Environmental Science and Pollution Research (2020) 27:17427–17428
https://doi.org/10.1007/s11356-020-08256-8

LETTER TO THE EDITOR

Exclusive partitioning of intra- and extra-cellular cyanotoxins: limitation of the conventional procedure

Samson Tilahun [1,2]

Received: 20 November 2019 / Accepted: 26 February 2020 / Published online: 6 March 2020

Reports show that the presence of cyanotoxins in drinking water supply lakes and reservoirs causes serious public health impact (Hawkins et al. 1985; Falconer et al. 1983; Carmichael et al. 2001; Jochimsen et al. 1998). Reliable public health risk assessment associated with cyanotoxins requires accurate and exclusive determination of both the cell-bound toxins (intracellular) and those dissolved in water (extra-cellular) fractions. A technically sound procedure for exclusive determination of intra- and extra-cellular cyanotoxins is a key step also for any scientific study related to the dynamics of synthesis and release of cyanotoxins. This important issue, however, seems to be given little attention in many of the reported studies. The conventional procedure currently available for partitioning the intra- and extra-cellular toxins has inherent limitation particularly from field samples collected from highly turbid water bodies. The conventional procedure for separation of the two fractions currently in use involves the filtration of the samples onto 0.7 μm GF/C filter paper (Lawton et al. 1994; Merel et al. 2013; Park et al. 1998; Zheng et al. 2004). In this procedure, it is assumed that the cell-bound toxins (intra-cellular) are retained in the filter paper and the soluble cyanotoxins (extra-cellular toxin) are recovered in the filtrate. Reports show that cyanotoxins have high tendency of binding to particulate matter (Wu et al. 2012). This implies that the extracellular toxins bound to particulate matter above particle size of 0.7 μm including those bound to cyanobacterial cell surfaces are retained on the GF/C not recovered in the filtrate. Tilahun et al. (2019) also noted that the procedure might overestimate the intra-cellular toxins and underestimate the extra-cellular fraction. One of the notions regarding cyanotoxins repeatedly indicated in the literature is that cyanotoxins normally remain intra-cellular unless released during cell lysis and decay (Park et al. 1998; Tsuji et al. 1994). This idea does not seem to survive the scientific scrutiny given the inherent problem of the conventional procedure for separation of the two fractions. The view that cyanotoxins normally remain intra-cellular might have resulted from a faulty procedure that caused infrequent detection of the extra-cellular toxins in the filtrate. This procedural limitation may lead to inaccurate public health risk assessment especially in thermally stratified lakes and in absence of visual cue of harmful algal bloom. This is particularly true as particulate-bound toxins may also serve as source of the toxins to the water column (Wörmer et al. 2011; Wu et al. 2012) later during mixing. Future climate scenario not only promotes the dominance of potentially toxic cyanobacteria (Paerl and Huisman 2009; Paerl and Paul 2012) but also may influence their community structure (Tilahun and Kifle 2019) which may challenge protection of public health through restoration efforts. In such situation, reliable public health risk assessment and establishing an early warning system could be one possible option which demands accurate determination of the two fractions. Furthermore, lack of accurate and exclusive partitioning procedure possibly partly contributed to the challenges for studies on the dynamics of the two fractions in relation to the environmental factors and for lack of conclusive evidence for the suggested eco-physiological roles of cyanotoxins. For instance, one of the suggested roles of cyanotoxins is their allelopathic effect against other organisms that compete for resources or against grazers that feed upon them (Engström-Öst et al. 2011; Henning et al. 2001; Kurmayer and Jüttner 1999; Merel et al. 2013). If the toxins are meant to have allelopathic effect, they are expected to be released actively and purposefully to attack the target organisms. Therefore, the idea that the toxins remain cell bound and only released during cell lysis and decay is a bit puzzling

Responsible editor: Vitor Manuel Oliveira Vasconcelos

✉ Samson Tilahun
samsontilahun@gmail.com

[1] Ethiopian Institute of Water Resources, Addis Ababa University, Addis Ababa, Ethiopia

[2] Department of Zoological Sciences, Addis Ababa University, Addis Ababa, Ethiopia

given the allelopathic role of the toxin. Environmental scientists and policy makers should take note of this procedural limitation before making any decisions and/or scientific conclusion. Future study should, therefore, address this procedural limitation through improving the methodology, as it is a key scientific issue for reliable public health risk assessment and understanding factors dictating the dynamics of the two fractions.

