Control of Eutrophication
Biological methods

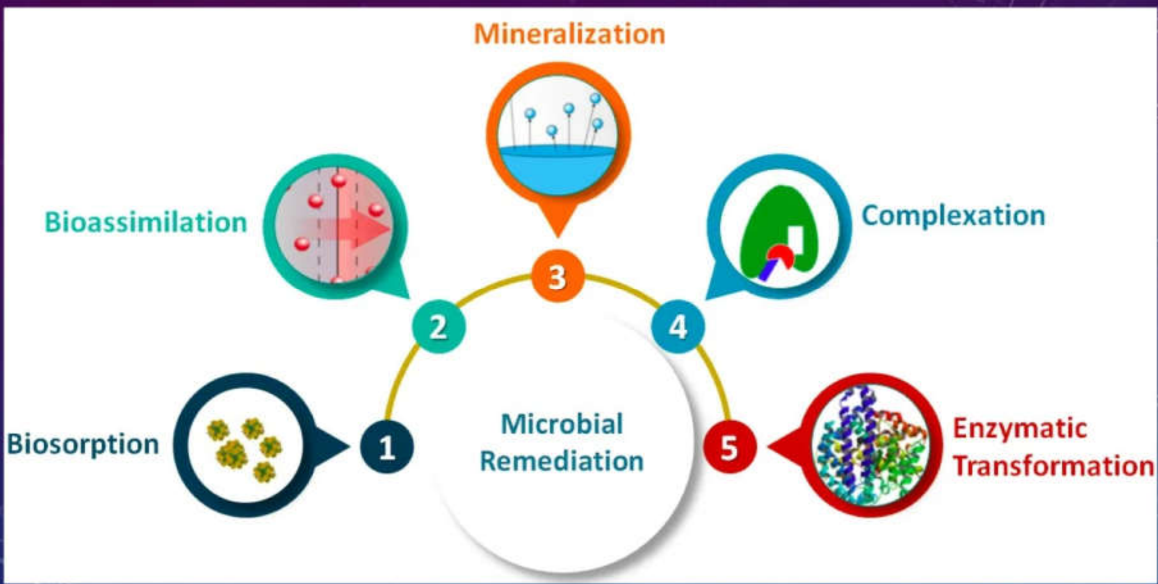
Biological methods

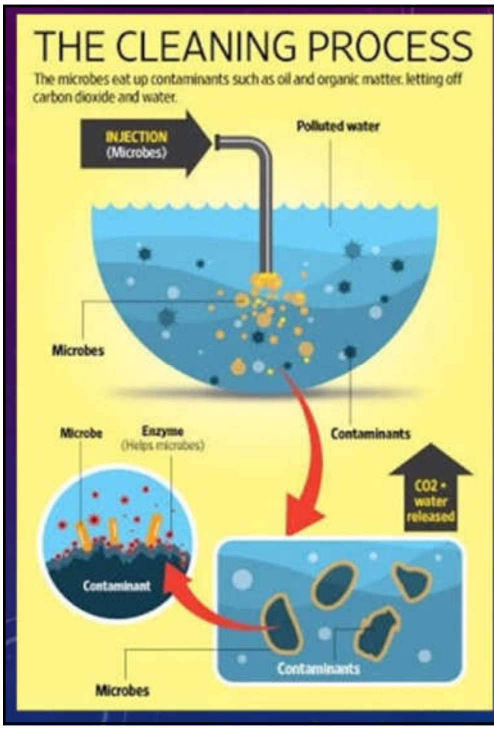
Several biological methods are used to adjust the stability of lake and buffer the speed of nutrient circulation by restoring and re-establishing a healthy ecosystem. Biological methods can reinforce the interaction between microorganisms and aquatic organisms and the self-purification ability of waters facing aquatic pollution. Majority of the biological methods rely on bioremediation techniques and biomanipulation.

