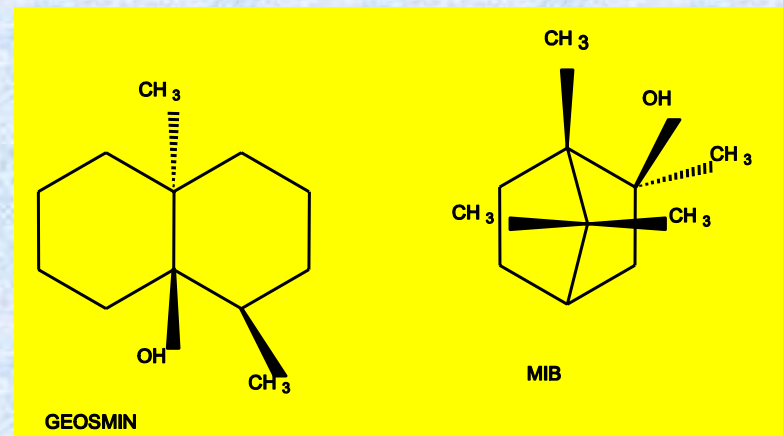


Taste and Odor, Algal Toxins Removal through Conventional and Advanced Processes

Dr. Chandra Mysore, PE, DEE
4/13/06

Why are algae problematic in WT?

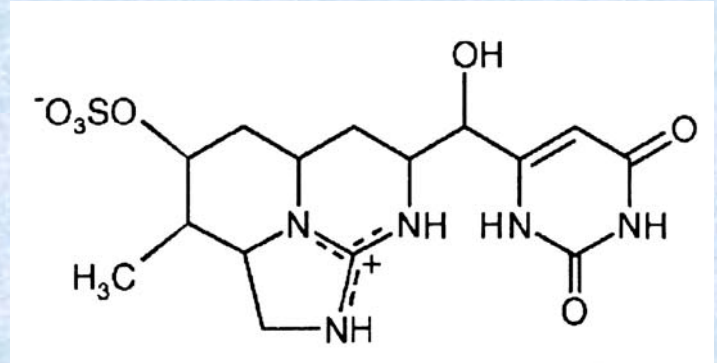
- ▶ clogging of the filters
- ▶ rapid variations in the water quality:
 - pH, Ammonia, Dissolved Oxygen, BDOC ...
- ▶ production of taste and odor (Geosmin and MIB detectable at part per trillion concentrations)
- ▶ potential production of **toxins**



