Remediation strategies in South Portugal reservoirs

Manuela Morais & Amely Zavattieri

Workshop on Observations in Atmospheric and Water sciences
Alqueva, 22 – 25 July 2014

"Filthy water cannot be washed"

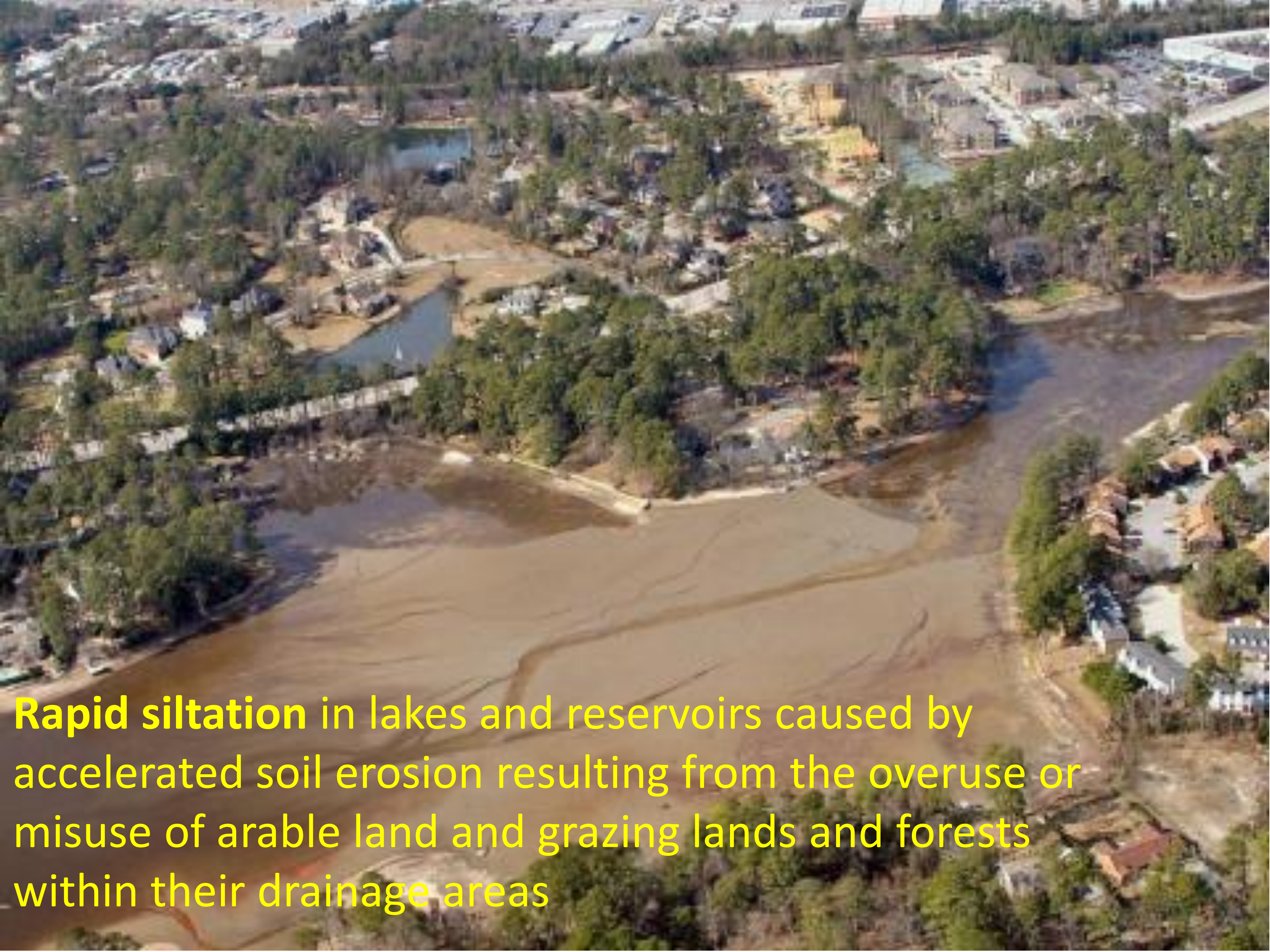
(Proverb from West Africa)

Human activities are degrading the quality of much more water than that withdrawn and consumed

Mayor environmental problems in lakes throughout the world

Low water levels expose the sandy lake bottom on Lake Michigan. Photo by Jeff J. Cashman.

Low water levels due to over use of water for irrigation, human and or animal consumption, high evaporation. Always resulting in a pronounced deterioration of the water quality and adverse changes in the ecosystem

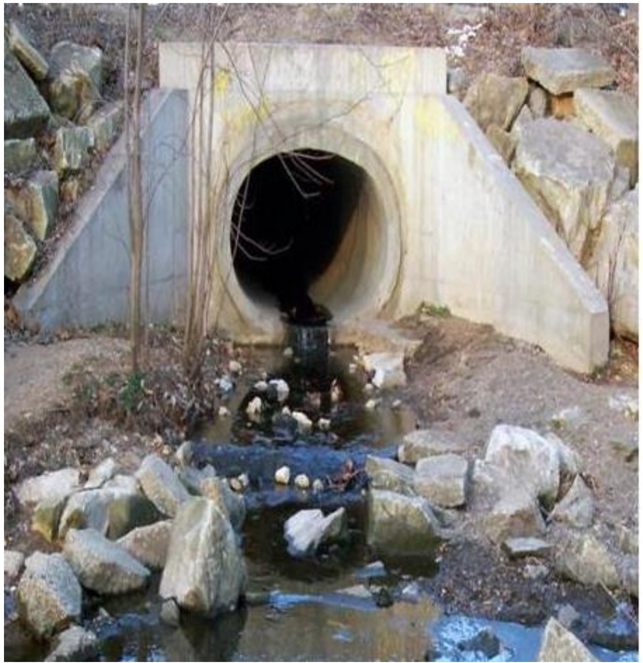


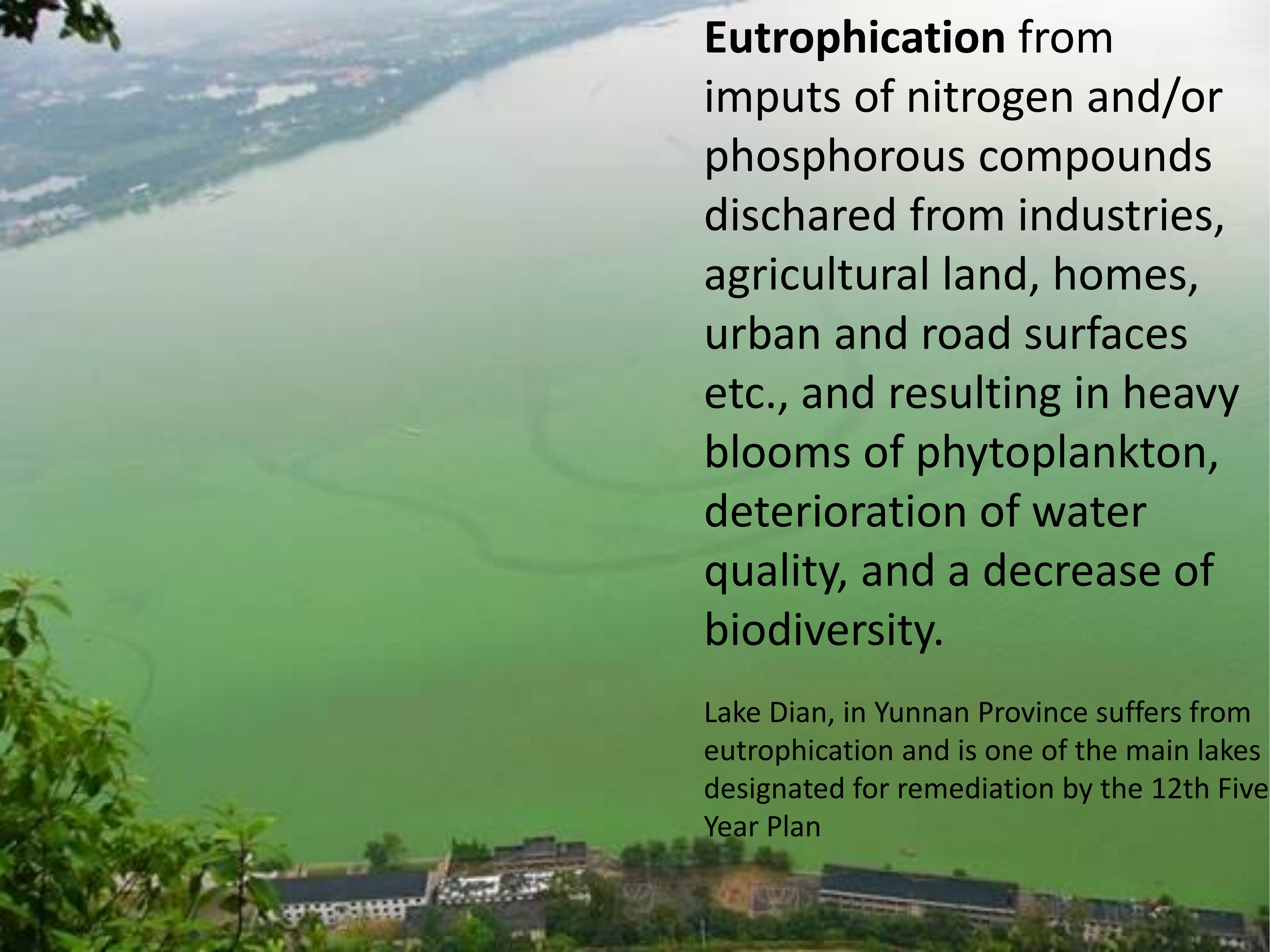
Rapid siltation in lakes and reservoirs caused by accelerated soil erosion resulting from the overuse or misuse of arable land and grazing lands and forests within their drainage areas

Acidification due to acid rains or sediments

The most significant impact from reduced inflows into the Coorong and Lakes Alexandrina and Albert Ramsar Site is the exposure of sediments high in sulfates which have the potential to oxidize and produce sulphuric acid upon re-wetting.

Contamination of water, sediments and organisms with toxic chemicals originated from agriculture (pesticides) and industrial wastes

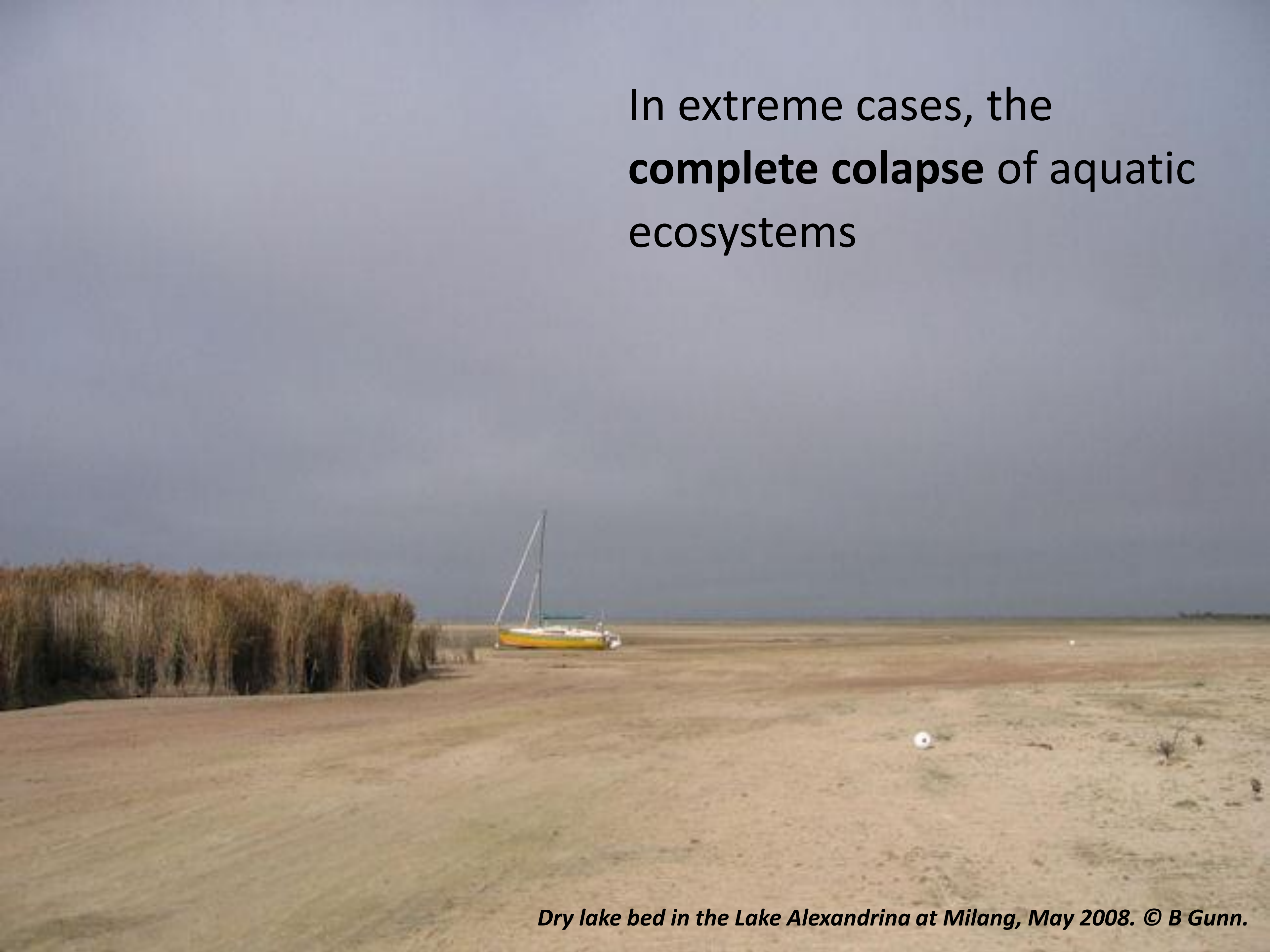




Eutrophication from imputs of nitrogen and/or phosphorous compounds dischared from industries, agricultural land, homes, urban and road surfaces etc., and resulting in heavy blooms of phytoplankton, deterioration of water quality, and a decrease of biodiversity.