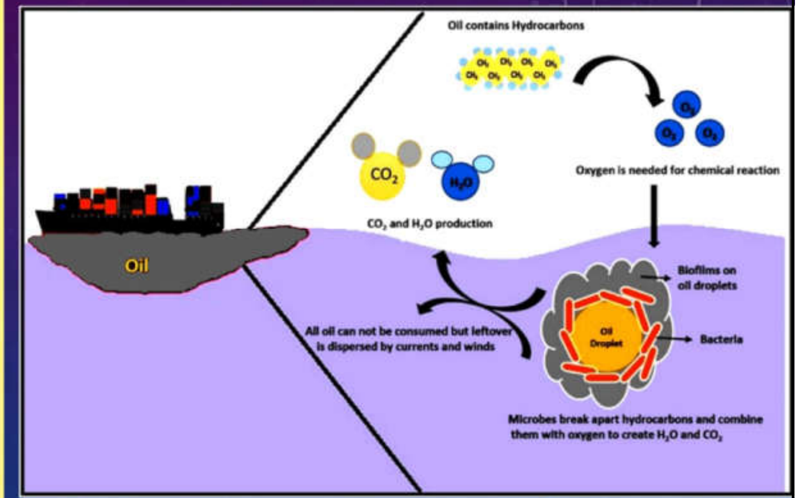
Microbial remediation

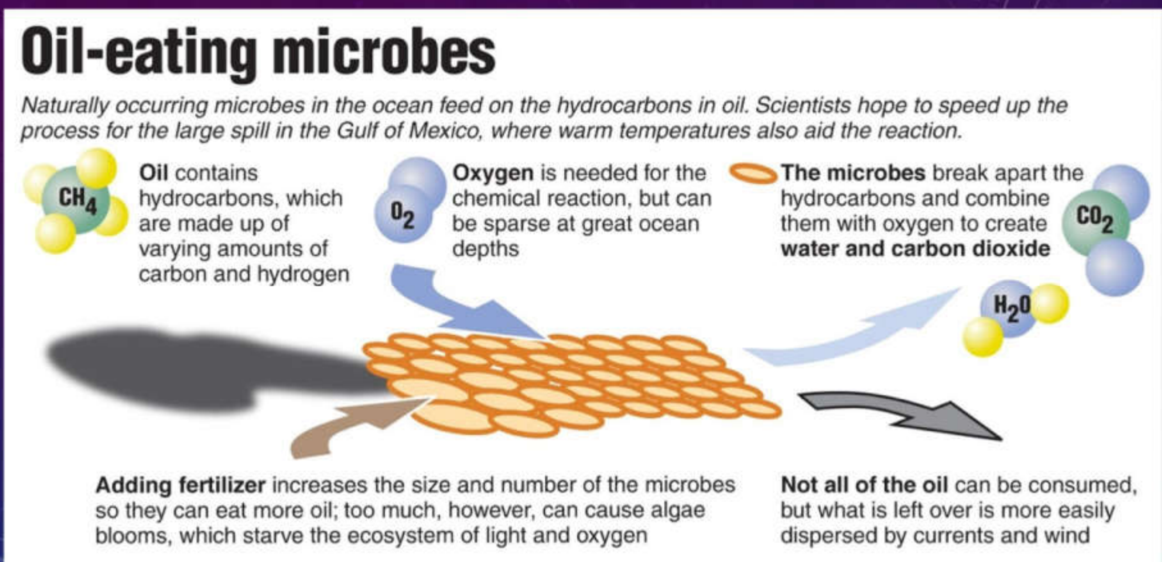
Eutrophication can enhance the biogeochemical cycling of both organic and inorganic contaminants. The microbial bioremediation method is accomplished by adding appropriate amounts of microorganisms to accelerate the decomposition of pollutants. During the process of microorganism reproduction a large amount of the decomposed organic matter serves as nutrients to be absorbed. The higher the microbial biomass and productivity are, the faster the nutrient cycles.

