. Kohoutek, L. Blaha, O. Adamovsky and B. Marsalek, "Evaluation of Extraction Approaches Linked to ELISA and HPLC for Analyses of Microcystin-LR, -RR and -YR in Freshwater Sediments with Different Organic Contents," Analytical and Bioanalytical Chemistry, Vol. 385, No. 8, 2006, pp. 1545-1551. doi:10.1007/s00216-006-0545-8

[9] J. McElhiney and L. A. Lawton, "Detection of the Cya- nobacterial Hepatotoxins Microcystins," Toxicology and Applied Pharmacology, Vol. 203, No. 3, 2005, pp. 219- 230. doi:10.1016/j.taap.2004.06.002

[10] A. Azoulay, P. Garzon and M. J. Eisenberg, "Comparison of Mineral Content of Tap Water and Bottled Waters," Journal of General Internal Medicine, Vol. 16, No. 3, 2000, pp. 168-175. doi:10.1111/j.1525-1497.2001.04189.x

[11] United States Environmental Protection Agency, "Water Quality Standards Handbook," 2nd Edition, United States Environmental Protection Agency, Washington DC, 1994.

[12] K. A. Loftin, M. T. Meyer, F. Rubio, L. Kamp, E. Hum- phries and E. Whereat, "Comparison of Two Cell Lysis Procedures for Recovery of Microcystins in Water Samples from Silver Lake in Dover, Delaware with Microcystin Producing Cyanobacterial Accumulations," USGS Open-File Report 2008-1341, p. 9.

[13] A. Zeck, A. Eikenberg, M. G. Weller and R. Niessner, "Highly Sensitive Immunoassay Based on a Monoclonal Antibody Specific for [4-Arginine]Microcystins," Analytical Chimica Acta, Vol. 441, No. 1, 2001, pp. 1-13. doi:10.1016/S0003-2670(01)01092-3

[14] F. G. Kari and W. Giger, "Speciation and Fate of Ethylenediaminetetraacetate (EDTA) in Municipal Wastewater Treatment," Water Research, Vol. 30, No. 1, 1996, pp. 122- 134. doi:10.1016/0043-1354(95)00125-5

[15] E. T. Gjessing, P. K. Egeberg and J. Hakedal, "Natural Organic Matter in Drinking Water—The 'NOM Typing Project' Background and Basic Characteristics of Original Water Samples and NOM Isolates," Environment International, Vol. 25, No. 2-3, 1999, pp. 145-159. doi:10.1016/S0160-4120(98)00119-6

[16] M. A. González-Martínez, R. Puchades and A. Maquieira, "Optical Immunosensors for Environmental Monitoring: How Far Have We Come?" Analytical and Bioanalytical Chemistry, Vol. 387, No. 1, 2007, pp. 205-214. doi:10.1007/s00216-006-0849-8

[17] C. Schmidtkunz, H. B. Stich and T. Welsch, "Improving the Selectivity and Confidence in the HPLC Analysis of Microcystins in Lake Sediments," Journal of Liquid Chro- matography and Related Technology, Vol. 32, No. 6, 2009, pp. 801-821. doi:10.1080/10826070902767999

[18] M. J. Miller and H. J. Fallowfield, "Degradation of Cya- nobacterial Hepatotoxins in Batch Experiments," Water Science and Technology, Vol. 43, No. 12, 2001, pp. 229- 232.

[19] G. Liu, Y. Qian, S. Dai and N. Feng, "Adsorption of Microcystin LR and LW on Suspended Particulate Matter (SPM) at Different pH," Water Air and Soil Pollution, Vol. 192, No. 1-4, 2008, pp. 1-4. doi:10.1007/s11270-008-9635-x

[20] H. Yan, A. Gong, H. He, J. Zhou, Y. Wei and L. Lu, "Adsorption of Microcystins by Carbon Nanotubes," Chemosphere, Vol. 62, No. 1, 2006, pp. 142-148.doi:10.1016/j.chemosphere.2005.03.075

[21] J. Lee and H. W. Walker, "Effect of Process Variables and Natural Organic Matter on Removal of Microcystins- LR by PAC-UF," Environmental Science and Technology, Vol. 40, No. 23, 2006, pp. 7336-7342.doi:10.1021/es060352r

[22] M. Campinas and J. Rosa, "The Ionic Strength Effect on Microcystin and Natural Organic Matter Surrogate Adsorption onto PAC," Journal of Colloid Interface Science, Vol. 299, No. 2, 2006, pp. 520-529. doi:10.1016/j.jcis.2006.02.042

[23] F. Long, A. Zhu, J.-W. Sheng, M. He and H.-C. Shi, "Ma- trix Effects on the Microcystin-LR Fluorescent Immunoassay Based on Optical Sensor," Sensors, Vol. 9, No. 4, 2009, pp. 3000-3010. doi:10.3390/s90403000

[24] N. Tippk?tter, H. Stückmann, S. Kroll, G. Winkelmann, U Noack, T. Scheper and R. Ulber, "A Semi-Quantitative Dipstick Assay for Microcystin," Analytical and Bioanalytical Chemistry, Vol. 394. No. 3, 2009, pp. 863-869.