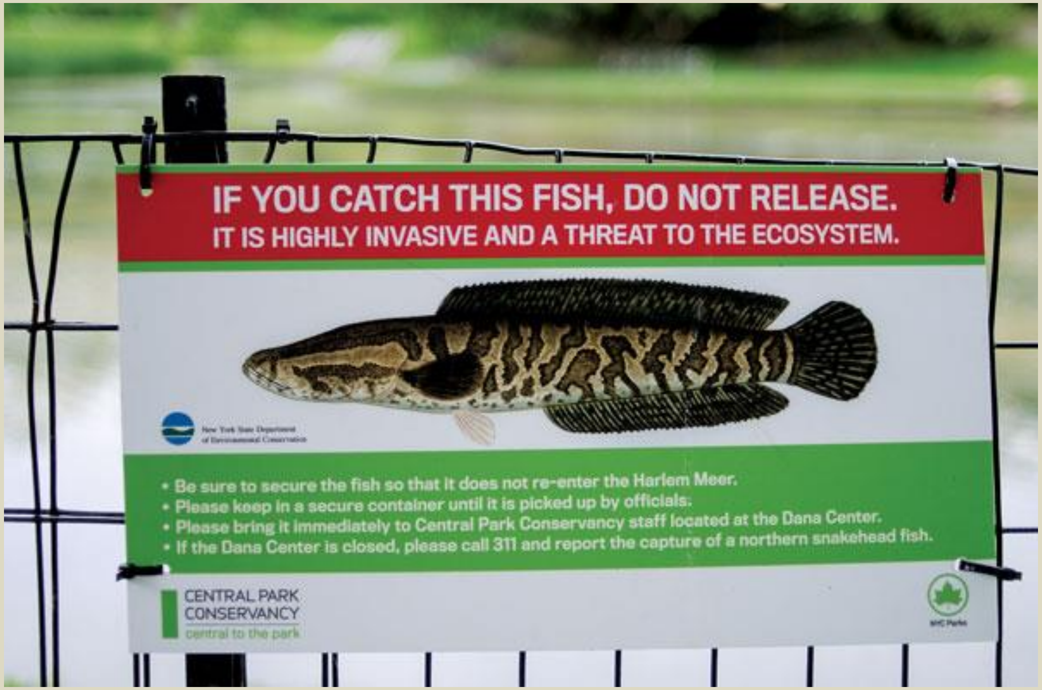
Lake Dian, in Yunnan Province suffers from eutrophication and is one of the main lakes designated for remediation by the 12th Five Year Plan

In extreme cases, the **complete colapse** of aquatic ecosystems



Dry lake bed in the Lake Alexandrina at Milang, May 2008. © B Gunn.

Introduction of non-indigenous species and Changes in the Food Web



Lake and Reservoir Restoration Guidance Manual

Prepared by the
North American Lake Management Society
Lynn Moore and Kent Thornton, editors

“Everything is connected to everything else”
&
“Nothing goes away”

Most Frequent Pollutants of Fresh Water

The main chemical, physical and microbial factors negatively affecting water quality include:

- Organic pollutants They easily decompose in water and consume dissolved oxygen, leading ultimately to eutrophication. They mainly originate from industrial wastewater and domestic sewage, as well as from seepage of old and new landfills.
- Nutrients. These include mainly **phosphate** and **nitrate** and their increased concentration can lead to eutrophication. They originate from human and animal waste, detergents and run-off from agricultural fertilizers.
- Heavy metals. Such pollution tends to be localized around industrial and mining centers. Heavy metals also originate from military activities and through leaching of decommissioned industrial sites and former military areas.
- Microbial contamination from bacteria such *as E.coli, protists* and *amoebae* that comes from untreated sewage as well as animal husbandry.
- Toxic organic compounds. These comprise industrial chemicals, plastics, dioxins, agricultural pesticides, oil and petroleum (group of hydrocarbons), and polycyclic hydrocarbons generated from burning of fuel. The group of persistent organic pollutants (POPs), such as endocrine disrupting chemicals, cyanotoxins, and compounds contained in antifouling paints, continue to be used in large quantities.

- Traces of chemicals and pharmaceutical drugs from medical waste are hazardous substances that are not necessarily removed by conventional drinking water treatment processes. They are now being recognized as carcinogens and endocrine disrupters and pose a great threat to water quality.
- Suspended particles. These can be either inorganic or organic matter and originate mainly from agricultural practices and land use change such as deforestation, and conversion to pasture at steep slopes leading to erosion.
- Nuclear waste. Nuclear waste leaks into aquifers and surface waters are also a major threat to water resources, especially in the transition economies of Central and Eastern Europe.

The following processes, which are intensified by unsustainable human activities, also contribute to significant levels of water pollution:

- Salinisation, mainly occurring in arid and semiarid regions. Although it can also occur naturally, unsustainable irrigation and inadequate drainage promotes secondary salinisation. It can also be the result of irrigation with salt water, after freshwater has been replaced in coastal aquifers due to over-abstraction.
- Acidification, which is connected to the lowering of the pH of the water due to sulphuric deposition produced by industrial activity and also urban emission

Eutrophication : Algal and Cyanobacterial Blooms

Cyanobacteria (Blue-Green Algae)

- Cyanobacteria (technically a bacteria, not an algae). They contain chloroplasts within the cells.

- Can exist in all settings from freshwater to terrestrial settings and from oligotrophic (low nutrient) to hypereutrophic (very high nutrient) environments.

- Some species have a competitive advantage over other algae by having the ability to fix nitrogen

- They can fixed atmospheric nitrogen into usable nitrogen (ammonia). This characteristic allows these species to exist in areas where low nitrogen availability inhibits growth. Therefore, under phosphorus-rich conditions, when nitrogen may be limited, blue-green cyanobacteria algae have a competitive advantage because they can utilize ("fix") nitrogen directly.

- Cyanobacteria can also successfully compete against other groups of such as green algae and diatoms because they can store phosphorus for later

Cyanobacteria and other Harmful Algal Blooms

They can grow so profusely that they can impart an objectionable odor, taste, and appearance to the water. **Many of these cyanobacteria release toxins into the water, causing health concerns** in both animals and humans.

Toxins: (skin irritations, allergic reactions, gastrointestinal symptoms, and respiratory problems)

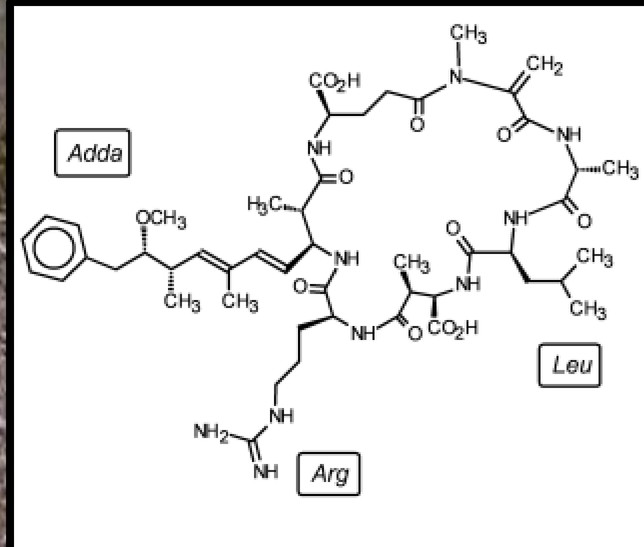
Prefer neutral to acidic water

Efficient buoyancy regulation

Dominance aided by high organics, high P: N ratio (due to N_2-fixation ability),

Not preferred food of microcrustaceans; protists, rotifers & flamingos

May be dormant for years, germinate when favorable



Microcystin-LR


Lakeshore
Edsel Ford Fwy
Grosse Ile
Monroe
Pelee Island
Toledo
Sandusky
Lorain
Westlake
Google

Remediation strategies

- ✓ Biological
- ✓ Chemical
- ✓ Mechanical

Bioremediation

Bioremediation is the application of a biological treatment, mainly microbes, to the cleanup hazardous contaminants in soil and surface or subsurface waters

The bacteria feed on the contamination, deriving nutrition for growth and for reproduction. Complex chemical reactions occur, but the result of this natural process is that contaminants are used up completely or are converted (or cleaved) into an innocuous product such as water and carbon dioxide. The microbes will survive and consume their contaminant food source until the unwanted pollutant is remediated.

Natural Bioremediation

Natural bioremediation has been occurring for millions of years. It is a natural part of the carbon, nitrogen, and sulfur cycles. Chemical energy present in waste materials is used by microorganisms to grow while they convert organic carbon and hydrogen to carbon dioxide and water.

Managed Bioremediation

When bioremediation is applied by people, microbial biodegradation processes are said to be managed. **However, bioremediation takes place naturally and often it occurs prior to efforts to manage the process**.

One of the first examples of managed bioremediation was land farming (refers to the managed biodegradation of organic compounds that are distributed onto the soil surface, fertilized, and then tilled).

Critical factors in deciding whether bioremediation is the appropriate method for site remediation

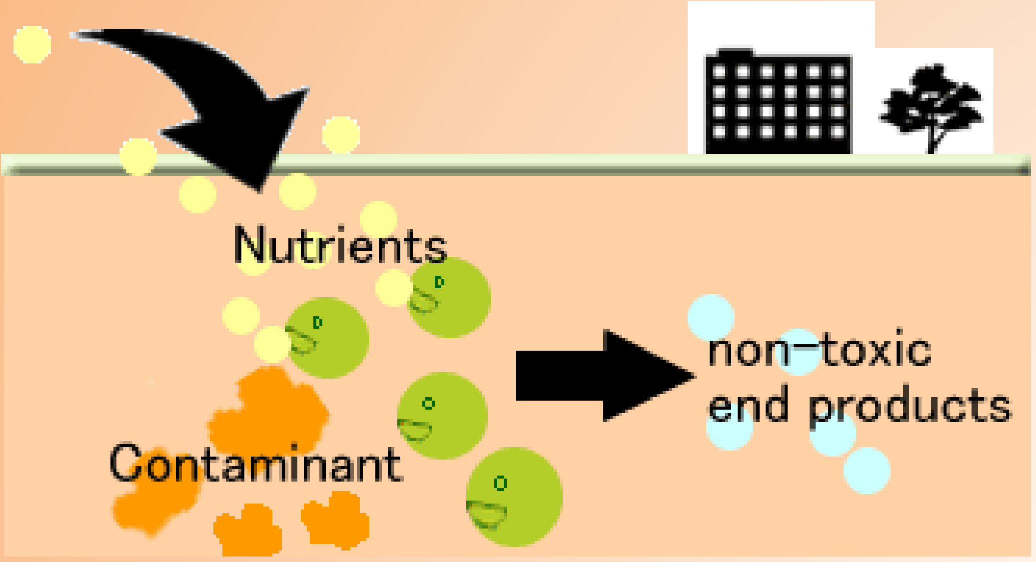
- **Whether or not the contaminants are susceptible to bioremediation by the organisms at the site (or by organisms that could be successfully added to the site).**

- **Whether or not the contaminants are accessible to the micro-organism (geological considerations may become a factor)**

- **Whether or not any inhibitory environmental conditions exist that may interfere with the growth and reproduction of these microbes.**

