
# Microalgae for effluent treatment

An effective, *Sustainable*, *Circular*, and revenue-generating *Clean* technology

Environalgae

# The Need….and the opportunity

- Impact of *Climate Change* is well known and gets discussed in perhaps every important international convention of developed and developing nations.
- The manufacturing sector across the world is now being tasked to audit and reduce *Scope 1*, *Scope 2* and *Scope 3* carbon emissions.
- In the conventional effluent treatment processes, *Scope 1* and *Scope 2* emissions are usually significant. Hence, switching to more sustainable wastewater mitigation technologies will soon be a need of the hour for most companies.
- (NEED) An ideal sustainable option for wastewater mitigation in the manufacturing sector should:
    - Utilize less energy
    - Result in very low carbon emissions
    - Produce clean water, and
    - Provide a co-product opportunity to improve the circularity quotient of your carbon!
- (OPPORTUNITY) Microalgae-based effluent treatment technology
    - Relies on sunlight as a source of energy; suitable weather conditions and ample sunlight availability throughout the year over here!
    - Consumes carbon and emits oxygen
    - Generates clean and compliant water suitable for discharge/ re-use
    - Produces microalgae-biomass for various end-use applications, thus recycling the carbon and nutrients from the manufacturing operations

# An Exciting Clean-Tech for Effluent treatment….

- **Sustainable -** Sunlight, the primary source of energy for our process, is free of cost, non-polluting and plentiful
- **Environment friendly* -** $O_2$ released by algae, improves overall air and water quality in the environment
- **Effective** (field data collected from one of our pilot-plant sites)

**Raw effluent**
- COD – 6,000 mg/L
- pH – 4.5
- TSS - ~1,000 mg/L
- Red coloration

**Algae pond culture**
- DO – 150-500% sat.
- pH – 7-8
- Green algal cells in suspension

**Treated water**
- COD – 60-120 mg/L
- pH – 7-8
- TSS - < 20 mg/L

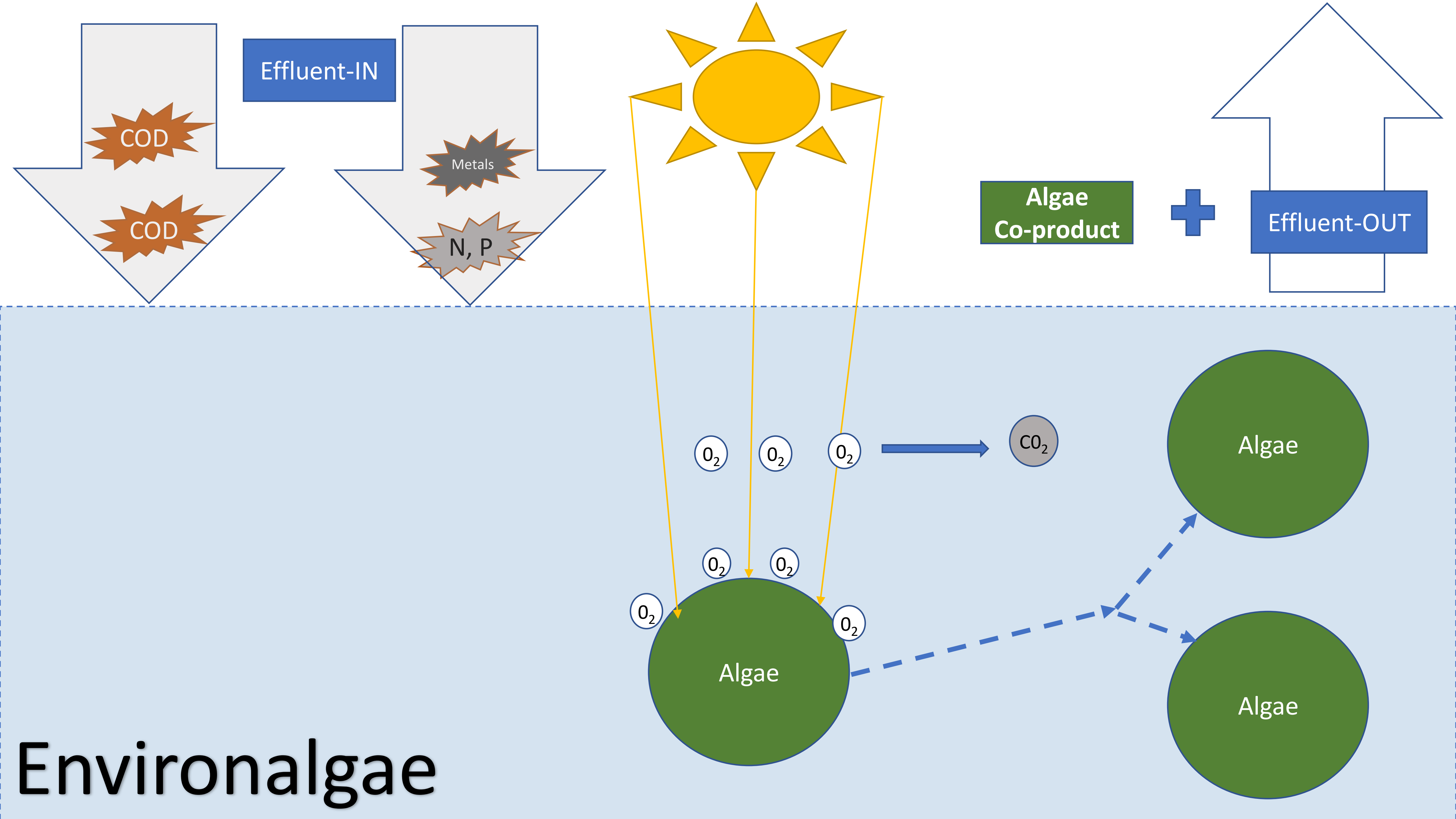
- **Lucrative** – Renewable algae biomass generated has potential value as feed, food and organic fertilizer. Protein content > 50%, high-value fats > 10% and high mineral and antioxidant content.