Contaminants that have accumulated in the water body, such as organic matter, N, and P, can be eliminated through nutrient cycling in the ecosystem. Thus, microbial remediation could gradually promote the balance of the aquatic ecosystem, including the plants, animals, and microorganisms, and finally achieving ecosystem remediation. It can be done on-site and coupled with other physical or chemical treatment methods.




THE CLEANING PROCESS
The microbes eat up contaminants such as oil and organic matter, letting off carbon dioxide and water.
INJECTION (Microbes)
Polluted water
Microbes
Microbe
Enzyme (Helps microbes)
Contaminants
CO2 + water released
Contaminant
Contaminants
Microbes


Oil contains Hydrocarbons
Oxygen is needed for chemical reaction
CO_2
H_2O
CO_2 and H_2O production
Oil
Biofilms on oil droplets
Oil Droplet
Bacteria
All oil can not be consumed but leftover is dispersed by currents and winds
Microbes break apart hydrocarbons and combine them with oxygen to create H_2O and CO_2


Oil-eating microbes
Naturally occurring microbes in the ocean feed on the hydrocarbons in oil. Scientists hope to speed up the process for the large spill in the Gulf of Mexico, where warm temperatures also aid the reaction.
CH_4
Oil contains hydrocarbons, which are made up of varying amounts of carbon and hydrogen
O_2
Oxygen is needed for the chemical reaction, but can be sparse at great ocean depths
The microbes break apart the hydrocarbons and combine them with oxygen to create water and carbon dioxide
CO_2
H_2O
Adding fertilizer increases the size and number of the microbes so they can eat more oil; too much, however, can cause algae blooms, which starve the ecosystem of light and oxygen
Not all of the oil can be consumed, but what is left over is more easily dispersed by currents and wind

But microbial activity is affected by several physicochemical environmental parameters. They must be screened regularly to minimize the microbial effects.

Successful microbial remediation requires several conditions.

- First, the target compound must be usable to microorganisms and not contain substances that inhibit bacterial degradation.

- Second, the microorganisms must be highly metabolically active.

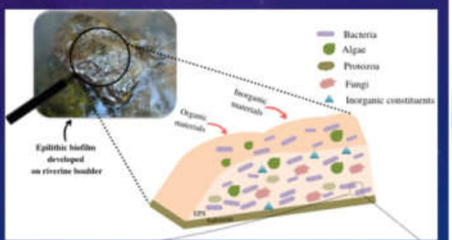
- Third, the technical costs must be as low as possible.

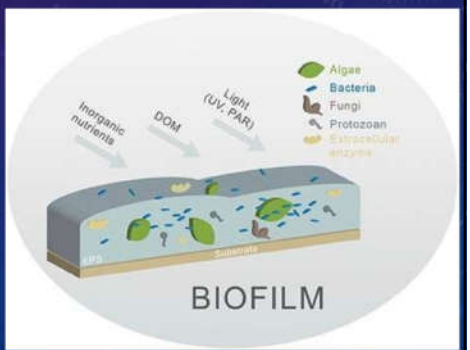
The disadvantages are the long-term remediation time, the difficulty in establishing microbial growth under harsh conditions, and the need for contaminant-specific microbial populations. Furthermore, in some cases, microbial metabolism of contaminants may produce toxic metabolites.

Biofilm technologies

Biofilms can be defined as communities of microorganisms attached to a surface. They can exist on all types of surfaces, including plastics, metals, glass, soil particles, wood, medical implant materials, and food products. Pollutants can be effectively intercepted, adsorbed, and degraded by a large number of microorganisms on the carrier.

Active barrier materials (zeolite, ceramic, and a lightweight porous media) or filamentous bamboo and plastic filling can be used to support biofilms.





Biomanipulation technologies

Biomanipulation, also known as food-web manipulation, manages biomes by altering their structure. This technology is supported by the trophic chain theory and has become a widely applied technique. There are two biomanipulation approaches for controlling algal bloom through fishes;

- reduction of algal biomass by direct grazing or
- indirect repression of algal bloom through fish-derived alterations in zooplankton* communities and nutrient cycling.