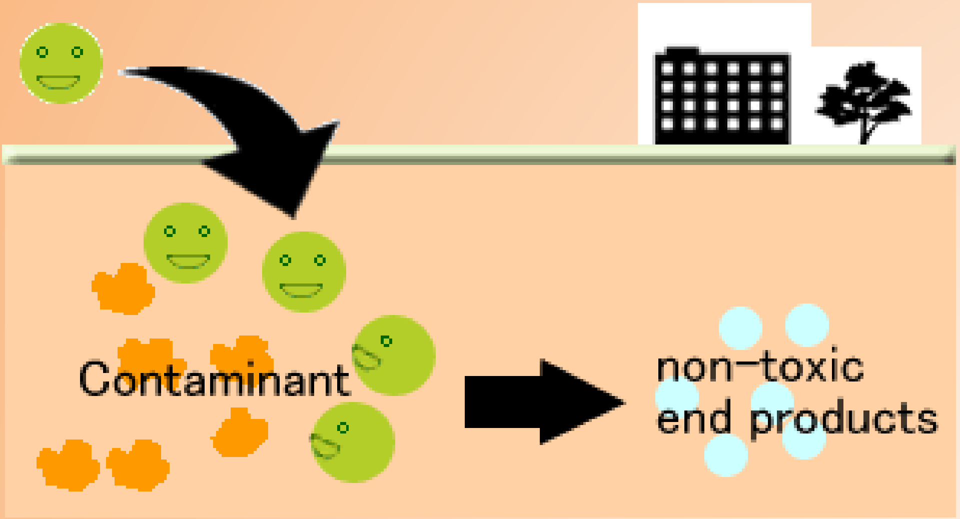
Biostimulation

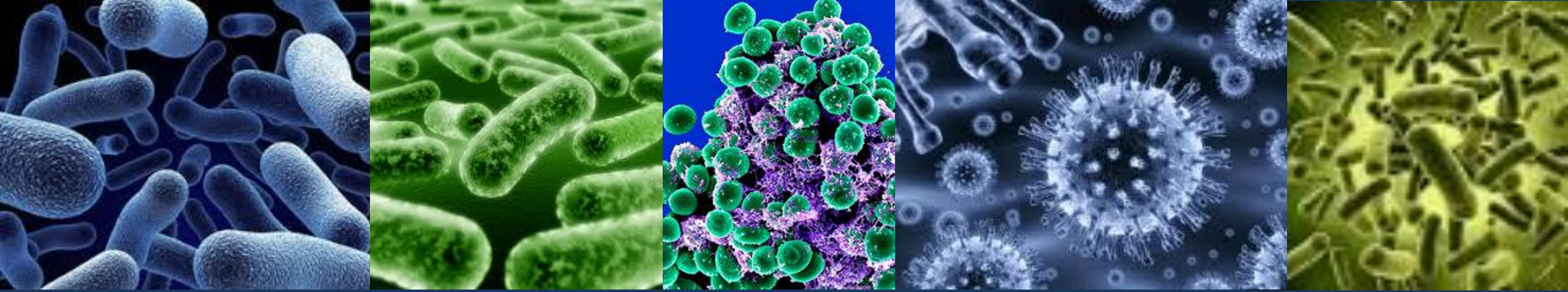
In this type of *bioremediation* the degradation capacity of microbes, **indigenous to contaminated site,** is exploited. Usually appropriate nutrients are applied to the contaminated sites to stimulate the population of microbes



Bioaugmentation

If the indigenous population of microbes is not capable of fully degrading the contaminants, **external source of super microbes are applied** to the contaminated media along with the nutrients or enzymes. These externally added microbes multiply and increase in population while degrading the contaminants and using the added nutrients

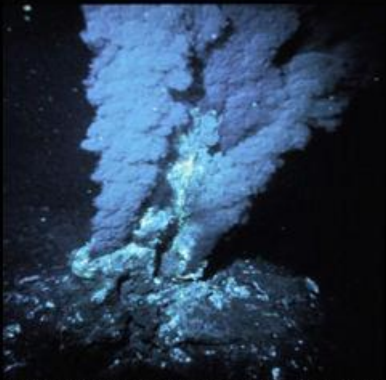




Why microorganisms???????

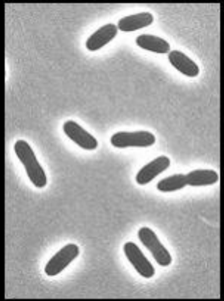
- Live virtually everywhere.
- They possess enzymes that allow them to use environmental contaminants as food
- They are so small that they are able to contact contaminants easily
- They have served in nature for billions of years: the breakdown of complex human, animal, and plant wastes so that life can continue from one generation to the next.
- Researchers are currently investigating ways to augment contained sites with nonnative microbes including genetically engineered microorganisms specially suited to degrading the contaminants of concern at particular sites. It is possible that this process, know as bioaugmentation, could expand the range of possibilities for future bioremediation systems.

TERMÓFILAS



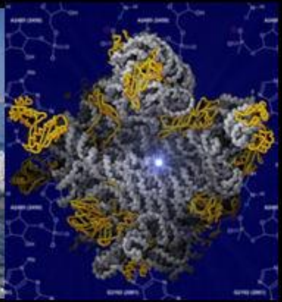
Los termófilos producen enzimas que son estables a altas temperaturas

FRIA COMODIDAD...



Psicrófilos, han especializado sus membranas celulares que no se endurecen en temperaturas heladas

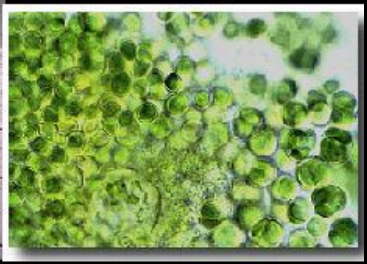
MAR MUERTO...PERO NO TANTO



Haloarcula marismortui, tiene proteínas que lo protegen de los efectos de la Sal

EN LA ARIDEZ DEL DESIERTO

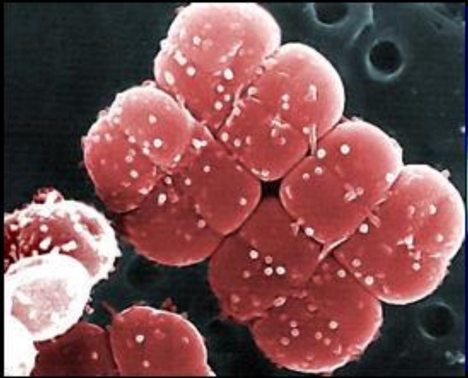
A pesar de estas secas condiciones se ha encontrado una bacteria llamada Chroococcidiopsis

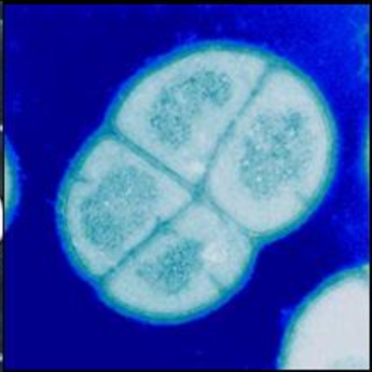


MUNDOS ALCALINOS

Natronomonas pharaonis, también presente en los mundos alcalinos de soda

RESISTIENDO LA RADIACIÓN





Bacteria Deinococcus radiodurans, puede resistir 2000 veces más una dosis de radiación

GEOBACTER

La bacteria Geobacter metallireducens (en verde) devorando material toxico radiactivo

Filme TED Shaily Mahendra

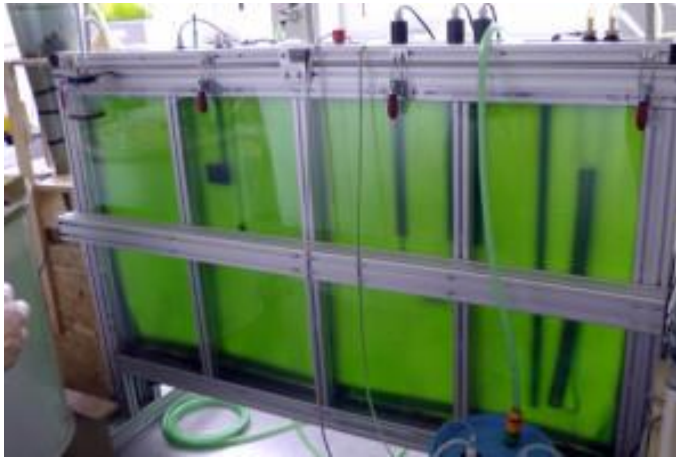
Steps towards bioremediation

- Isolation of the target microorganism
- Mass-produce standardized pro-biotic bacteria and fungi into industrial concentrated inoculum's.

These selected formulations, **of multiple strains of bacteria**, can be targeted to address specific contaminants.

Many of the most toxic environmental contaminants are now candidates for bioremediation.

Photobioreactor

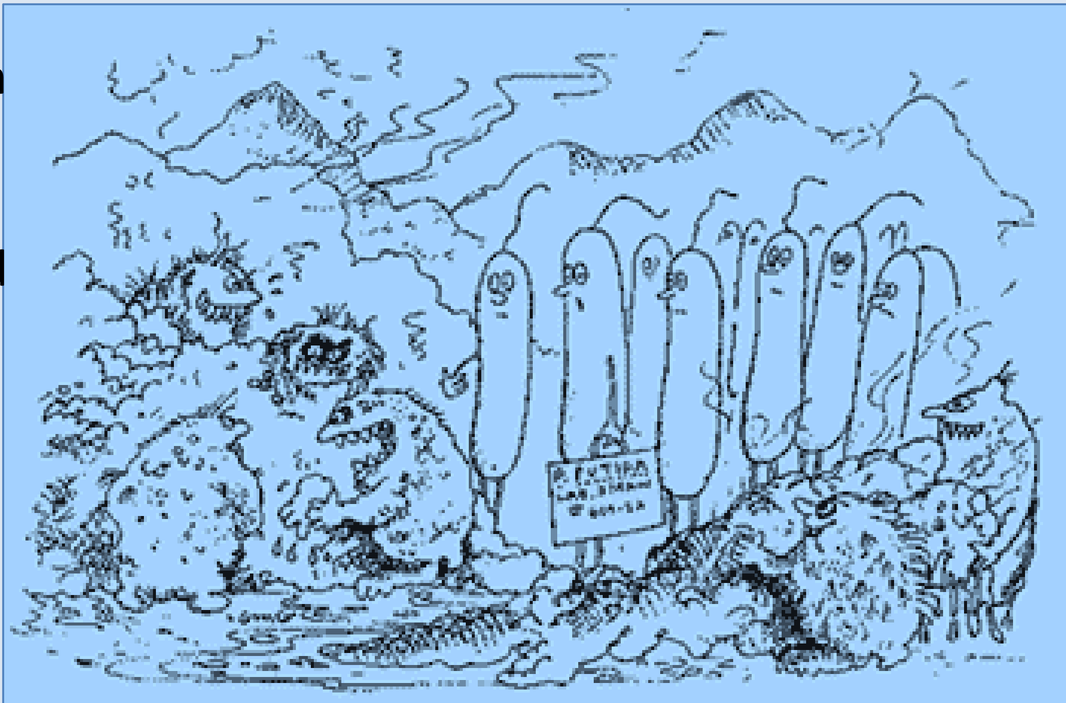


Bioremediation and the Role Of Nutrient Reduction

How does nutrient reduction help reduce algal blooms?

T**he growth of algae can be manipulated by nutrient dynamics**. This is can be achieved through **bioaugmentation in a process called biological nutrient removal (BNR).**

The bacteria used in bioaugmentation are selected specifically for their ability to degrade organic material and detritus, and nitrify ammonia and because of the high CFU counts (colony forming units) do so at an accelerate rate. **These bacteria consume the nutrients in the water. The microbes ingest carbon, nitrogen, phosphorous at a ratio of 100:10:4. In the presence of calcium carbonate and high pH, an insoluble phosphorous particulate is created by the death of the microbes.**



"Oh dear! I didn't realize 'in the field' would be like this! We should have stayed in the laboratory."

Pond or Lake Bioremediation

Products

Bioclean Pond Clarifier is a **consortium of beneficial microbes which are natural and safe.** They have the ability to degrade number of compounds. The biological system is designed in such a way that it can be used both in natural and manmade ponds/lakes.

It is an effective natural way to establish and maintain cleaner pond and lake water without chemicals

Benefits:

- **Decomposes organic sludge (lodo)**
- **Reduces ammonia levels, and hence controls algae growth.**
- **Stabilizes oxygen levels, so that the fish can breathe easier.**
- **Prevents over-blooming of algae.**
- **Prevents and treats floating clumps resulting from dead planktons.**
- **Reduces formation of Hydrogen Sulphide.**
- **Improves water clarity.**
- **Reduces BOD and COD levels.**
- **Reverts back the pond/lake to its natural eco system.**
- **Improves over all aquatic life inside the pond/lake.**

Package: Air tight package is done in order to keep it out of moisture.
Shelf life – 2 years from the date of packing
Dosage and Recommendation: Dosage is highly dependent on the pollution level and the waste volume. Initial dosage 2 to 4 kg per acre/foot of water , subsequently use 1 kg per acre/foot of water monthly.

BOD e COD

Biochemical oxygen demand (**BOD)** is the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period.

Chemical oxygen demand (COD) test is commonly used to indirectly measure the amount of organic compounds in water. Most applications of COD determine the amount of organic pollutants found in surface water (e.g. lakes and rivers) or wastewater, making COD a useful measure of water quality. It is expressed in milligrams per liter (mg/L) also referred to as ppm (parts per million), which indicates the mass of oxygen consumed per liter of solution.

