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Evaluation of three field test kits to detect microcystins from a public health perspective

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ABSTRACT

Cyanobacteria blooms may present a public health concern in sources of drinking water and recreational water due to the production of toxins by some species, microcystins being the most commonly found. It is possible to detect microcystins using instrumental analyses and field test kits. While instrumental analysis methods are accurate, they are also costly, and in regions with a high incidence of blooms the time to report is lengthy (days). On the other hand, the use of commercially available test kits may provide quicker results at a lower cost. The purpose of this work was to evaluate three commercially available kits: the Immunochromatographic Strip Test for the Detection of Microcystins and Nodularins in Source Drinking Water at 1 μg/L (Abraxis strip test), the Abraxis Microcystin Tube Kit and the Envirologix QualiTube Kit. The evaluation of each kit focussed on the interpretation of the results by the end-user and the validity of a test kit was based on four indices: sensitivity, specificity, positive predictive rate (PPR) and negative predictive rate (NPR) (false positive/negative) based on the manufacturer's specifications. The results indicate that there are challenges in the visual interpretation of the results at levels close to the threshold value for each kit. The scope of each kit must be understood: free vs. total, qualitative vs. semiquantitative. For instance, the Envirologix Qualitube Kit does not provide a lysing agent, therefore it will underestimate the levels of total microcystin if a lysing step is not included. In the case of the Abraxis strip test, the kit provides information on the absence/presence of microcystin at a threshold value of 1 μg/L, but false positives were encountered.

1. Introduction

Cyanobacteria, commonly known as blue-green algae, are found in water bodies worldwide. When cyanobacteria form large colonies which accumulate, the event is known as a bloom. Cyanobacteria blooms may present a public health concern in drinking and recreational water sources, as certain cyanobacteria species produce toxins that may be harmful to humans. Based on their target tissues, these cyanotoxins are categorized as hepatotoxic (microcystins, nodularins), neurotoxic (anatoxin-a, saxitoxins) or cytotoxic (cylindrospermopsin) (Codd et al., 2005). Microcystin is the most commonly produced toxin, with over 90 different microcystin variants identified (Sivonen and Jones, 1999; McElhiney and Lawton, 2005). In Canada, although microcystin-LR (MC-LR) prevails in algae blooms, other variants such as MC-LA and MC-RR have also been detected. There are several approaches used to monitor cyanobacterial blooms (Srivastava et al., 2013). The challenge is that not all cyanobacteria blooms produce toxins and there are no visual indicators of the presence of toxins, therefore experimental methods to determine or estimate microcystins levels are necessary. These methods must be accurate and rapid to enable a real-time response as authorities must respond promptly to bloom events in drinking or recreational water sources to minimize exposure to toxins.

Canada has seen an increase in the number of algal blooms reported annually, attributed to increased monitoring, increased public awareness and, in some areas, increased nutrient input (Fortin et al., 2010). This increase has prompted the implementation of monitoring programmes by some Canadian provinces. Health Canada (Health Canada, 1999) has established a drinking water quality guideline for total cyanobacterial toxins of 1.5 μg/L based on the toxicity of MC-LR (currently under review). Total microcystin refers to "all the measureable microcystin variants that are in the water (free) as well as bound to or inside the cyanobacteria cells". In addition, Health Canada provides a stepwise protocol (Fig. 1) to monitor water sources for human