The first one is more productive-efficient than others because of shorter food chain and less energy consumption. Many whole lake biomanipulation experiments have been performed in many developed countries to improve water quality in lakes and reservoirs.

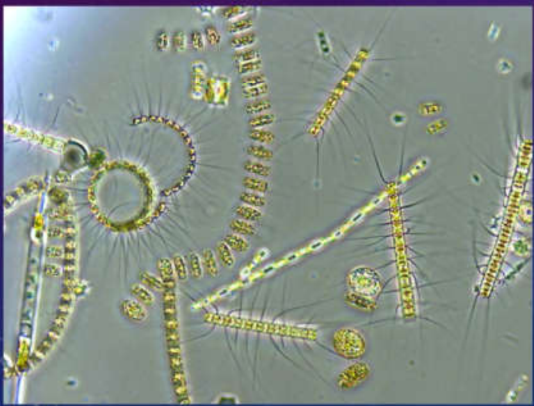
A paranthesis here: Plankton

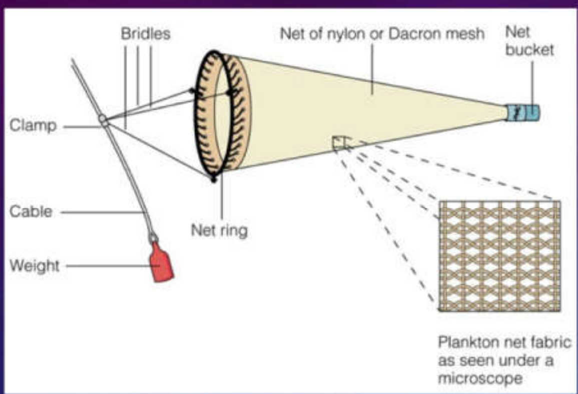
Plankton, marine and freshwater organisms that, are nonmotile or too small or weak to swim against the current, exist in a drifting state. The term plankton is a collective name for all such organisms—including certain algae, bacteria, protozoans, crustaceans, mollusks, and coelenterates, as well as representatives from almost every other phylum of animals.

The most basic categories divide plankton into two groups: phytoplankton (plants) and zooplankton (animals).

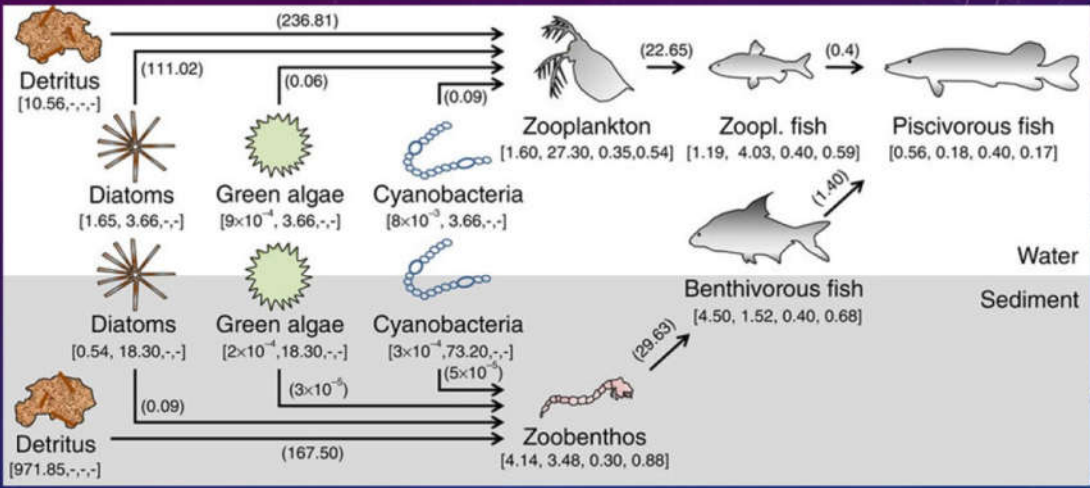
Phytoplankton are microscopic plants, but they play a huge role in the marine food web. Like plants on land, phytoplankton perform photosynthesis. Since they need the sun's energy, phytoplankton are found near the water's surface.