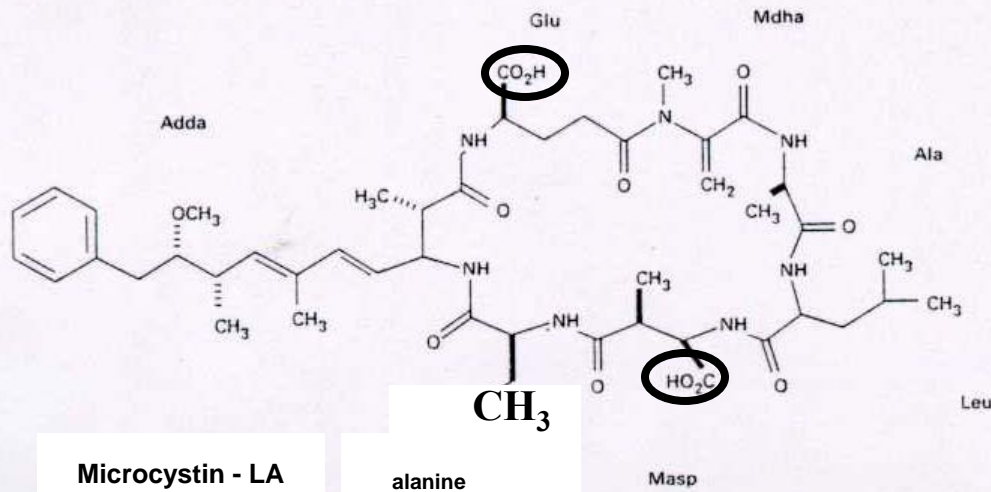
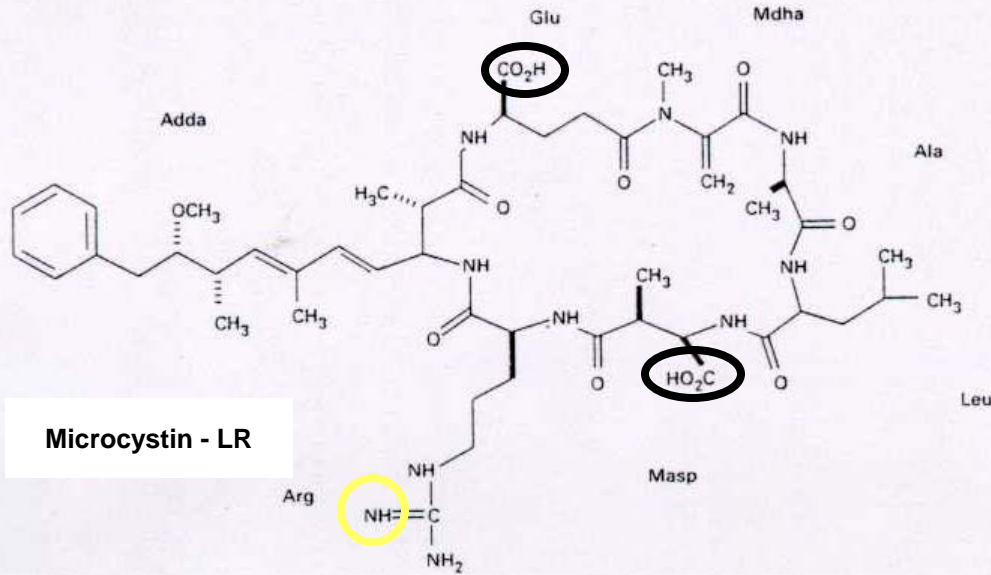
Sources of algal toxins in drinking water

50% of the known genera of cyanobacteria are capable of producing toxins

Microcystis, Anabaena, Oscillatoria, Nostoc, Hapalosiphon, Anabaenopsis, Nodularia, Lynbya, Schizothrix, Cylindrospermopsis



Structure of microcystin -LR & LA



| analogue | Molecular weight |
|----------|------------------|
| m-LR | 994 |
| m-LA | 909 |

| analogue | Charge at pH 7- 8.5 |
|----------|---------------------|
| m-LR | -1 |
| m-LA | -2 |

m-LA is more hydrophobic than m-LR

Control of cyanobacterial blooms

- ▶ **Bloom prevention rather than reactive eradication is safest**
- ▶ **Watershed management to minimize nutrient input (N and P)**
- ▶ **Copper treatment must be well managed**
 - Apply when cell counts are low
- ▶ **In-reservoir non-chemical methods (aeration, mixing ...)**
- ▶ **Biological methods**

Treatment technologies for toxins removal in the WTP

▶ **Coagulation and Sand Filtration**

▶ **Floatation**

▶ **Oxidation**

- chlorination

- ozonation

▶ **Adsorption**

- PAC

- GAC

▶ **Ozonation + BAF**

Coagulation and filtration

- ▶ **Coagulation with either alum or ferric chloride and filtration can remove 95% of microcystin (most of the toxin is bound with *Microcystis*)**
- ▶ **Effective removal by lime (coagulation of whole cells) in some cases**

Floatation

▶ Dissolved air floatation

- removal of intact cells
- may be useful as a pre-treatment before chemical oxidation

