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Assessment of the potential toxicity of cyanobacteria in Murchison Bay and Napoleon Gulf (Lake Victoria, Uganda)

Summary Notes n°3

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Monitoring of the water quality performed in Murchison Bay (MB) and the Napoleon Gulf (NG) has revealed the dominance of cyanobacteria known to be potentially able to produce cyanotoxins into phytoplankton communities. Knowing that there are multiple water uses in these areas, including the supply of drinking water for human populations, the issue of the potential toxicity of cyanobacterial blooms is very important in the framework of global policies aiming to improve public health. Identification and quantification of the cyanotoxins produced by the bloom-forming cyanobacteria in MB and NG were thus undertaken. These analyses were conducted in various places, including recreational areas and drinking water abstraction points.

I. Strategy for the monitoring and identification/ quantification of cyanotoxins

The locations of the sampling points in MB and NG are shown in Figure 1. At each site, i) inshore stations in the bay and gulf, ii) recreational areas, iii) drinking water abstraction points for the cities of Kampala and Jinja and iv) offshore areas were distinguished. Monthly sampling was performed between November 2017 and October 2018.

Intracellular cyanotoxins were identified and quantified through ultrahigh-performance liquid chromatography (UHPLC) coupled upstream to a high-resolution mass spectrometer (MS) system.