Zooplankton include microscopic animals, the young of larger invertebrates and fish, and weak swimmers like jellyfish. Most zooplankton eat phytoplankton, and most are, in turn, eaten by larger animals (or by each other).

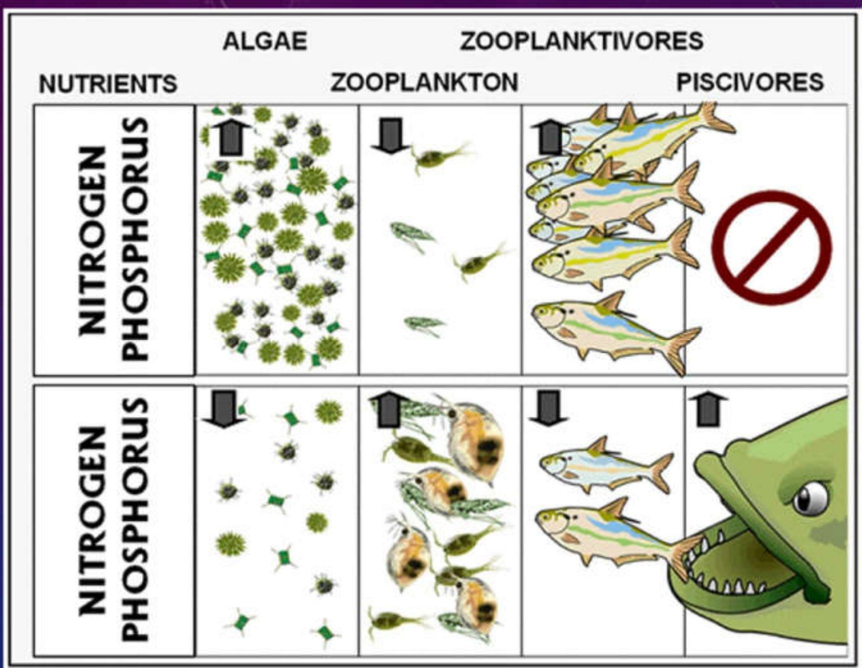


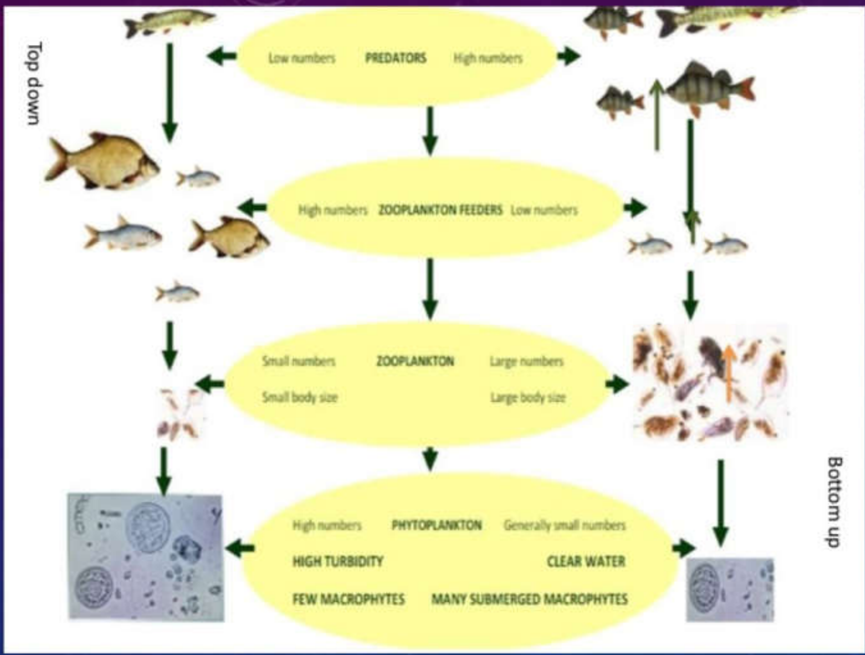


Plankton nets



Another paranthesis: Aquatic food webs





Due to food-chain characteristics, artificially increasing or decreasing organisms may control the number of target organisms and avoid the emergence of algal reproduction. It can be used to foster microorganisms that are harmless to humans but compete with phytoplankton for nutrients. Fishery manipulation includes use of fish as carriers to extract plant nutrients, such as P, thereby reducing the nutrient load in the water and sediment layers to purify lakes.

Grass carp

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Some effects of eutrophication and the removal of aquatic plants by grass carp (Ctenopharyngodon idella) on rainbow trout (Salmo gairdnerii) in Lake Parkinson, New Zealand