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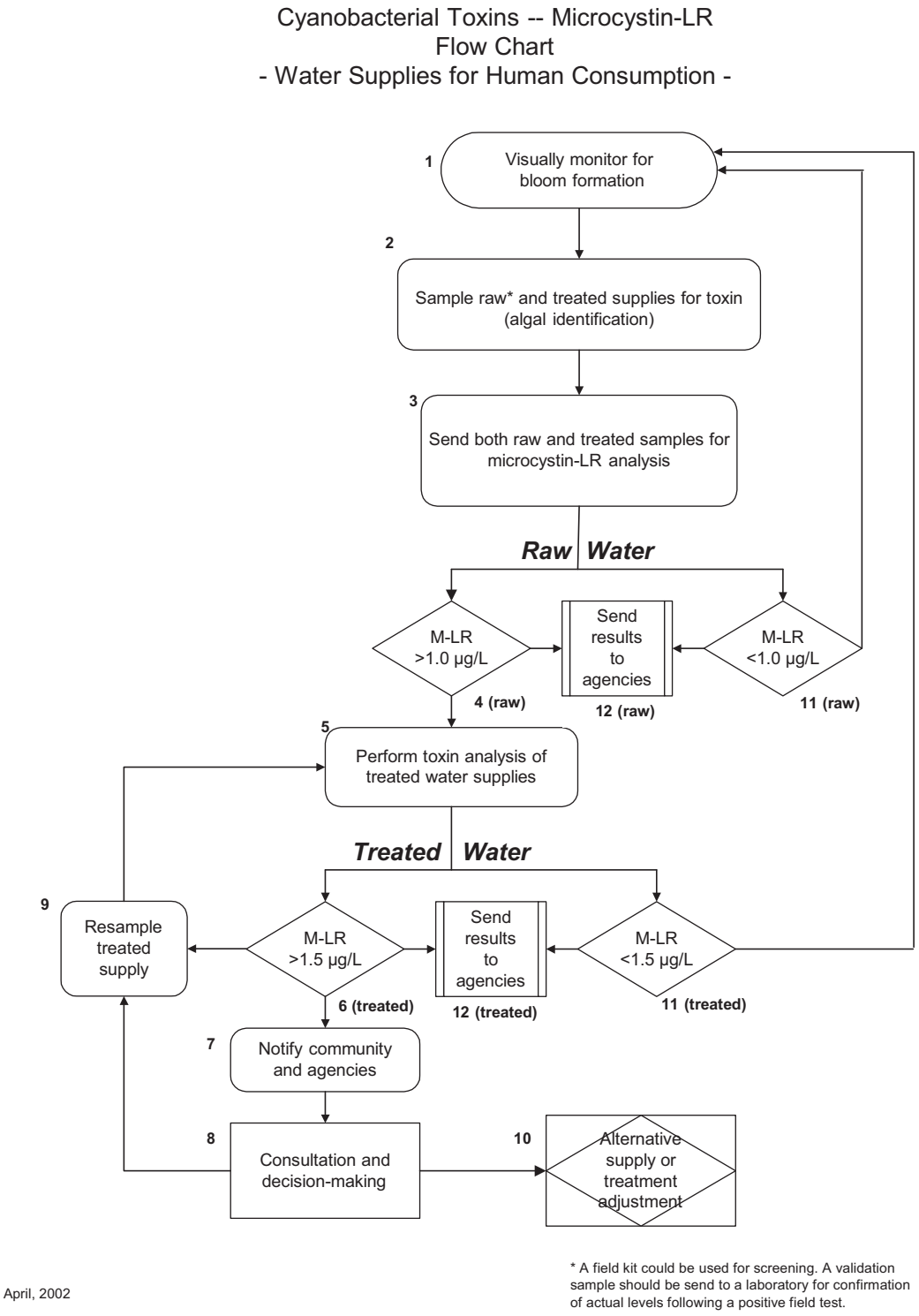

Fig. 1. Flow chart modified from the Guidelines for Canadian Drinking Water Quality: supporting documentation. cyanobacterial toxins-microcystin-LR. Annex A. Water supplies for human consumption.

use that may be affected by cyanobacteria blooms (Health Canada, 1999). Water treatment plants are asked to monitor bloom formation and collect samples (raw and treated) when a bloom is visible. The use of screening tests is recommended at this stage and if the test result is >1 μg/L, samples should then be sent to an accredited laboratory for confirmation.

Laboratory analysis is commonly used to detect microcystins during the monitoring process. The prevailing methods are liquid chromatography (LC) with ultraviolet (UV) (Lawton et al., 1994) or mass spectrometric (MS) detection (Meriluoto et al., 2004; Wang et al., 2007; Bogialli et al., 2006). Instrumental analysis methods are quantitative and accurate, but also costly and time consuming, which may result in significant delays in providing public health advice regarding a bloom. Considerations such as sample shipping time, sample preparation, and delayed lab throughput in regions with a high incidence of blooms lengthen the time between sampling and result delivery to several days or longer.