Biodredging and Loch Lomond

Biodredging uses probiotic bacteria, one-cell organisms. Their metabolic enzymes act to chemically degrade the muck lying on the bottom of the lake and digest them into smaller chemical substances. The result is to reduce the bottom layer of muck which makes the water deeper and helps create a clearer, cleaner, and healthier lake.

The product used by our lake management company McCloud Aquatics is BioDredge from Naturalake Biosciences in Madison, WI. My review of their Safety Data Sheet (Revision Date 8/02/2019) indicates no health or safety concerns. These are aerobic bacteria, which means they use oxygen, as opposed to anerobic bacteria that may make sulfurous byproducts which have an unpleasant odor and may be unhealthy for higher forms of life. The association to oxygen should be familiar because having enough dissolved oxygen is good in general, which is why aeration has been used in the past and is another option for lake management.

The gut of warm-blooded animals, including humans, relies upon bacteria to complete the digestion of complex food. Probiotic supplements are commonly used to help with digestive issues. Lake biodredging products are absolutely not intestinal coliform bacteria (like *E. Coli*), the type that can temporarily close the lake after strong rains, for example.

Using bacteria may also sound scary because we hear of other types that cause infection and have become antibiotic-resistant (MRSA). But the lake is not our human body, she is an outdoor living ecosystem which needs to be in a state of balance, unlike a swimming pool which does not support life like fish and is maintained by disinfectants like chlorine or salt.

> "I've always thought of the bacteria helping the ecosystem find its equilibrium again."
> Josh Rogers, McCloud Aquatics

> "Right there in the middle of our neighborhood we have a treasure and it's oh so good. First thing you see coming up Beach Drive- it's not a thing at all: she's alive."
> Roger Hammer, *Rock Around the Loch*

Microbes are found throughout the human body, mainly on the external and internal surfaces, including the gastrointestinal tract, skin, saliva, oral mucosa, and conjunctiva. An average 155 lb. human body hosts some 10 trillion bacteria, most of which are in the gut.

Biodredging is a good addition to our toolkit to manage lake quality. Other lakes have reported good experience with this approach. While I am not a professional limnologist my conclusions are based on available data and scientific studies, and express my opinion as a concerned resident.

April 2024
Roger Franz, BA, MS, Chemistry

Appendix

Notes for further follow up, courtesy of the Dept. of Limnology, U. Wisc. Madison

- Suggest talking with somebody from the Illinois Lakes Management Association for alternatives to probiotic additives for a shallow warm water impoundment.
- Big advocate of the Lake Wingra carp removal project.
- With a fish community of native warm water fish (and virtually no carp) and maybe an aerator plus aquatic plant harvesting in certain areas, that might be the best they can hope for.
- Indian Lake in northwest Dane County is probably a pretty good analog of managing a similar size and depth lake. The county removed carp recently to improve water quality (i.e., reduce algae blooms), which in turn would increase aquatic plants like has happened in the past. Have seen Indian Lake with water clarity less than 0.5 feet, and then later with great clarity but lots of aquatic plants and a decent fishery with an aerator used to prevent winterkill (fish die-off from lack of oxygen under the ice). Then during a major flooding event, carp migrated up a small outlet stream and proliferated in the lake causing it to go back to a turbid-algal state. Dane County and the DNR have trying to get it back to clearer water with aquatic plants in the last few years by carp removal and fish stocking.
- Suggest contacting the Dane County Lakes and Watershed Dept., specifically Pete Jopke (jopke@countyofdane.com).

Other References.

- Sender, et. al., "Revised Estimates for the Number of Human and Bacteria Cells in the Body"

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4991899/
PLoS Biol. 2016 Aug; 14(8): e1002533.
Published online 2016 Aug 19.
"…we find $3.8 \cdot 10^{13}$ bacteria in the colon with a standard error uncertainty of 25% and a variation of 52% SD over a population of 70 kg males. Considering that the contribution to the total number of bacteria from other organs is at most 10^{12}, we use $3.8 \cdot 10^{13}$ as our estimate for the number of bacteria across the whole body of the "reference man."