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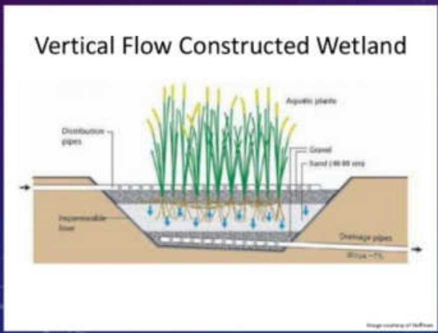
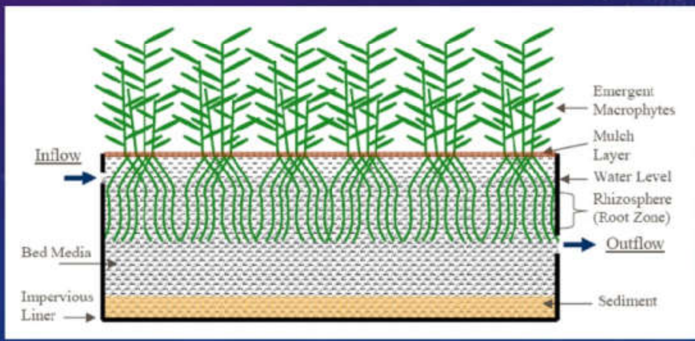
Constructed wetlands

Wetland systems are important places to improve water quality and protect biodiversity. Constructed wetlands (CWs) were initially developed approximately 40 years ago for the purpose of exploiting and improving the biodegradation abilities of plants. There are three main types of CWs, namely vertical CWs, subsurface flow CWs, and surface flow CWs. The best removal effect on ammonia nitrogen (NH_3-N), TN, and TP is attained by vertical CWs.



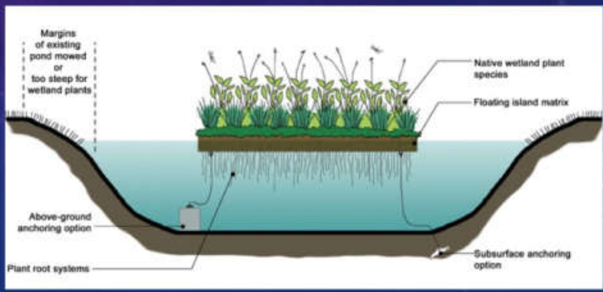


Compared with conventional treatment systems, CWs are low cost, effective, easily operated and maintained, and environmentally friendly. They have been frequently used for nutrient removal from polluted lakes in developing countries and to solve non-point source nutrient introduction into water bodies.

