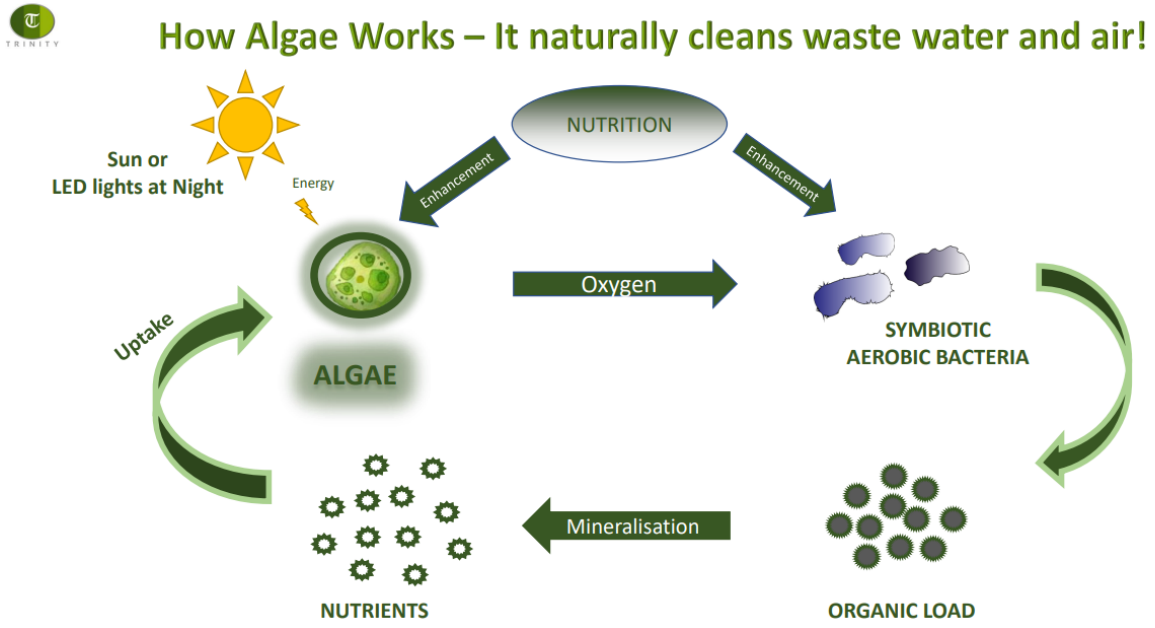
PHYCOREMEDIATION TECHNOLOGY



Phycoremediation Technology

Phycoremediation is a highly advanced technology that involves the remediation of contaminantsin a water body using algae (micro and macro). Algae fix carbon dioxide by photosynthesis and remove excess nutrients effectively. It removes pathogens and toxic materials from wastewater. Xenobiotics, chemicals and heavy metals are known to be detoxified, transformed, accumulated or volatilized by algal metabolism. It offers multiple advantages over conventional methods of remediation because of its effectiveness, efficiency and eco-friendly nature.

Basics

What is Phycoremediation?

Phycoremediation is the use of macro-algae or micro-algae for the removal or biotransformation ofpollutants, including nutrients and xenobiotics from wastewater and CO_2 from waste air.

What are algae?

A group of aquatics, most primitive photosynthetic organisms ranging from unicellular to multicellular forms and generally possess chlorophyll but lack true roots, stems and leaves characteristic of terrestrial plants.

What is special about microalgae?

The green-cell factories of microalgae tackle simultaneously more than one problem, a solution notcapable by conventional chemical processes. That is, for example, problems such as pH correction, sludge removal, TDS reduction, BOD and COD removal, etc. can be handled simultaneously by micro-algal treatment (Phycoremediation), whereas in conventional methods, separate methods orstages of treatments are used.

Is Phycoremediation environmentally safe? How so?

Microalgae are naturally occurring living organisms and therefore Phycoremediation is a naturally occurring phenomenon. The micro-algae used in Phycoremediation are already present in nature and are at work consuming unwanted materials. After Phycoremediation is completed, the environment is virtually restored to its pristine condition.

Can Phycoremediation help in selective treatments?

The unique feature of Phycoremediation is that while it can be used in the treatment of a widevariety of effluents, it can also be highly specific, for example, in the treatment of heavy metal-bearing effluents or dyeing effluents or treatment of R/O rejects.