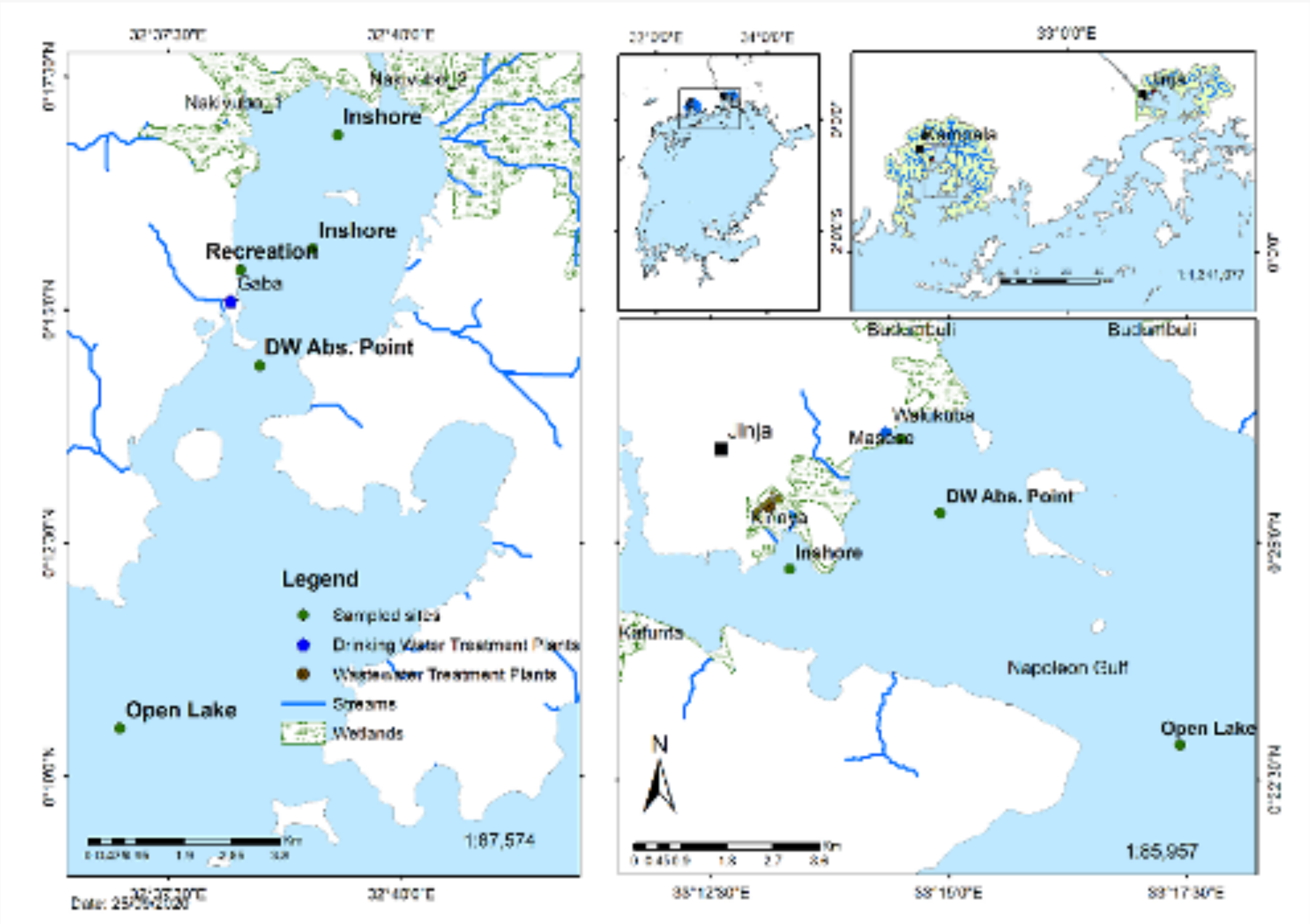

Fig 1. Maps of Murchison Bay (MB) and Napoleon Gulf (NG) with the locations of our sampling stations at each site

II. Composition of the cyanobacterial communities

A total of 46 cyanobacterial taxa belonging to 16 genera were recovered from MB and NG during monitoring. Among them, twelve potentially toxigenic cyanobacterial species belonging to three genera, *Dolichospermum, Microcystis* and *Oscillatoria*, were found in both bays. The most abundant bloom-forming toxigenic cyanobacterial species in MB were *Microcystis flos aquae* and *Microcystis aeruginosa*, with the latter being frequently associated in the literature with a high health risk for human populations. In NG, a codominance of *M. flos aquae* and *Dolichospermum circinale* was found, and these two species were generally associated with low to moderate health risks.

III. Identification and quantification of cyanotoxins

Among the four cyanotoxin families (cylindropsermopsin, saxitoxin, anatoxin and microcystin) potentially produced by the cyanobacterial species found in Lake Victoria, only one of them (microcystin) was found in environmental samples and in cyanobacterial strains isolated from the lake.

In this microcystin family, three variants (MC-LR, MC-YR and MC-RR) were detected in our sample, knowing that MC-LR is the most toxic variant. As shown in Figure 2, the MC-RR variant was dominant in NG (75 - 90%), while in MB, MC-LR and MC-RR cooccurred (40-60%), and MC-YR was only detected in inshore areas of MB.

Microcystins were detected throughout the year in both MB and NG, but their concentrations were much higher in MB (max value in MC-RR+LR >14 µg/L) than in NG (max value in MC-RR+LR <0.25 µg/L). Peak levels of MC-LR and MC-RR were found in June in inshore areas of MB, while in the recreational area, peak levels of microcystins were recorded in November. There were no observable microcystin peaks at the drinking water abstraction point or offshore areas in the MB.

In NG, the highest microcystin concentrations were found from December 2017 to March 2018, with very small peaks of MC-RR being prominent in December at all the sampled stations. During the second half of the year (between May and October 2018), there was almost zero (0) toxin production in NG, and it was occasionally below the level of quantification (<LOQ, Figure 2).

These data show that in MB, the MC concentrations can exceed the health hazard thresholds defined by the WHO for bathing activities or direct consumption of water lake. Conversely, all values recorded in NG were far below these thresholds.