Other biological methods

Phytoremediation

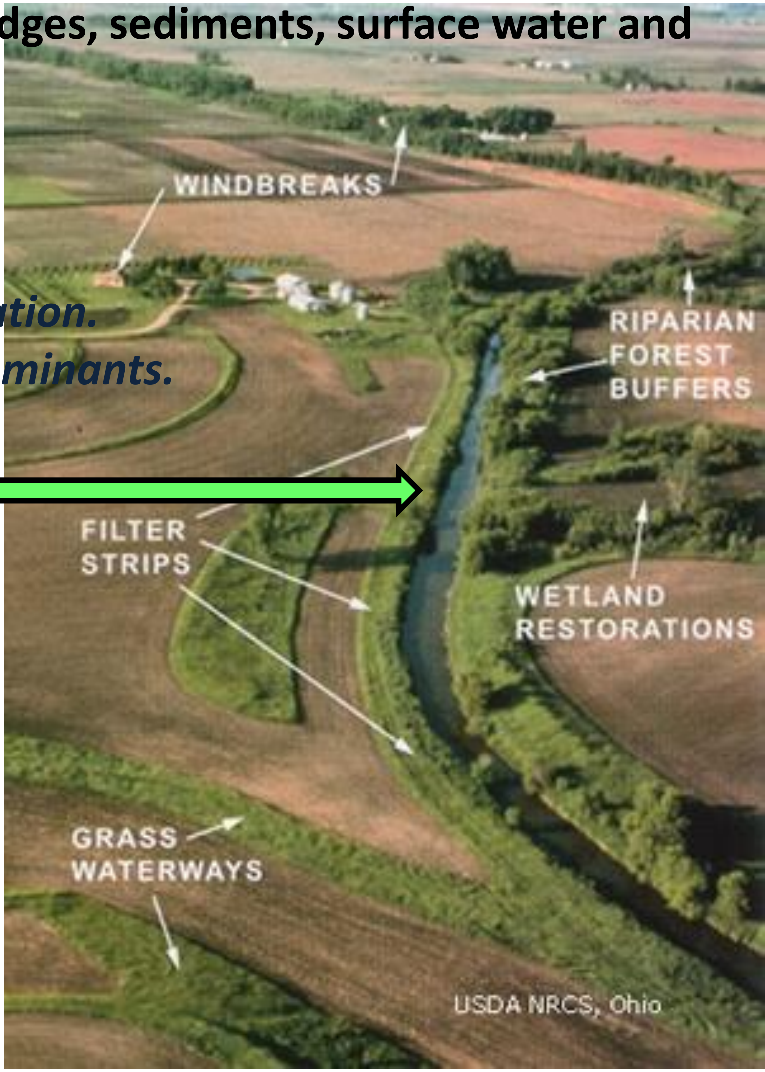
Phytoremediation is the direct use of living green plants for in situ, removal, degradation, or containment of contaminants in soils, sludges, sediments, surface water and groundwater.

Phytoremediation is:

A low cost, solar energy driven cleanup technique.
Most useful at sites with shallow, low levels of contamination.
Useful for treating a wide variety of environmental contaminants.
Effective in place of mechanical cleanup methods

Protection of Riparian Corridors

One of the promising aspects of phytotechnologies is the possibility of deriving additional benefit from the planted system during or after the prevention or clean-up of pollution. Trees planted as a riparian corridor that protect streams from agricultural pollution may be managed to provide **forest products like nuts, fruits, lumber or fibre.** Trees can be selected that do not move toxins from roots to above ground, thus allowing for a safe harvest while roots clean up groundwater.




China
Hydroponic treatment of piggery effluent
Vietnam
18 16:16
THE VETIVER NETWORK (INTERNATIONAL)

Superfloats wetlands can be utilised in a wide range of applications; specially to . improve the eco-systems of the waterways.

Phytoremediation using Azolla

DFWI | DARRIN FRESH WATER INSTITUTE

Margaret A. and David M. Darrin '40 Fresh Water Institute

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Background:

Azolla, an aquatic floating **fern**, is one of the many plant species with the ability to **hyperaccumulate contaminants** from its environment, making it an ideal candidate for phytoremediation systems (Sood et al. 2012).

Gaining a better understanding of what contaminants the ferns can remediate and how they are affected by certain contaminants will ultimately lead to these plants being used successfully in remediation sites.

Non Biological metods

Cooper Sulphate

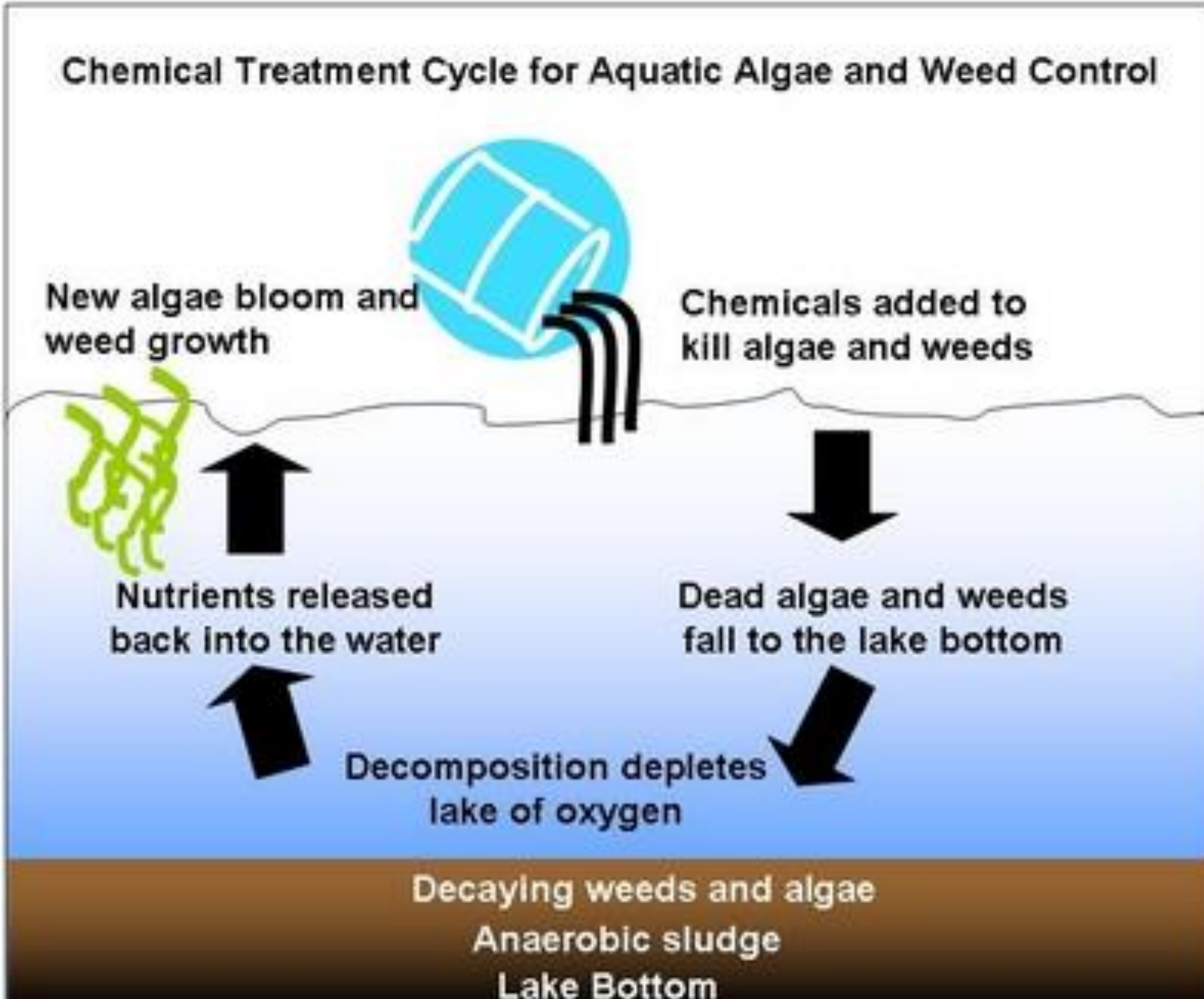
- In many cases, copper sulfate is used as a **quick remedy for unbalanced, out of control pond water conditions.** Copper sulfate does produce a fast result. But the results are temporary, as the copper sulfate does not address the initial problem of nutrient overload. The algae will bounce back in a few days.

- As an inorganic salt, is applied to relatively hard water it rapidly forms **precipitates of copper hydroxide or copper carbonate**. When this happens, the copper is no longer effective as an algaecide.

- Additionally, application of copper sulfate **adds heavy metals** into the environment. Copper sulfate and chelated copper compounds applied at the recommended rates **are lethal to fish eggs and some species of newly hatched fish.**

- **Kill the natural microbes** that normally and naturally inhabit a pond or lake, thu throwing the pond or lake further out of balance. Beneficial microbes, especially fragile ones like those belonging to the Nitrobacteraceae family and assist in the reduction of ammonia, are especially susceptible to copper treatments.

- <u>Copper-Resistant Algae</u> - some type of filamentous algae can be especially troublesome because they are resistant to normal applications of copper compounds. *Pithophora*, is one of them. Algal blooms should be controlled by decreasing nutrient concentrations in the water body.


Chemical Treatment Cycle for Aquatic Algae and Weed Control
New algae bloom and weed growth
Chemicals added to kill algae and weeds
Nutrients released back into the water
Dead algae and weeds fall to the lake bottom
Decomposition depletes lake of oxygen
Decaying weeds and algae
Anaerobic sludge
Lake Bottom

Advantages of Bioremediation

Bioremediation with natural bacteria have several advantages:

- Completely non-toxic to plants, animals, aquatic life and people.
- Through biological nutrient removal(BNR), eliminates the cause of algal blooms
- No harmful residual effects.
- Completely and naturally biodegradable.
- Long-term effect.
- No applicator license required

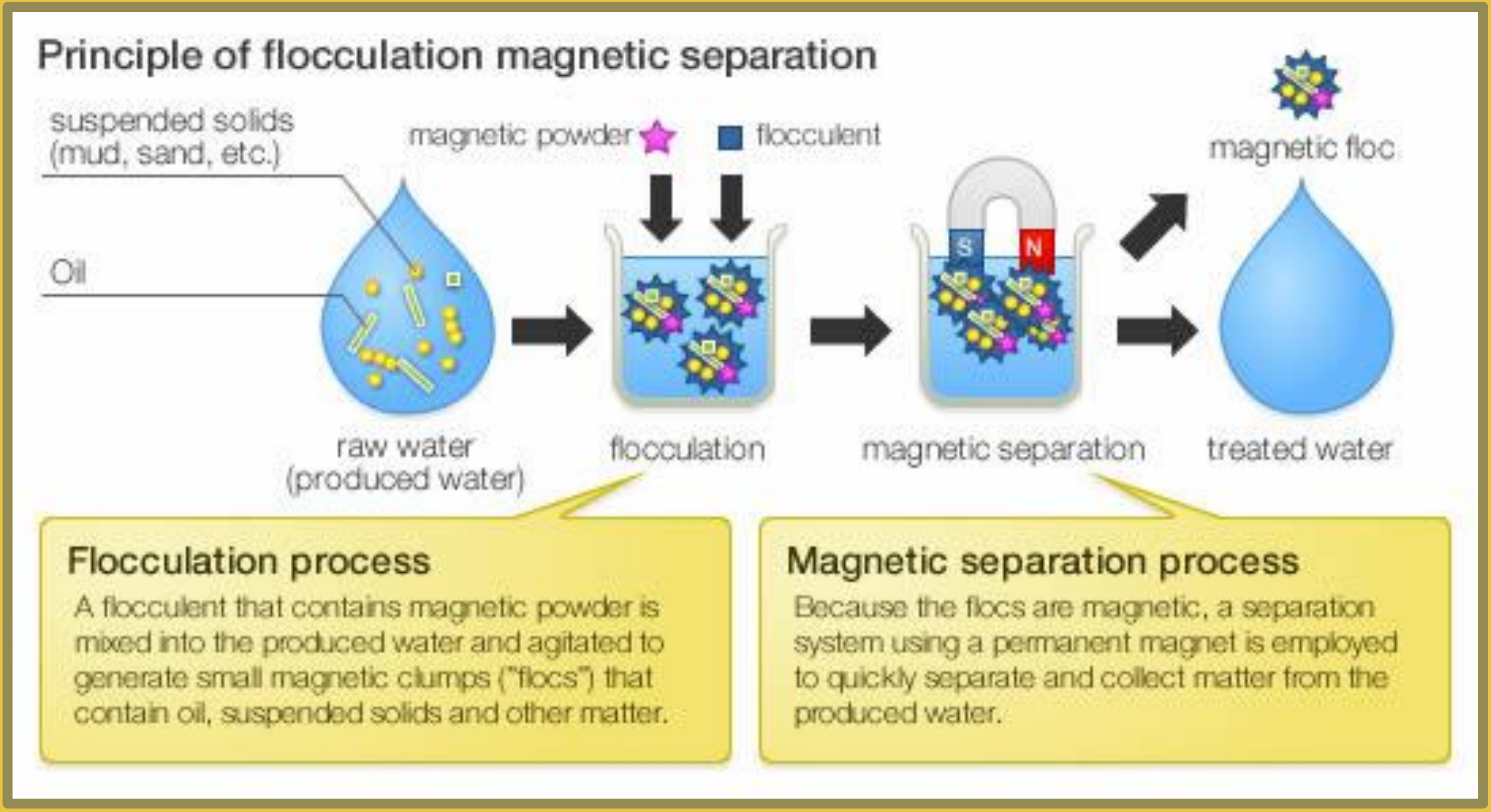
Disadvantages of Bioremediation

- -It is limited to biodegradable compounds
- -Bioremediation technologies should be developed to have suitable technologies for sites that have a scattered combination of contaminants, such as solids, liquids, and gases
- -After the process, the biodegradation products can result to be more toxic comparatively with parent compound
- -the process is often highly specific

Coagulation-magnetic separation method

Removal of algal blooms from freshwater by the coagulation-magnetic separation method.