Is there any specific method for running the Phycoremediation ETP?

Phycoremediation is case-specific as the process can be operated batch-wise, semi-continuous or in a continuous mode.

Are there any constraints in using Phycoremediation concerning the characteristic of the effluent?

This technology is flexible enough to handle bulk fluctuations in the quality and quantity of effluent feed. Moreover, it has been proved by us to be effective in treating an array of effluents such as those of dye, food, chemical, pharmaceutical, dairy, oil drilling and pigment industries.

Is it easy to separate algae from the effluent after treatment?

There is no need to separate algae from the treated effluent as the process is ecologically safe and natural. Since microalgae are heavier than other microbes' algal cells can be easily sedimented and harvested. In addition, micro-algae such as filamentous algae are available with high auto-flocculation capacity.

How about using this technology along with other ETP methods?

It is highly compatible with existing operations such as physical, chemical, and other biologicalmethods.

Is there a need to employ specialists to operate the Phycoremediation plant?

Phycoremediation technology is robust as it minimizes automation, maintenance, and the need forskilled operators.

Will there be any sludge generation in the process?

Phycoremediation assures nil sludge generation and as a result, there is no disruption of surrounding non-contaminated areas.

Is there any need for additional nutrient addition?

Nutrient addition for the growth enhancement of algae is required only to initiate the process. These chemicals are of negligible cost. Once the culture is established there is no need to add any further nutrition as there is plenty of nutrition available for Phycoremediation in all water bodies.

Do we need to seed the Phycoremediation plant with algal cultures at regular intervals?

As micro-algae multiply fast, the cultures replenish themselves with fresh feed of effluents andhence there is only a one-time addition.

Will there be any foul smell generated from the Phycoremediation plant?

Micro-algae are adept in removing the obnoxious odours present in the effluent and converting them to rich algal smell. In addition, they make the coloured effluent into colourless.

Why micro-algae? Why not other alternatives such as using bacteria and fungi?

1) Oxygenation of environment.
2) CO_2 sequestration – mitigate CO_2 emissions, sequester carbon, and generate valuable bioproducts.
3) Sustainable and eco-friendly from an ecological perspective
4) Commercial benefits derived from biomass and other extracted biochemicals It has the potential to treat highly polluted water.

Is this technology cost-effective?

Yes, it is because it saves power and a lot of chemicals. The process generally is much economic than other technologies as there is virtually little investment in “capital equipment”. Furthermore, the only energy requirement for the process is solar energy, which is abundantly available in our country.

What is the social acceptability level of Phycoremediation?

The crucial factor for social acceptance, particularly by environmentalists, is the conclusive impact of microalgae on biodiversity and this factor is best accepted in Phycoremediation when compared with other methods.

Facts

1) Nature has been using Algae for cleaning water and sustaining bio-life for millions of years by creating a natural food chain. Almost the entire oxygen in water be it in sea, oceans or rivers is only because of Algae.
2) Photosynthesis (Chlorophyll in Algae using Sunlight and Carbon Dioxide) is the main action (Bio-Oxygenation) performed by Algae in water to increase DO levels which takes care of BOD and COD demands up to 99 % and also reduces EC, TC and TSS up to CPCB standards without addition of any chemicals and electricity
3) Apart from Bio Oxygenation, pollutants Like Nitrates, Phosphates, Sulphates, Carbonates etc. including heavy metals like Cr, Arsenic, Mercury, Fluoride etc. are absorbed by Algae. These pollutants are necessary for contributing to the growth of customized Algae (for cell formation and energy required by the algal cell) Absorption of pollutants by Algae leads to the cleaning of Effluents. It may be mentioned here that where TDS is high, the reduction does not take place beyond 30-40 % but all remaining TDS is bio-transformed to Bio Fertilizers, a source of revenue
4) Since carbon dioxide is used during the process of photosynthesis, this is a highly carbon-negative technology. Approx. 70 % of oxygen in this world is produced by Algae and the rest by trees.
5) But without Algae the entire bio life in natural water bodies will cease to exist. An aerobic bacterium that helps clean water has a symbiotic relationship with Algae.