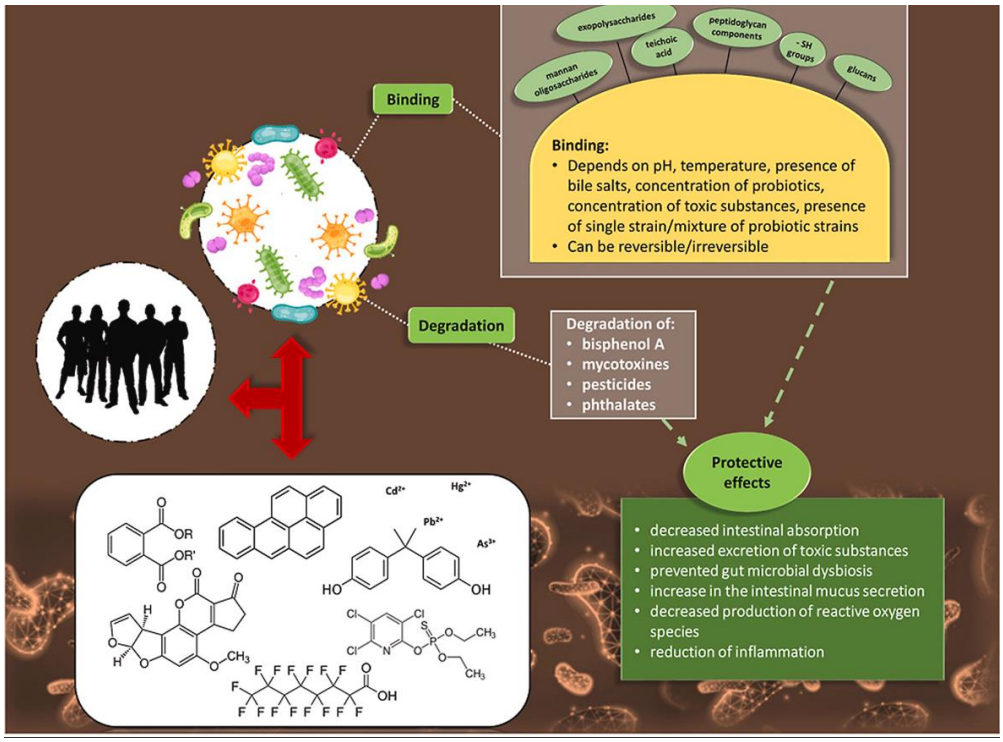
- Hu et. al. *Journal of Contaminant Hydrology*, Volume 261, February 2024, 104306. Distribution of organophosphorus pesticides and its potential connection with probiotics in sediments of a shallow freshwater lake

https://www.sciencedirect.com/science/article/abs/pii/S016977222400010X
Microbes play a fundamental function in lake ecosystems, as they actively decompose organic matter and facilitate nutrient cycling (Mellado and Vera, 2021). They are perhaps the most sensitive indicators of lake change (Kuang et al., 2022). According to the Food and Agriculture Organization/World Health Organization (FAO/WHO), probiotics are "live microorganisms that, when administered in adequate amounts, confer a health benefit on the host" (Baralić et al., 2022; Hill et al., 2014). Common probiotics include *Bifidobacterium*, *Streptococcus*, *Bacillus*, *Lactobacillus*, *Saccharomyces*, *Coccidioides* and *Propionibacterium* (Eze et al., 2023). Probiotics have the potential to enhance the health of both animals and humans by optimizing gut health through the modulation of the

microbiota, promoting and maturing the immune system, synthesizing and increasing the bioavailability of nutrients, alleviating symptoms of lactose intolerance, and lowering the risk of specific diseases (Thilagavathi, 2020). Additionally, probiotics possess the capability to detoxify environmental pollutants and hinder their toxicity by binding to these toxicants and facilitating enzymatic reactions (Khorshidian et al., 2016; Urban and Kuthan, 2004). The presence of pesticides has been demonstrated to influence both the abundance and diversity of probiotic species (Kalia and Gosal, 2011; Syromyatnikov et al., 2020; Zhang et al., 2017). Furthermore, experimental evidence supports the notion that probiotic microorganisms exhibit the capacity to bind and/or metabolize diverse chemical contaminants, including OPPs, mycotoxins, and heavy metals (Feng et al., 2018; Średnicka et al., 2021). When it comes to the connection between OPPs and probiotics, most recent studies have elucidated the detoxification mechanisms of probiotics against OPPs (Cycoń et al., 2009; Lee et al., 2021; Liu et al., 2022a, Liu et al., 2022b). Certain studies indicated that probiotics can diminish the levels of OPPs through processes involving adsorption and microbial enzyme activity. Specifically, adsorption, or binding, emerges as a reduction mechanism employed by probiotics against OPPs, with some strains, such as *Lactobacillus plantarum* P9, emphasizing degradation as a primary mechanism rather than adsorption (Li et al., 2018; Sarlak et al., 2021; Wang et al., 2016). Probiotics leverage enzymes like phosphodiesterase, phosphatases, carboxylesterases, and organophosphate hydrolases during the bioremediation process to break down pesticides, fulfilling their nitrogen, carbon, and energy requirements. Furthermore, the fermentation process serves as another avenue through which probiotics metabolize pesticides (Salih et al., 2023).