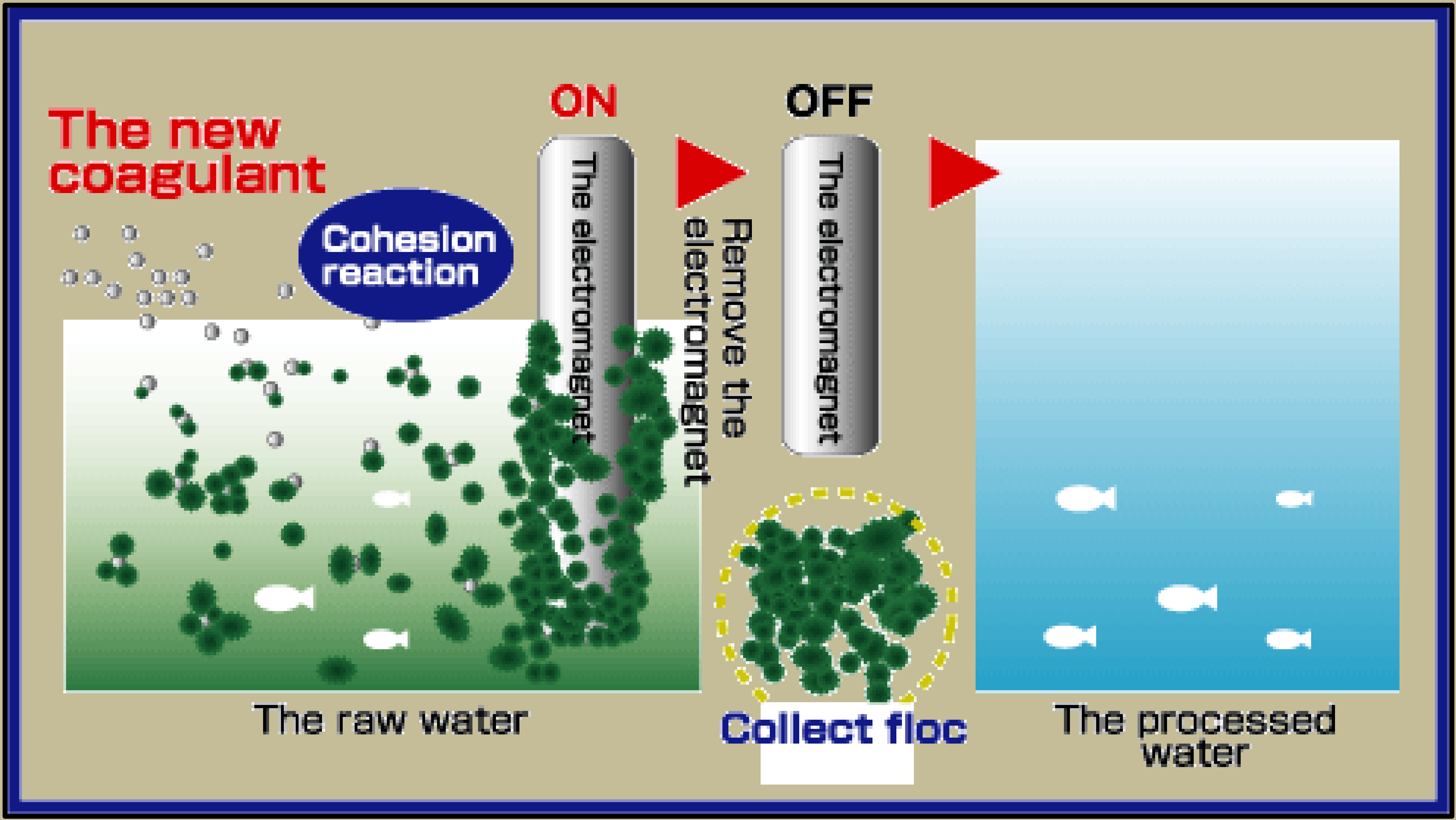
Liu D[1], Wang P, Wei G, Dong W, Hui F.
Author information
[1]Department of Environmental Science and Engineering, Fudan University, Shanghai 200433, China. dliu1982@hotmail.com



Magnetic Polymer

Removal of algal blooms in freshwater using magnetic polymer.

Liu D[1], Li F, Zhang B.



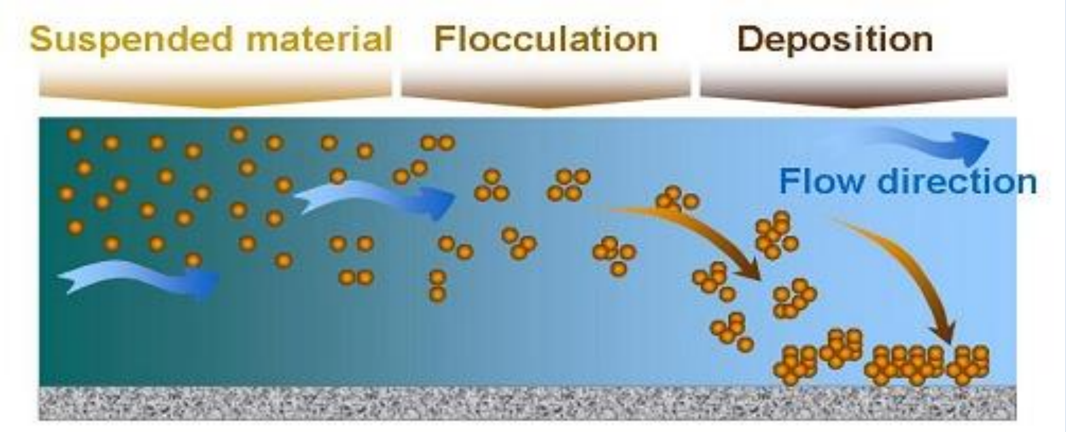
Clay Flocculation (argila)

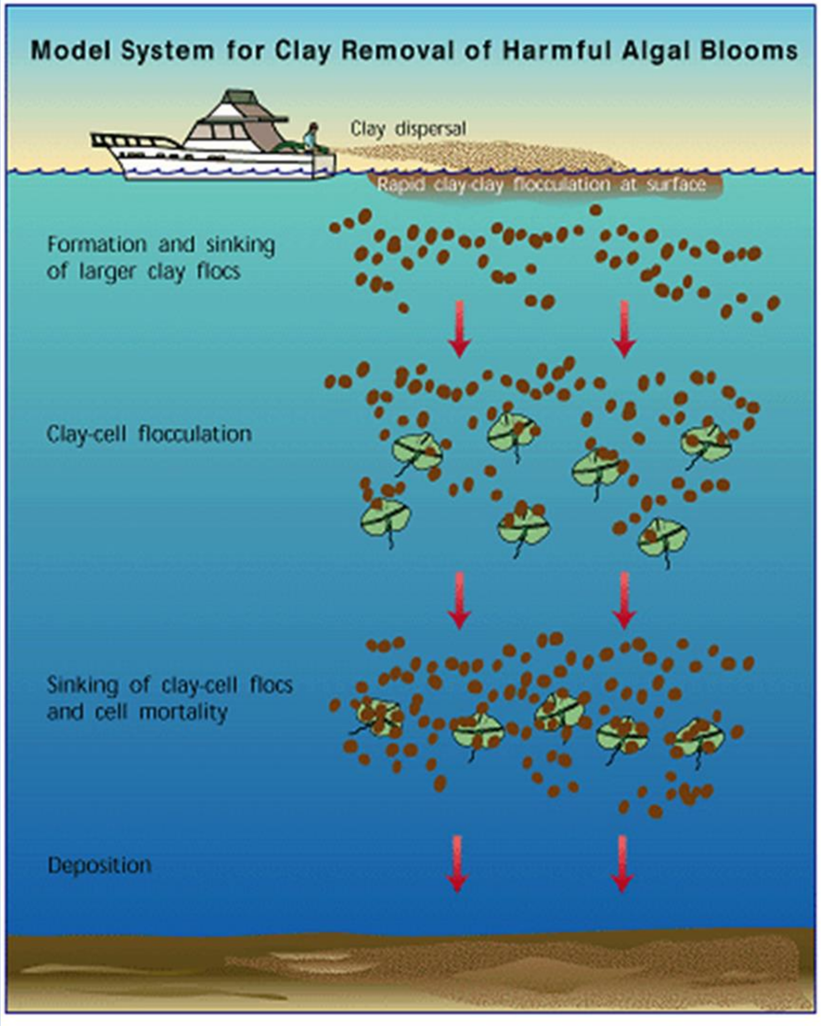
Controlling harmful algal blooms through clay flocculation.

Sengco MR[1], Anderson DM.
[1]Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA 02543 USA. msengco@whoi.edu

The potential use of clays to control harmful algal blooms (HABs) has been explored in East Asia, Australia, the United States, and Sweden. In Japan and South Korea, minerals such as montmorillonite, kaolinite, and yellow loess,

Cell removal occurs through the flocculation of algal and mineral particles, leading to the formation of larger aggregates (i.e. marine snow), which rapidly settle and further entrain cells during their descent

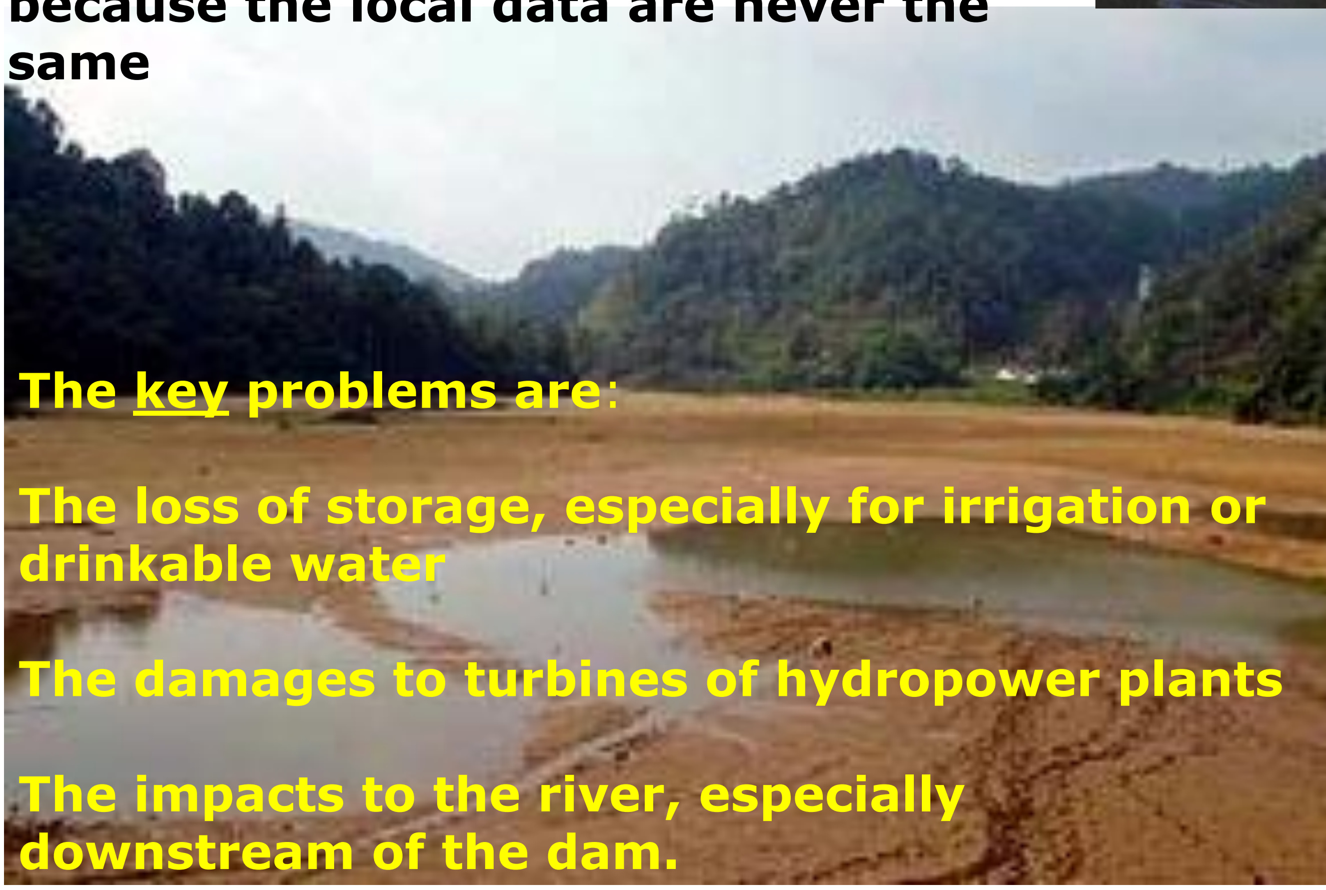




Siltation

The siltation may reduce by decades the possible long life of 50 % of dams and lakes and may be a key problem within few decades for over 10% of large or small dams.