Known pollutants that can be removed

1) pH correction Acidic to Normal (from 1.5 to 6.5-8.5)
2) Bio-oxygenation by Algae meets BOD and COD as per CPCB requirements
3) Reduces, EC, FC and TC effectively by more than 99%
4) Improves TSS and TDS as per agreed norms
5) Reduces Nitrates, Sulphates, Carbonates etc.
6) Reduces heavy metals like Chromium, Mercury, Lead, Ni, Al etc
7) Reduces hardness up to 70 %
8) Reduces TDS to biofertilizers
9) Increases Fish Production without the need for changing water
10) Able to achieve ZLD (zero Liquid discharge)

Phycoremediation is the most suitable **Nature-based, carbon-negative, and minimal chemical usage treatment method for the restoration and rejuvenation of waterbodies polluted by domestic, agricultural, and even industrial discharges within the drains and waterbody.**

It Promotes:

1. Complete restoration of the Ecosystem around the drains flowing into ponds, rivers, and surrounding areas.

2. Removal of harmful aquatic weeds as well as other toxic species from the subsequent water system;

3. Increasing Dissolved Oxygen to more than the stipulated 6mg/L, and bringing the BOD, COD, TC, FC and pH Levels within the CPCB requirements;

4. Consumption of excess nutrient elements like Nitrogen, Phosphorus, Sulphates etc., along with heavy metals and metals to balance the ecology;

5. Comprehensive remedial solution for both treatment methods for polluted water, as well as preventive measures for ecological restoration**.**

6. The algal treatment is a highly **carbon-negative technology and will also lead to natural air purification, resulting in an Oxygen-rich environment.**

7. It created multiple new revenue generation avenues like fish farming, algal farming, bio-fertilizers, organic animal feed, bio-food, bio-fuel etc., which can lead to exponential holistic economic development of the local communities as well as the state.

The entire process is implemented without chemical usage or hampering the current flow or topography of the rivers. The technology will ensure sustainable water quality improvement along with improvements in ecology and natural restoration**.**

PHYCOREMEDIATION CAN PROMOTE / LEAD TO:

1. Positive impact on the ecology and overall improvement of the environment as well as drain water creating bio-drains that can be eventually used for irrigation/construction or even industrial purposes.

2. Natural Restoration within and around the city waterworks.

3. Natural measures to prevent groundwater contamination as well as waterbed erosion by enrichment of water beds with organic, highly nutritious, and pro-life organic biomass.

4. The above in turn promotes groundwater recharge.

5. Ecological restoration by supporting self-preservation of the waterbodies; and lastly.

6. Livelihood Enhancement.

To conclude, the vision of cleaner waterbodies can be achieved using microalgal and native microbial strains. This scientifically designed nature-based treatment will help to achieve all the goals in the most economical, holistic, natural, safe, and effective way by creating self-sustainable water bodies. Additionally, this will also promote water reuse/recyclability and ecosystem enrichment. In a limited time, this scientifically layered approach can turn around the prolonged harmful impacts of detrimental practices polluting the waterbodies and banks of the rivers, in the most natural way.

TRINITY

TECHNO-COMMERCIAL COMPARISON OF DIFFERENT TECHNOLOGIES

PARAMETERS	CONSTRUCTED WETLAND	PHYCOREMEDIATION	ETP / STP / SBR	BACTERIAL BIOREMEDIATION
Capital Expenditure	Costly because it requires a large land area & and extensive segmentation along with continuous aeration	Less Costly due to eco-friendly setups as well as natural aeration by algal consortia.	Costly due to intensive civil structure requirement, land requirement and heavy aeration requirement.	Less Costly
Operation cost	Moderate because of periodic pruning and removal of plant debris	Low	High	Low
Power Consumption	Low	Low	High	Very Low
Source of Energy	Sunlight	Sunlight	Electricity	Electricity
External Aeration	Yes	NIL	Yes	Yes, to retain homogenous conditions
Usage of Toxic Chemicals	Yes, but less toxic (Chlorination)	NIL	More (Chlorination & Poly-electrolytes)	NIL
Carbon Footprint	High (Methane due to marshy conditions)	NIL, CARBON NEGATIVE technology	Extremely high	Extremely high because it releases CO_2
Space requirement for Treatment	Very Large	Comparatively Far Less	Large	Low
Time Required for Set-up	5 to 6 months	1 to 3 months	20 to 24 months	1 to 3 months
Sludge generation	High	Almost NIL Sludge as reusable/remunerative algal biomass	Extremely High	Extremely High