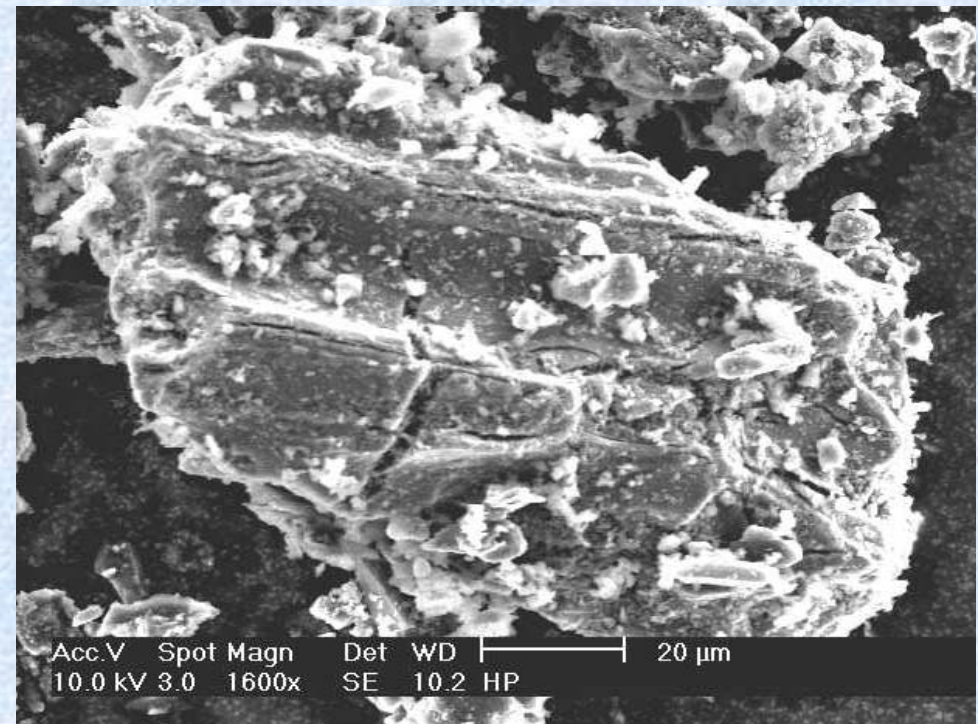
▶ Ozo-floatation

- removal of cells
- risk of lysis in some cases

Adsorption (PAC, GAC)

► PAC is effective but with variable removal rates

- doses: 15 to 50 mg/L
- contact time = 45 min
- wood-based carbon is more effective
- Removes most microcystins,
- can remove saxitoxins, cylindrospermopsin
- will not remove microcystin LA



► > 90 % of removal until DOC saturation of GAC

Oxidation (Chlorination, Ozonation)

- ▶ **Chlorination can be effective if free chlorine residual of 0.5 mg/L can be maintained for 30 minutes at pH <8**
 - can remove most microcystins
 - can remove **Cylindrospermopsin**
- ▶ **Chloramination is completely ineffective**
- ▶ **as a pre-oxidant, KMnO₄ has shown mixed results**
- ▶ **Ozonation**
 - **Very effective**
 - **Rapid and complete destruction of microcystins by ozonation**

Summary of Treatment Processes

| Toxin | PAC | GAC (Adsorbed) | Chlorine | Ozone | Ozone/ BAF |
|--------------------|-----|-------------------|----------|-------|---------------|
| Microcystin-LR | ✓ | ✗ | ✓ | ✓ | ✓✓ |
| Microcystin-LA | ✗ | ✗ | ✓ | ✓ | ✓✓ |
| Cylindrospermopsin | ✓ | ✗ | ✓ | ✓ | ✓✓ |
| Saxitoxins | ✓ | ✓ | * | ✗ | ✓ |
| Anatoxin a | ✓ | ✗ | ✗ | ✓ | ✓ |

GACads: granular activated carbon functioning in adsorption mode

* : Yes, at pH > 8.0, BAF: granular activated carbon functioning as a biofilter

Summary

- ▶ More research required into the production of toxins, purpose, identification of strains responsible
- ▶ The diverse nature of the toxins, in terms of chemical structure, and toxicity, requires different treatment options for their control in drinking water



Summary (cont'd)

- ▶ prevent bloom in preference to in-reservoir bloom treatment or in-plant toxin treatment
- ▶ remove intact cells to maximum degree possible
- ▶ avoid pre-treatment causing cell lysis
- ▶ ozonation and BAF (multiple barrier concept) process offers a robust barrier against most toxins