Compliance with ethical standards

Conflict of interests The author declares that there are no conflicts of interest.

References

Carmichael WW, Azevedo S, An JS, Molica R, Jochimsen EM, Lau S, Rinehart KL, Shaw GR, Eaglesham GK (2001) Human fatalities from cyanobacteria: chemical and biological evidence for cyanotoxins. Environ Health Perspect 109:663

Engström-Öst J, Hogfors H, El-Shehawy R, De Stasio B, Vehmaa A, Gorokhova E (2011) Toxin-producing cyanobacterium Nodularia spumigena, potential competitors and grazers: testing mechanisms of reciprocal interactions. Aquat Microb Ecol 62:39–48

Falconer I, Beresford A, Runnegar MT (1983) Evidence of liver damage by toxin from a bloom of the blue-green alga, Microcystis aeruginosa. Med J Aust 1:511–514

Hawkins PR, Runnegar MT, Jackson A, Falconer I (1985) Severe hepatotoxicity caused by the tropical cyanobacterium (blue-green alga) Cylindrospermopsis raciborskii (Woloszynska) Seenaya and Subba Raju isolated from a domestic water supply reservoir. Appl Environ Microbiol 50:1292–1295

Henning M, Rohrlack T, Kohl J-G (2001) Response of Daphnia galeata fed with Microcystis strains with and without microcystins. Cyanotoxins—Occurrence, causes, consequences, p 266–277

Jochimsen EM, Carmichael WW, An J, Cardo DM, Cookson ST, Holmes CE, Antunes MB, de Melo Filho DA, Lyra TM, Barreto VST (1998) Liver failure and death after exposure to microcystins at a hemodialysis center in Brazil. N Engl J Med 338:873–878

Kurmayer R, Jüttner F (1999) Strategies for the coexistance of zooplankton with the toxic cyanobacterium Planktothrix rubescens in Lake Zürich. J Plankton Res 21:659–683

Lawton LA, Edwards C, Codd GA (1994) Extraction and high-performance liquid chromatographic method for the determination of microcystins in raw and treated waters. Analyst 119:1525–1530

Merel S, Walker D, Chicana R, Snyder S, Baurès E, Thomas O (2013) State of knowledge and concerns on cyanobacterial blooms and cyanotoxins. Environ Int 59:303–327

Paerl HW, Huisman J (2009) Climate change: a catalyst for global expansion of harmful cyanobacterial blooms. Environ Microbiol Rep 1: 27–37

Paerl HW, Paul VJ (2012) Climate change: links to global expansion of harmful cyanobacteria. Water Res 46:1349–1363

Park HD, Iwami C, Watanabe MF, Harada KI, Okino T, Hayashi H (1998) Temporal variabilities of the concentrations of intra- and extracellular microcystin and toxic Microcystis species in a hypertrophic lake, Lake Suwa, Japan (1991–1994). Environ Toxicol Water Qual 13:61–72

Tilahun S, Kifle D (2019) The influence of El Niño-induced drought on cyanobacterial community structure in a shallow tropical reservoir (Koka Reservoir, Ethiopia). Aquat Ecol 53:61–77

Tilahun S, Kifle D, Zewde TW, Johansen JA, Demissie TB, Hansen JH (2019) Temporal dynamics of intra-and extra-cellular microcystins concentrations in Koka Reservoir (Ethiopia): implications for public health risk. Toxicon 168:83–93

Tsuji K, Naito S, Kondo F, Ishikawa N, Watanabe MF, Suzuki M, Harada K-I (1994) Stability of microcystins from cyanobacteria: effect of light on decomposition and isomerization. Environ Sci Technol 28: 173–177

Wörmer L, Cirés S, Quesada A (2011) Importance of natural sedimentation in the fate of microcystins. Chemosphere 82:1141–1146

Wu X, Wang C, Xiao B, Wang Y, Zheng N, Liu J (2012) Optimal strategies for determination of free/extractable and total microcystins in lake sediment. Anal Chim Acta 709:66–72

Zheng L, Xie P, Li Y, Yang H, Wang S, Guo N (2004) Variation of intracellular and extracellular microcystins in a shallow, hypereutrophic subtropical Chinese lake with dense cyanobacterial blooms. Bull Environ Contam Toxicol 73:698–706