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PARAMETERS	CONSTRUCTED WETLAND	PHYCOREMEDIATION	ETP / STP / SBR	BACTERIAL BIOREMEDIATION
Water Conservation	Extremely Low due to heavy surface area evaporation	90-95 % Conservation	Moderate	90-95% but still polluted with microbial growths
Nutrition in Treated Water	Extremely Low	Optimum for plant growth and other uses	Low	Moderate however unusable if CODs are high
Scaling up	Easy	Very Easy and Quick	Extremely Expensive and time-consuming	Very Easy and Quick
Manpower	Less	Less and unskilled manpower (easy knowledge transfer)	Skilled and expensive manpower required	Less
Disease	Promotes mosquito Breeding and contamination of earth/aquifers	Extremely good for the environment and positive ecology; eradicates/reduces microbial as well as chemical contaminants	Chlorination may be carcinogenic	Heavy chances of mutation promoting pathogenicity, and this technology also promotes mosquito breeding
Improvement in DO Parameter	Low	Very High	Low	Low
Reduction of BOD & COD percentages	BOD: 40-50% COD: 20-30%	High BOD and COD Reductions: 90-99% with minimal power units and no chemical use	Up to 90% BOD & COD reduction; but only after chlorination and heavy power consumption	Up to 50-70% BOD & COD reduction but with the use of many strains collectively that might be prone to mutation

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PARAMETERS	CONSTRUCTED WETLAND	PHYCOREMEDIATION	ETP / STP / SBR	BACTERIAL
Reduction of Heavy Metals	Up to 70%	Up to 95%	Up to 90%	Up to 90% however, the chances of mutation is high
Removal of Nitrates	Moderate (Up to 60%)	High (90-95%)	No Denitrification process	Depends on the bacterial strain (70-90%)
Ease of operation	Effluents have multiple types of contaminants, a single plant species cannot remove all the contaminants, so more space and multiple steps are needed for the effluent treatment	Phycoremediation is a single step process performed using algal consortia	Multi-step process	Single-step process
Removal of Odour	Marshy smell due to high **methane generation**	All Foul Odour removed	The stinking smell in the environment persists	Lesser odour removal potential
Type of Sludge	Toxic	Non-toxic, even if produced in small quantities	Toxic	Toxic
Circular Economy Model	None	Multiple models exist	Low	Low
Carbon Negative	None	YES	NO	NO

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COST STRUCTURE FOR WATERBODY TREATMENT AND REJUVENATION

Our tentative estimate of the treatment cost of a waterbody is based on the following assumptions:

1. Area of the waterbody – 1 acre (~ 4000 sq. m.)
2. Depth of the waterbody - ~ 1 m
3. Volume of water in the waterbody – 4000 Cu.m (4 million litres)
4. Total treatment time – 1 Year followed by 3 years of maintenance.

S.No.	Component of the Commercial Structure	Amount (INR)
1.	Treatment cost for 1 year	21 Lakhs
2.	Operation & Maintenance Cost (@ 3 lakhs/year for 3 years)	9 lakhs

The treatment costs shall include:

1. Construction of temporary treatment sites (High-rate algal ponds)
2. Supply of nutrition for the growth of algae (treatment time and maintenance period)
3. Manpower (for treatment time and maintenance period)
4. Instruments and machinery required for treatment and maintenance (3 years)
5. Installation of LED lights, floating fountains, and their maintenance (for 3 years) after treatment.

The above costs **DOES NOT** include:

1. GST and other taxes
2. Rent for the treatment site.
3. Power supply at the treatment site
4. Cost of construction of approach road, if not available

However, this should be clearly understood that the above pricing is only indicative of the earlier defined assumptions. The cost of the treatment process will vary depending upon:

1. The volumetric dimension of the waterbody and the water in it.
2. The level of organic contaminants (COD/BOD etc.)
3. Presence of heavy metals

Compared to the efficacy of Phycoremediation technology and its advantages over other conventional technologies which have large requirements of land and high initial fixed cost, the cost of treating effluent with Phycoremediation technology with Green Micro Algae Consortia is highly competitive as well as one of the more economical, sustainable, and long-term options. This will not only improve the city ecosystem but will also ensure in reactivating the sustainable, self-cleaning mechanism of the waterbodies.