- K. Baralić *et al., Food Chem. Toxicol.* (2022). Probiotic cultures as a potential protective strategy against the toxicity of environmentally relevant chemicals: state-of-the-art knowledge https://www.sciencedirect.com/science/article/abs/pii/S0278691522007803

  Key points:
  Probiotic cultures are able to bind/degrade various toxic substances.
  Probiotics decrease intestinal absorption/increase excretion of toxic substances.
  Probiotics prevent gut microbial dysbiosis and increase intestinal mucus secretion.
  Probiotics decrease oxidative stress and inflammation.
  Multi-strain probiotics are proposed for removal of toxic substances mixtures.



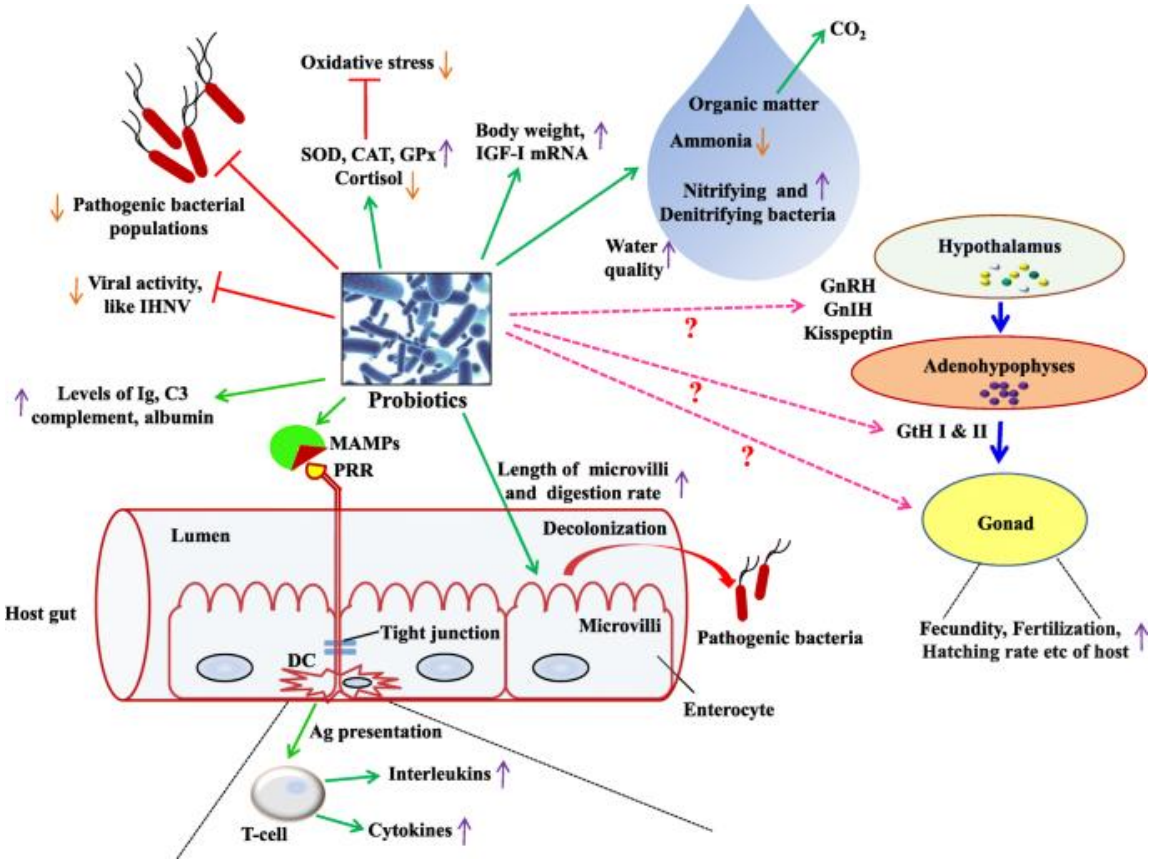
- Hasan et. al, *The Journal of Basic and Applied Zoology*, 27 August 2020