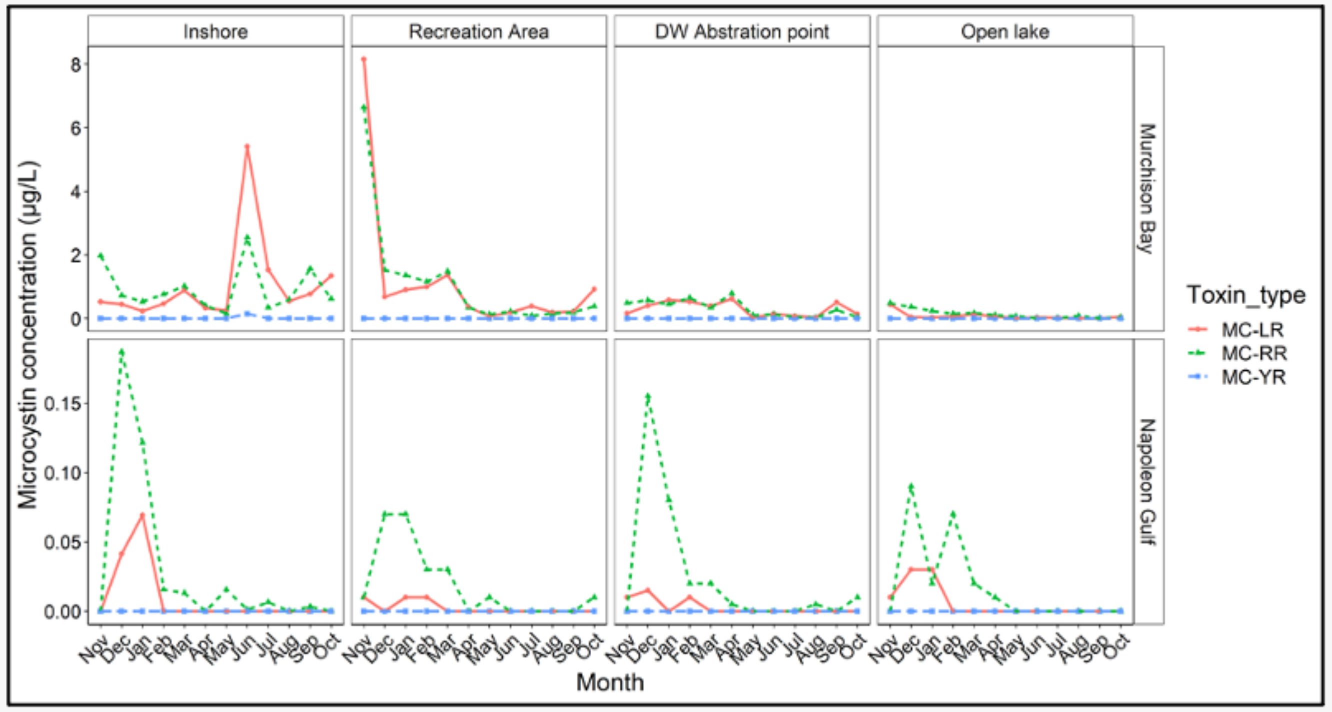

Fig 2. Temporal variation in microcystin production at each station from Murchison Bay (note the different scales for microcystin concentrations at the two sites)

IV. Relationship between environmental/ biological variables and toxin concentrations

When examining the relationship between environmental/ biological variables and microcystin concentrations, a positive correlation was found between cyanobacteria abundances and microcystin concentrations. This correlation was much stronger between *Microcystis* abundances and microcystin concentrations than between *Dolichospermum* abundances and microcystin concentrations. The findings suggest that *Microcystis sp.* is the major microcystin producer in the cyanobacterial community of both bays.

V. Conclusions

Bloom-forming cyanobacteria in MB and NG are able to produce harmful cyanotoxins belonging to the microcystin family, which is known to be involved in serious health problems for humans and animals.

Microcystin concentrations were much higher in MB than in NG. Our data suggest that the main explanations for these differences in toxin concentrations are due to (i) the higher cyanobacterial biomasses in MB than in NG and (ii) the dominance of *Microcystis aeruginosa* in MB, which seems to be the main microcystin producer in both bays.

If microcystin concentrations are not harmful for people using water in NG (whatever their use), there is a real MC exposure risk for people living around MB due to the following: (i) consumption of nontreated water for cooking and/or drinking, knowing that it has been reported in another study that household treatment methods are inadequate to remove MC and may even increase their concentration; (ii) presence of MC-contaminated fishes, as reported in other studies; and (iii) bathing activities, in particular for young people who are more susceptible to these cyanotoxins.

Taken together, these data emphasize the need to better inform local populations on the issue of cyanobacteria and toxic risks associated with their blooms and to work on individual water treatment solutions allowing us to limit this exposure for populations having no access to safe water.

Redactors of this Summary Note:

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