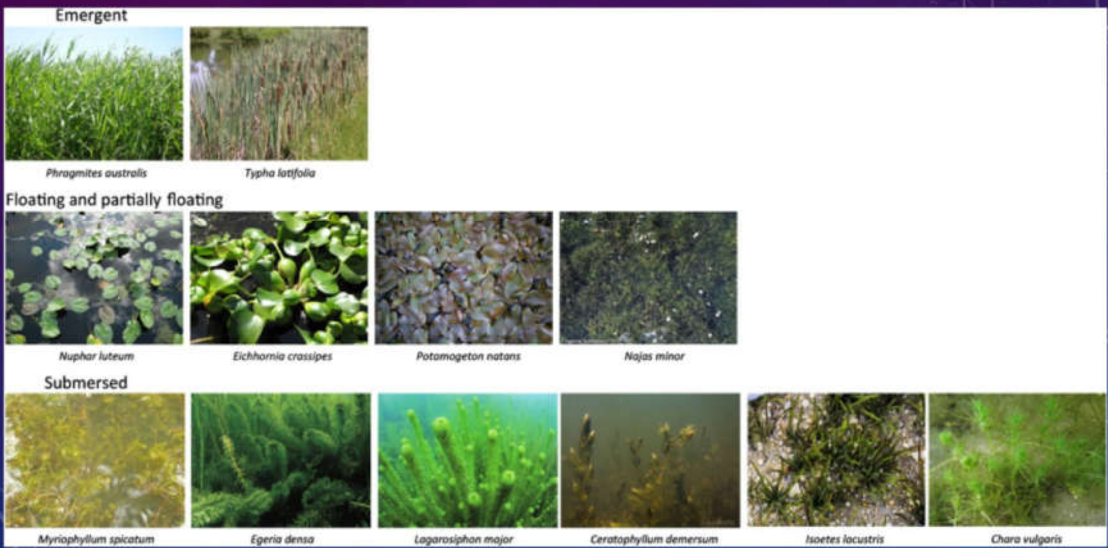
The disadvantage of this system is its relatively slow operational rate. Space availability and waterline limitations affect the application of wetland technologies. In addition, precipitates formed by chemical reactions are released when environmental conditions, such as temperature and pH, are changed. With the contaminated area increasing, the processing cost will become higher. If the nutrient input is too large, the ecosystem will quickly collapse.

Floating wetland islands/floating beds

A technique called artificial floating islands/floating beds can also restore eutrophic lakes by ecological engineering principles to decrease N, and P contents. This technology uses floating beds as carriers of aquatic or wetland plants. Plants grow well on the water's surface and can be applied to ecological remediation of polluted waters. Plants has a wide adaptability and flexibility, thus this system is considered as a promising technique. A combination of aquatic ecological floating islands/beds and other water treatment technologies can notably improves water purification. This technology has the advantages of being low-cost, eco-friendly, and is easy and effective to use.



Different plant species have different effects on the removal of pollutants in floating islands. Thus,choosing right plant plays a central role. Aquatic plants can be categorized as emergent plants, floating leaf plants and submerged plants.



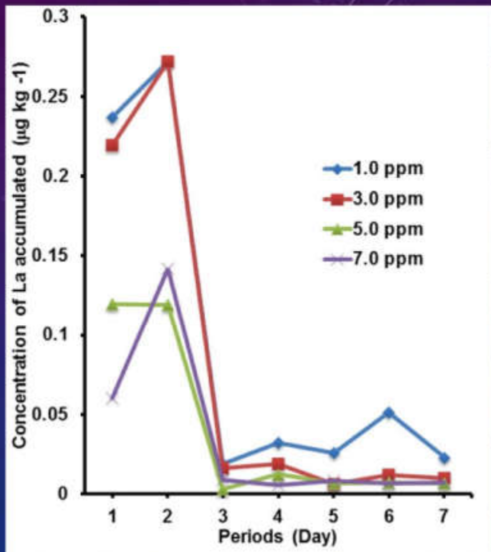


Figure 1: Concentration of La accumulated by root section of *P. stratiotes* for all treatments

Results of two case studies with *Pistia straiotes* exposed to Hg and La.