Cost efficiency of various solutions for siltation mitigation has varied greatly Is not easy to optimize their choice because the local data are never the same



The key problems are:

The loss of storage, especially for irrigation or drinkable water

The damages to turbines of hydropower plants

The impacts to the river, especially downstream of the dam.

Dredging Highlight - Mission Lake

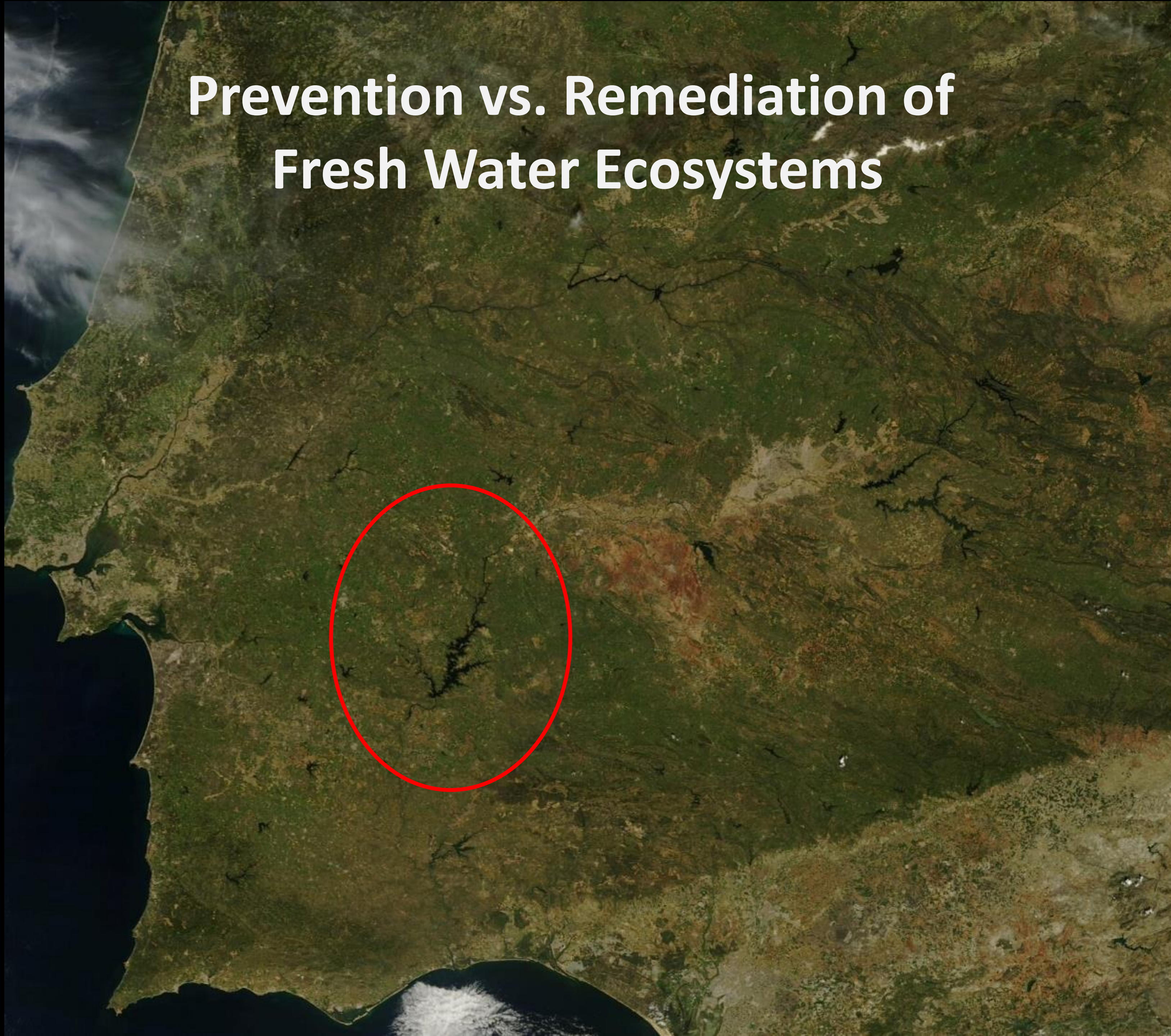
The Mission Lake project is a joint venture between the state of Kansas, and the City of Horton to restore the la water storage capacity, by dredging 1 million yards of sediment.

Geo-Textile Tubes (Geotubes)

Geotubes are **filled with slurry** and used to build structures such as breakwaters, shoreline protection or island creation.

Dredged material is pumped directly into the tubes, where the material is dewatered and hauled away or used for fill or topsoil. This solution is an excellent option for projects with limited settling areas

Prevention vs. Remediation of Fresh Water Ecosystems



Remediation strategies in South Portugal reservoirs

Management of all water resources in the European Union is regulated by the Water Framework Directive (WFD; EC, 2000).

The purpose of the WFD is to establish a framework for the protection of surface waters (including rivers, lakes, transitional and coastal waters) and ground waters throughout the EU territory.

The main environmental objectives are:
to achieve and maintain good status for all surface waters and ground waters by the target date of 2015;
to prevent deterioration;
to ensure the conservation of high water quality where it still exists.

This is to be accomplished by implementing the measures necessary to:

- prevent deterioration of the status of waters;
- protect, enhance and restore all bodies of surface waters and ground waters.
- promote sustainable water use (through effective pricing of water services),
- progressively reduce discharges of priority substances and cease or phase discharges of priority hazardous substances for surface waters,
- ensure progressive reduction of pollution of groundwater,
- mitigate the effects of floods and droughts,
- ensure sufficient supply of water,
- protect the marine environment.

For surface waters the overall aim of the Water Framework Directive (WFD) is for Member States to achieve “good ecological status” and “good surface water chemical status” in all bodies of surface water by 2015.
Some water bodies may not achieve this objective for different reasons. For example, under certain conditions the WFD permits Member States to identify and designate artificial water bodies (AWB) and heavily modified water bodies (HMWB) in accordance with Article 4(3).
Instead of "good ecological status", the principal environmental objective for HMWBs and for AWBs is “good ecological potential” (GEP) and “good surface water chemical status”, which has to be achieved by 2015.

The Directive requires surface water classification through the assessment of ecological status or ecological potential, and surface water chemical status

Abiotic typology

To achieve good status is necessary to classify, being essential to define the Reference conditions for measuring deviations

↓

NECESSARY TO DEFINE REGIONS WITH SIMILAR CHARACTERISTICS

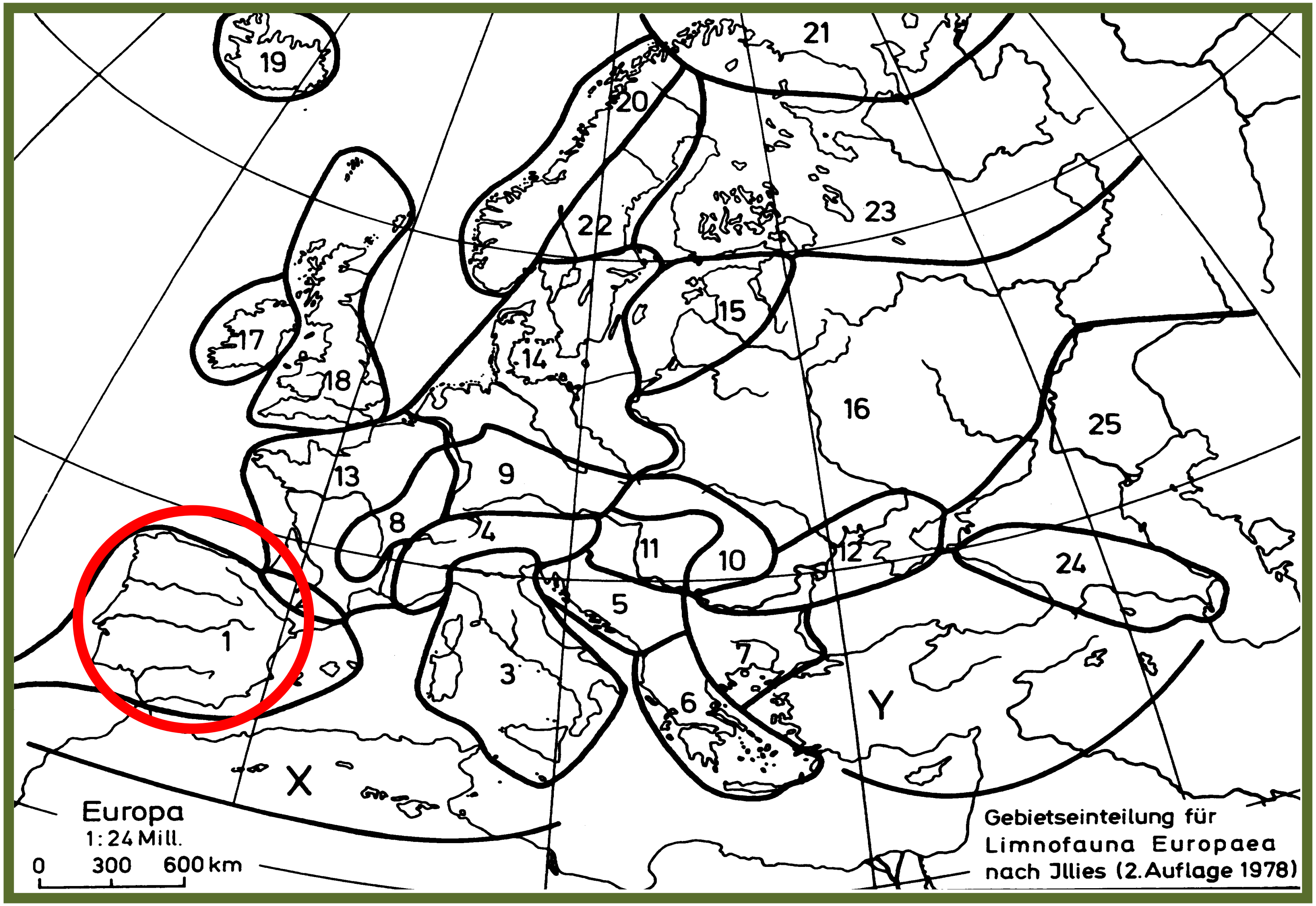
↓

Definition of na abiotic typology

For heavily modified and artificial water bodies (HMWB&AWB), reference conditions are defined as Maximum ecological potential (MEP).