[25] J. S. Metcalf, P. Hyendstand, K. A. Beattie and G. A. Codd, "Effects of Physicochemical Variables and Cyanobacterial Extracts on the Immunoassay of Microcystin-LR by Two ELISA Kits," Journal of Applied Microbiology, Vol. 89, No. 3, 2000, pp. 532-538.doi:10.1046/j.1365-2672.2000.01141.x

[26] C. Rivasseau, P. Racaud, A. Deguin and M.-C. Hennion, "Evaluation of an ELISA Kit for the Monitoring of Microcystins (Cyanobacterial Toxins) in Water and Algae Environmental Samples," Environmental Science and Technology, Vol. 33, No. 9, 1999, pp. 1520-1527.doi:10.1021/es980460g

[27] C. Rivasseau and M.-C. Hennion, "Potential Immunoextraction Coupled to Analytical and Bioanalytical Methods (Liquid Chromatography, ELISA Kit and Phosphatase Inhibition Test) for an Improved Environmental Monitoring of Cyanobacterial Toxins," Analytica Chimica Acta, Vol. 399, No. 1, 1999, pp. 75-87.doi:10.1016/S0003-2670(99)00578-4

[28] J.-W. Sheng, M. He, H.-C. Shi and Y. Qian, "A Comprehensive Immunoassay for the Detection of Microcystins in Waters Based on Polyclonal Antibodies," Analytica Chimica Acta, Vol. 527, No. 2, 2006, pp. 309-315.doi:10.1016/j.aca.2006.05.040

[29] H. Mhadhbi, S. Ben-Rejeb, C. Cleroux, A. Marte and P. Delahaut, "Generation and Characterization of Polyclonal Antibodies against Microcystins—Application to Immunoassays and Immunoaffinity Sample Preparation Prior to Analysis by Liquid Chromatography and UV Detection," Talanta, Vol. 70, No. 2, 2006, pp. 225-235.doi:10.1016/j.talanta.2006.02.029

[30] L. Wang, W. Chen, D. Xu, B. S. Shim, Y. Zhu, F. Sun, L. Liu, C. Peng, Z. Jin, C. Xu and N. A. Kotov, "Simple, Rapid, Sensitive, and Versatile SWNT-Rapid Sensor for Environmental Toxin Detection Competitive with ELISA," Nano Letters, Vol. 9, No. 12, 2009, pp. 4147-4152. doi:10.1021/nl902368r

[31] T. Tsutsumi, S. Nagata, A. Hasegawa and Y. Ueno, "Im- munoaffinity Column as Clean-Up Tool for Determination of Trace Amounts of Microcystins in Tap Water," Food Chemistry and Toxicology, Vol. 38, No. 7, 2000, pp. 593-597. doi:10.1016/S0278-6915(00)00044-2

[32] F. Kondo, H. Matsumoto, A. Yamada, K. Tsuji, Y. Ueno and K.-I. Harada, "Immunoaffinity Purification Method for Detection and Quantification of Microcystins in Lake Water," Toxicon, Vol. 38, No. 7, 2000, pp. 813-823.doi:10.1016/S0041-0101(99)00194-4

[33] J. F. Lawrence and C. Menard, "Determination of Microcystins in Blue-Green Algae, Fish and Water Using Liquid Chromatography with Ultraviolet Detection after Sample Clean-Up Employing Immunoaffinity Chromatography," Journal of Chromatography A, Vol. 922, No. 1-2, 2001, pp. 111-117. doi:10.1016/S0021-9673(01)00924-4

[34] J. McElhiney, M. Drever, L. A. Lawton and A. J. Porter, "Rapid Isolation of a Single-Chain Antibody against the Cyanobacterial Toxin Microcystin-LR by Phage Display and Its Use in the Immunoaffinity Concentration of Microcystins from Water," Applied Environmental Microbiology, Vol. 68, No. 11, 2002, pp. 5288-5295.doi:10.1128/AEM.68.11.5288-5295.2002

[35] E. C. Aguete, A. Gago-Martinez, J. M. Le?o and J. A. Rodriguez-Vazquez, "HPLC and HPCE Analysis of Microcystins RR, LR and YR Present in Cyanobacteria and Water by Using Immunoaffinity Extraction," Talanta, Vol. 59, No. 4, 2003, pp. 697-705.doi:10.1016/S0039-9140(02)00610-0