Recent studies on probiotics as beneficial mediator in aquaculture: a review
https://basicandappliedzoology.springeropen.com/articles/10.1186/s41936-020-00190-y
Gives this detail of bacteria species and effects.

Name of the probiotics	Beneficial effects	Reference(s)
Bacillus spp.	Reduces the load of ammonia and nitrite	Porubcan (1991)
Enterococcus faecium ZJ4	Improves water quality and enhances immunity	Wang and Wang (2008)
Lactobacillus acidophilus	Improves water quality	Dohail, Abdullah, Roshada, and Aliyu-Paiko (2009)
Bacillus NL110, *Vibrio* NE1	Reducesammonia and nitrite concentration	Mujeeb Rahiman, Yousuf, Thomas, and Hatha (2010)
Nitrosomonas sp.,*Nitrobacters* sp.	Reduces the concentration of ammonia, phosphates and nitrite in culture pond	Padmavathi, Sunitha, and Veeraiah (2012)

Rhodopseudomonas palustris, Lactobacillus plantarum, Lactobacillus casei, Saccharomyces cerevisiae	Reduces nitrate load, maintain water pH and enhances dissolve oxygen concentration	Melgar Valdes, Barba Macías, Alvarez-González, Tovilla Hernández, and Sánchez (2013)
Paenibacillus polymyxa	Enhances immunity and reduces pathogenic stress	Giri, Sukumaran, and Oviya (2013)
Lactobacillus rhamnosus	Reduces pathogen load in culture tank	Talpur et al. (2013)
Pseudomonas sp.	Enhances transcription rate of anti-microbial peptide	Ruangsri, Lokesh, Fernandes, and Kiron (2014)
Bacillus spp	Promotes the growth of beneficial algae and reduces the growth of harmful algae	Lukwambe et al. (2015)
Nitrosomonas sp., *Nitrobacters* sp.	Reduces pathogen load in culture pond and increases dissolved oxygen content	Sunitha and Krishna (2016)

Probiotics help to improve water quality due to their ability to participate in the turnover of organic nutrients in aquaculture (Wang & Wang, 2008; Wang, Zheng, Liao, Huang, & Sun, 2007). Organic enrichment and nitrogenous wastes, including ammonium and ammonia (NH_3), are a serious concern in aquaculture, for example in pond rearing of catfish (Sahu et al., 2008). To date, the information regarding the maintenance of the balance of $NH_3/NO_2/NO_3$ in pond by probiotic candidates is limited (Wang et al., 2007) (Fig. 2). There is a strong tendency to combine different photosynthetic bacteria, *Bacillus*, nitrifiers, and denitrifiers together; therefore, probiotics are often labeled as multifunctional and can be applied to various species under diverse culture conditions (Wang & Wang, 2008). Apart from these, probiotics are more efficient in transforming the organic matter to CO_2 (Fig. 2); therefore, it is suggested to maintain their high levels in production ponds to reduce the organic carbon load and to enhance the water quality and fish health.


Oxidative stress
SOD, CAT, GPx
Cortisol
Body weight,
IGF-I mRNA
CO_2
Organic matter
Ammonia
Nitrifying and
Denitrifying bacteria
Water
quality
Pathogenic bacterial
populations
Viral activity,
like IHNV
Probiotics
Hypothalamus
GnRH
GnIH
Kisspeptin
Adenohypophyses
GtH I & II
Gonad
Levels of Ig, C3
complement, albumin
MAMPs
PRR
Length of microvilli
and digestion rate
Decolonization
Lumen
Host gut
Tight junction
DC
Microvilli
Pathogenic bacteria
Enterocyte
Fecundity, Fertilization,
Hatching rate etc of host
Ag presentation
Interleukins
T-cell
Cytokines