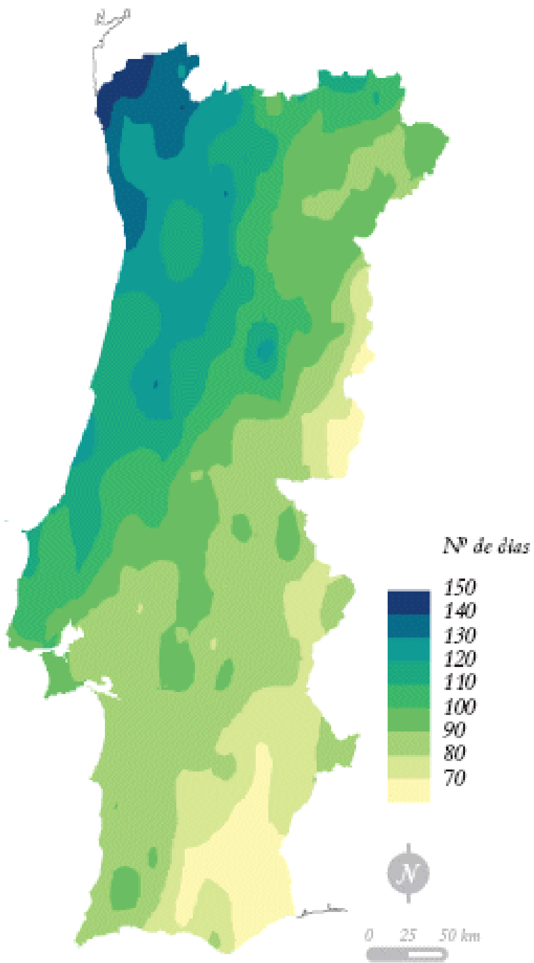
Intended to describe the best approximation to a natural aquatic ecosystem that could be achieved given the hydromorphological characteristics that cannot be changed without significant adverse effects on the specified use or the wider environment. Accordingly, the MEP biological conditions should reflect, as far as possible, the biological conditions associated with the closest comparable natural water body type at reference conditions, given the MEP hydromorphological and associated physico-chemical conditions

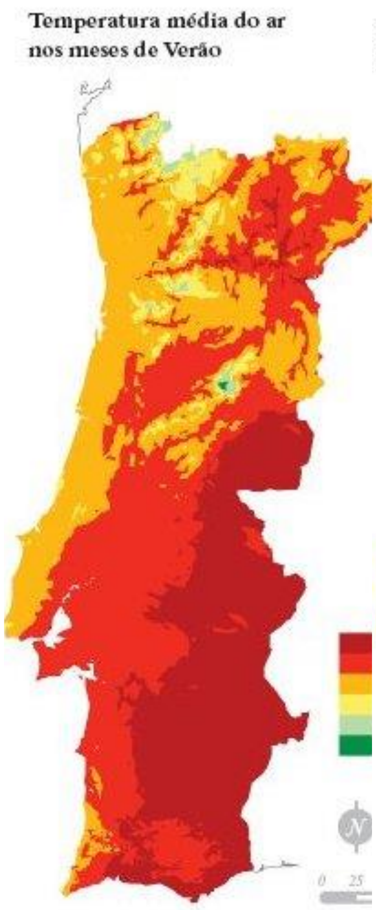
Bio-geographic regions of Europe (Illies, 1978)

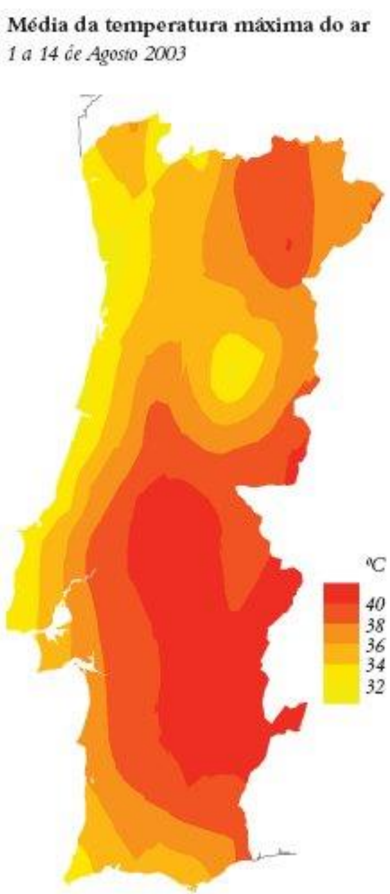


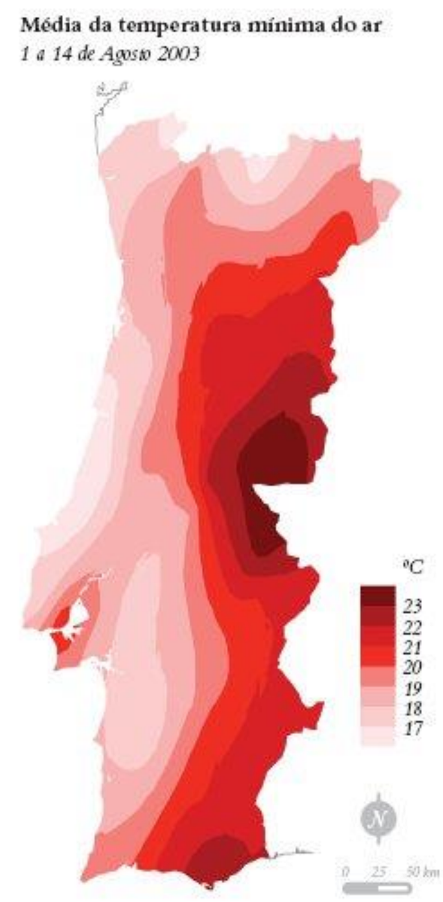
«Portugal is mediterranean by conditions, atlantic by position»
(Pequito Rebelo em "A Terra Portuguesa" – 1929)

Influence of latitude, altitude and disntance from the sea.



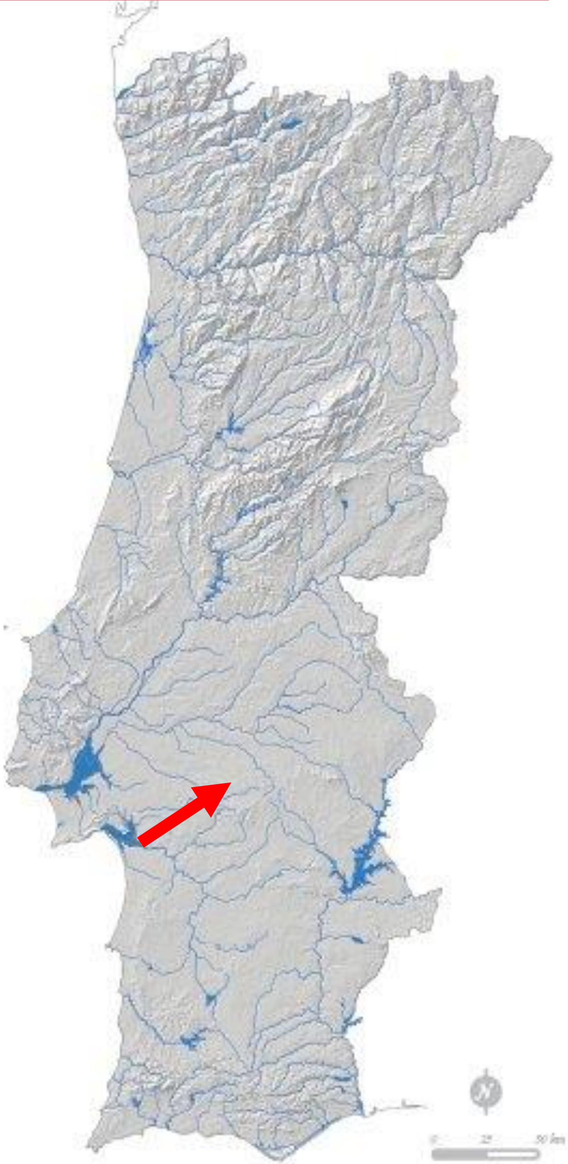


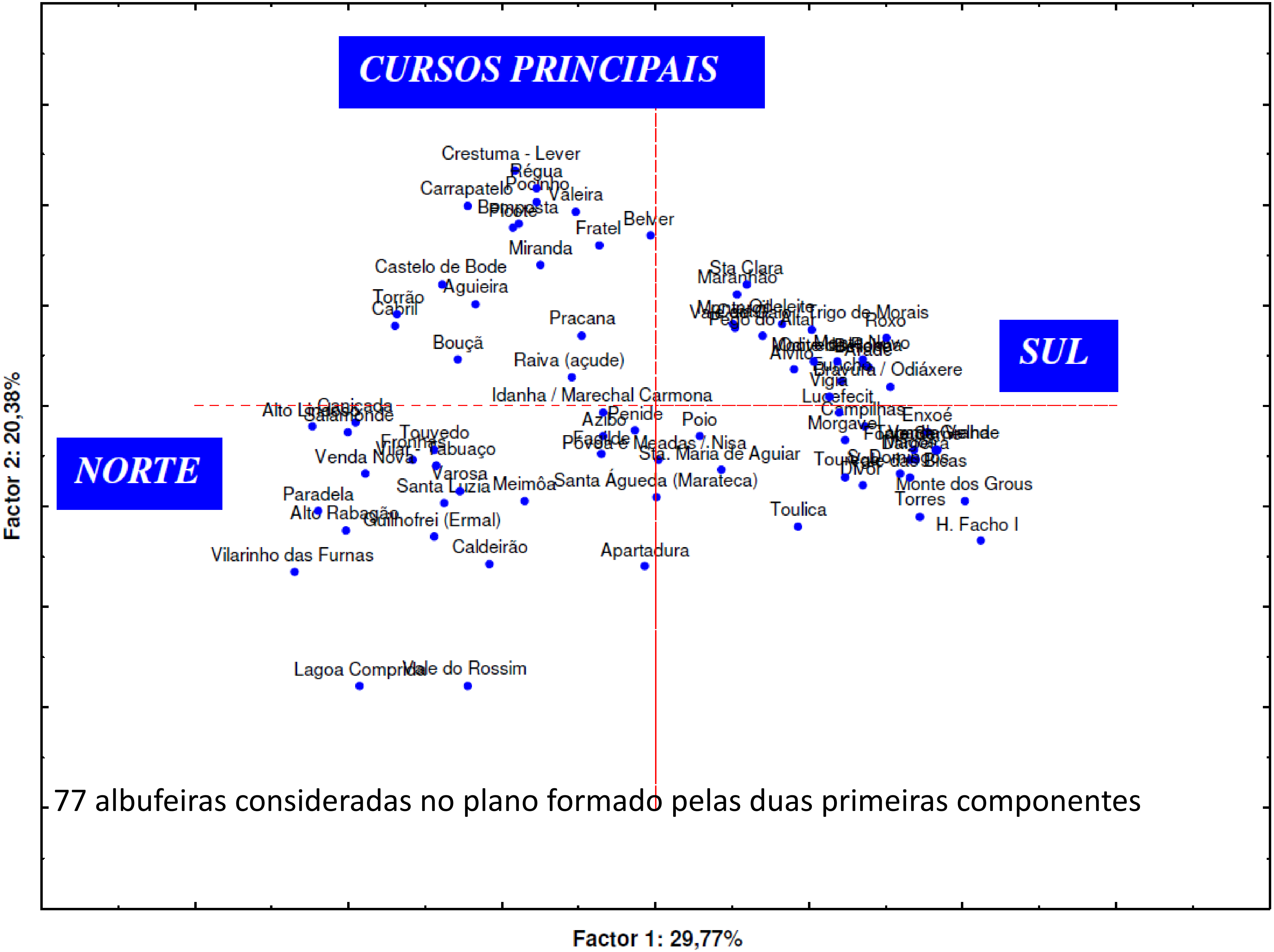




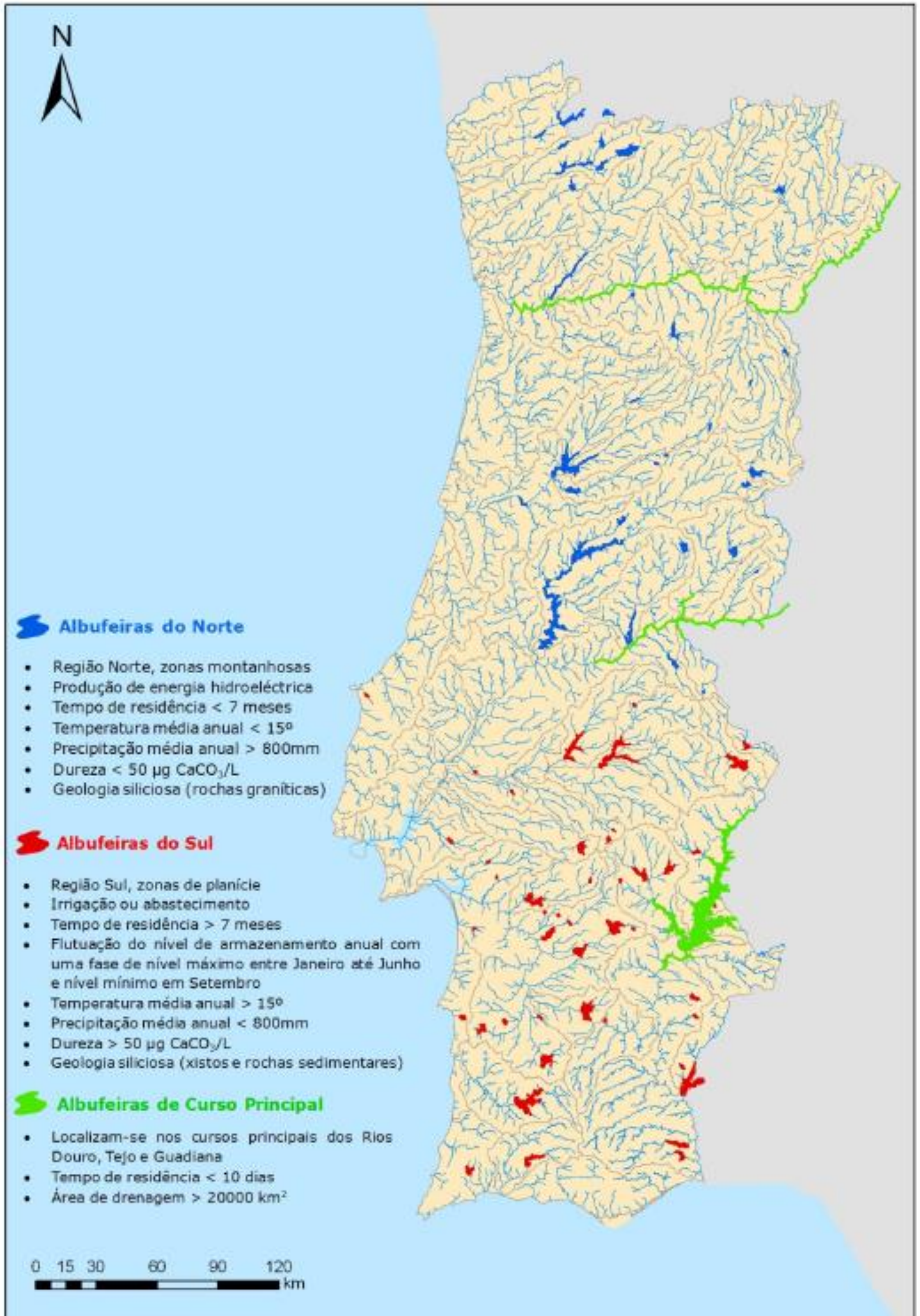
«Portugal is mediterranean by conditions, atlantic by position»
(Pequito Rebelo em "A Terra Portuguesa" – 1929)

In terms of hydrology the North is much more important than the South, where all streams are temporaries





77 albufeiras consideradas no plano formado pelas duas primeiras componentes


N
Albufeiras do Norte
Região Norte, zonas montanhosas
Produção de energia hidroeléctrica
Tempo de residência < 7 meses
Temperatura média anual < 15º
Precipitação média anual > 800mm
Dureza < 50 µg $CaCO_3$/L
Geologia siliciosa (rochas graníticas)
Albufeiras do Sul
Região Sul, zonas de planície
Irrigação ou abastecimento
Tempo de residência > 7 meses
Flutuação do nível de armazenamento anual com uma fase de nível máximo entre Janeiro até Junho e nível mínimo em Setembro
Temperatura média anual > 15º
Precipitação média anual < 800mm
Dureza > 50 µg $CaCO_3$/L
Geologia siliciosa (xistos e rochas sedimentares)
Albufeiras de Curso Principal
Localizam-se nos cursos principais dos Rios Douro, Tejo e Guadiana
Tempo de residência < 10 dias
Área de drenagem > 20000 km²
0 15 30 60 90 120
km

For the hydrographic regions 6 e 7 the INAG defined 36 Heavy Modified Water Bodies – Reservoirs, which include nine for human supply

Monitorizações efectuadas pela ARH Alentejo

With a variable periodicity (physic-chemical monthly and seasonal phytoplankton physicochemical monthly and seasonal phytoplankton) the ARH monitorized 16 reservoirs.

Bacia	Local	rede	Ano
SADO	Albufeira Alvito	RH6	2009
	Albufeira Campilhas	RH6	2009
	Albufeira Fonte Serne	RH6	2009
	Albufeira Monte da Rocha	RH6	2009
	Albufeira Odivelas	RH6	2009
	Albufeira Pego do Altar	RH6	2009
	Albufeira Roxo	RH6	2009
MIRA	Albufeira Santa Clara	RH6	2009
	Albufeira Trigo de Morais - Vale do Gaio	RH7	2009
	Albufeira Abrilongo	RH7	2009
	Albufeira Caia	RH7	2009
GUADIANA	Albufeira Enxoe	RH7	2009
	Albufeira Lucefecit	RH7	2009
	Albufeira Monte Novo	RH7	2009
	Albufeira Tapada Grande	RH7	2009
	Albufeira Vigia	RH7	2009

- Evaluation of chemical status;
- Evaluation of biological status – phytoplankton community

Monitorizações efectuadas pela ARH Alentejo

9 das quais são de abastecimento Público + Açude do Bufo

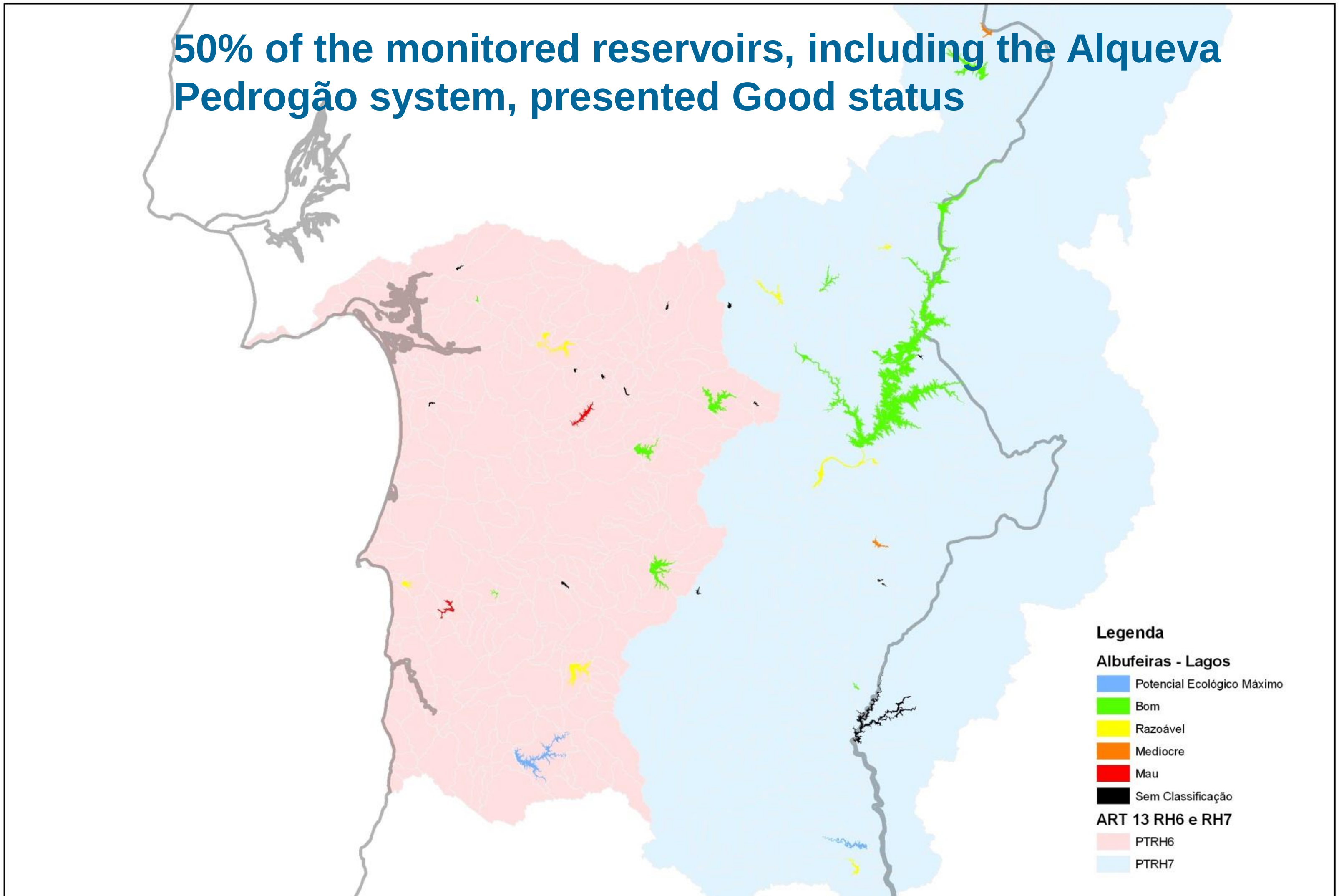
Valores médios 2009

Local	rede	pH	OD (%)	OD (mg/L)	Nitratos (mg/L NO3-)	Cl a (mg/m3)	Fosforo T. (mg/l P)
Alb. Alvito	RH6	8,40	96,00	8,70	2,10	5,40	0,04
Alb. Roxo	RH6	8,29	99,40	9,00	2,01	5,30	0,06
Alb.Monte da Rocha	RH6	8,13	71,03	6,37	2,45	6,50	0,05
Alb. Santa Clara	RH6	7,96	82,41	7,25	2,00	1,22	0,05
Alb. Caia	RH7	8,36	96,85	8,52	2,25	3,99	0,07
Alb. Vigia	RH7	8,11	99,19	9,70	2,06	5,33	0,05
Alb.Monte Novo	RH7	8,51	95,40	8,47	2,00	21,00	0,07
Alb. Enxoé	RH7	8,63	89,20	8,15	2,04	27,26	0,12
Alb. Tapada Grande	RH7	7,96	89,60	7,93	2,00	1,99	0,04
Açude do Bufo	RH7	8,70	84,00	7,10	-	72,00	-

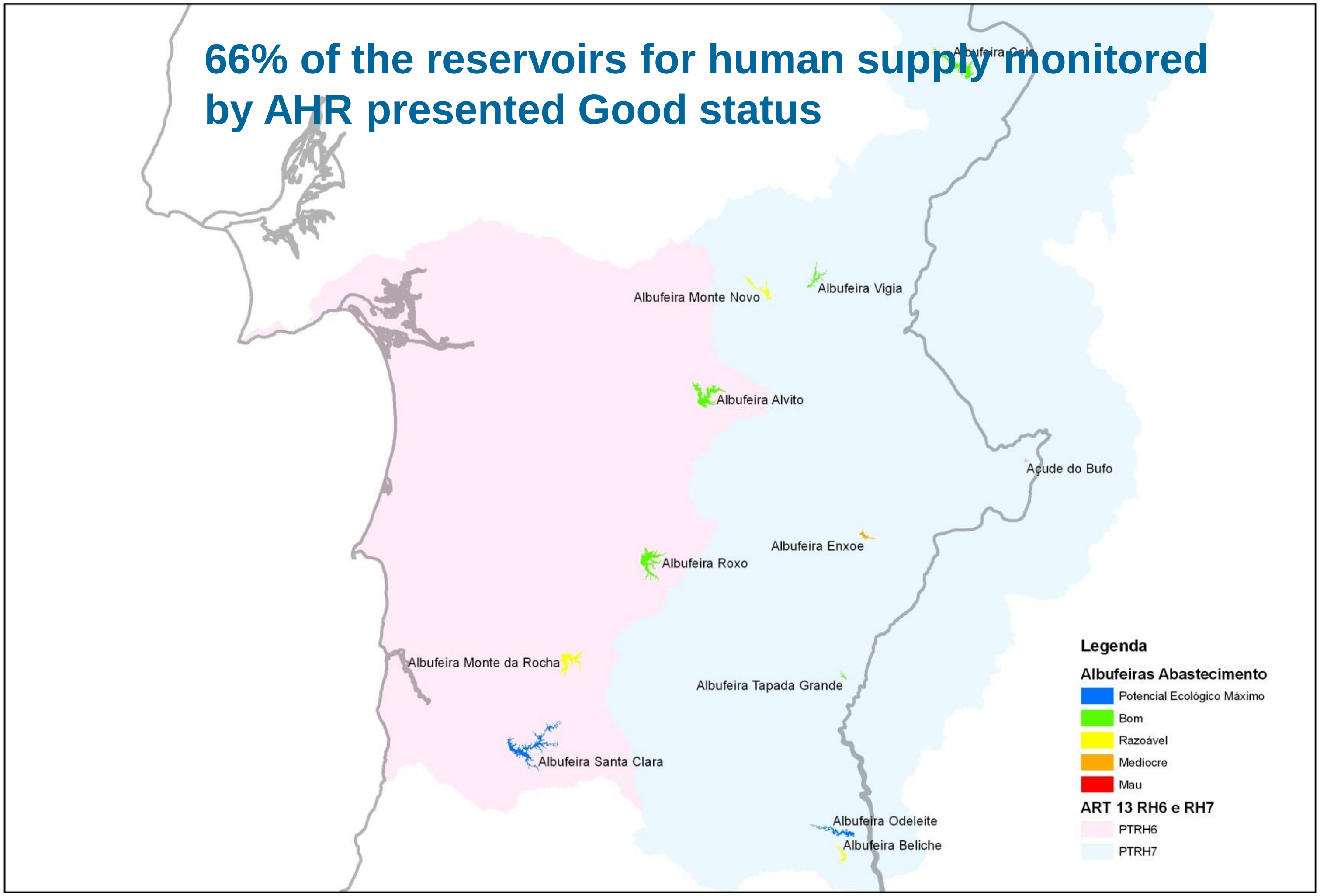
Variáveis respónsáveis pela classificação a baixo de BOM

Monitoring carried out by the ARH Alentejo

50% of the monitored reservoirs, including the Alqueva Pedrogão system, presented Good status



Monitorizações efectuadas pela ARH Alentejo



Major Problems in water for public supply

Total Phosphorus values exceed the set limit (0.07 mg P / L);
Concentration of chlorophyll a on Spring / Summer period (> 9.5 mg / L);
Presence of Blooms of Cyanobacteria blooms (densities exceeding 2,000 cells / mL)