* – Most of the natural water body pollution by algae is from toxic blue-green algae (cyanobacteria), we are proposing use of beneficial green microalgae for this application

# How does our process work?

A short schematics-based animation to illustrate the process of pollutant abatement by photosynthetic microalgae.

PS – You will need to click multiple times on the next slide for the animation to execute


Effluent-IN
COD
COD
Metals
N, P
Algae
Co-product
Effluent-OUT
$O_2$
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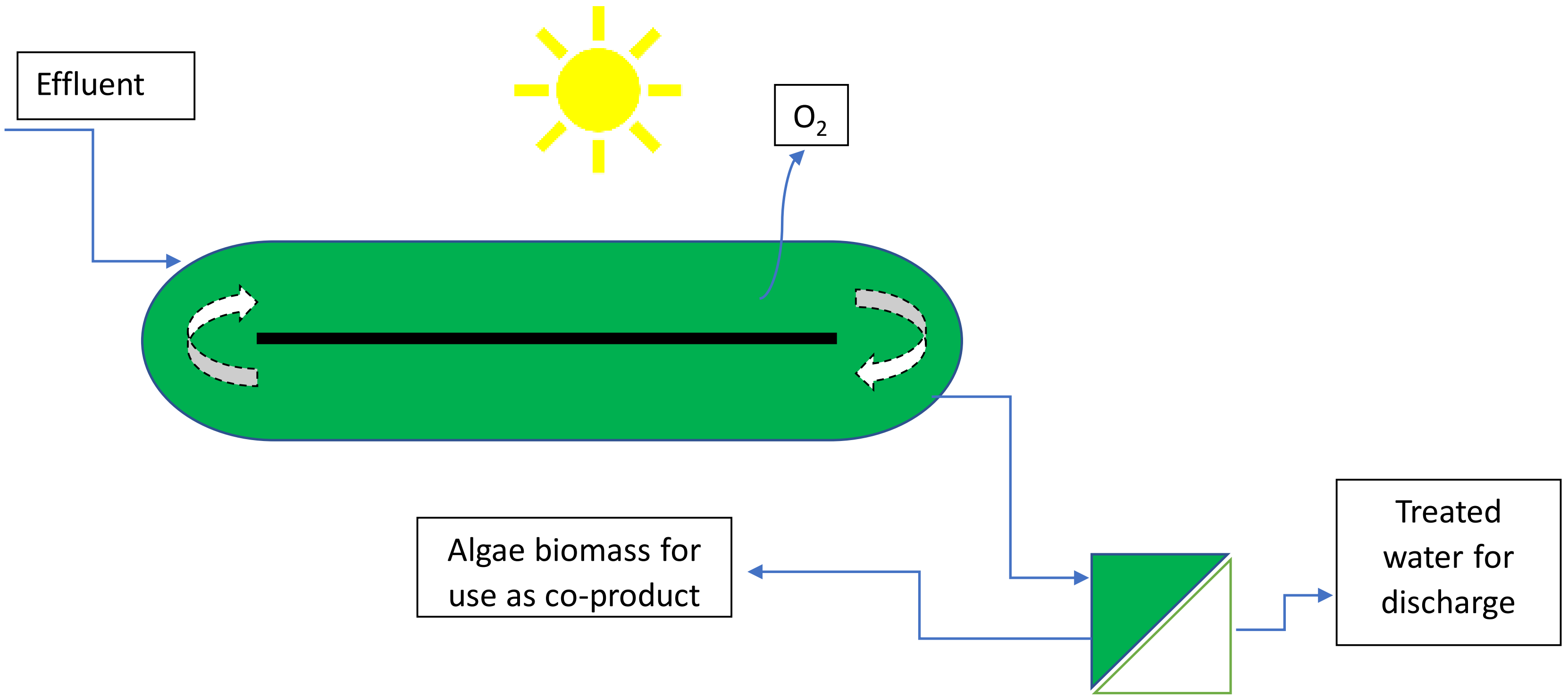
Environalgae

# Typical block-diagram for algae-based effluent treatment



# Algae versus other ETP options

| Parameter | Conventional effluent treatment | Microalgae |
|---|---|---|
| **Oxidizing agents** | • Need to be added at high mixing energy costs | • Generated by microalgae through photosynthesis using sunlight |
| **pH** | • Relatively narrow range tolerated once the process/ equipment are stabilized | • Microalgae can perform in the range of 4-9 pH |
| **TDS/ Salinity** | • Values> 5,000 mg/L impact processes and material of construction | • Can perform at values in excess of 30,000 mg/L |
| **N, P etc.** | • Difficult/ expensive to remove | • Decisive advantage through N, P, K removal |
| **Metals incl. heavy metals** | • Difficult/ expensive to remove | • Known ability of microalgae to sequester all metals from water |
| **Operational exposure risks** | • High temperatures or deep & anoxic water bodies, corrosive oxidizing agents, toxic off-gases | • Shallow (<30 cm deep) water bodies that emit oxygen! |
| **Carbon emissions** | • Generated and released into the atmosphere | • Utilized by microalgae to produce more algal biomass |
| **Generated bio-sludge** | • Needs to be disposed | • Platform feedstock for fuel, fertilizer, feed, biochemicals and food |
| **Carbon capture** | • None | • Huge potential to integrate carbon capture with effluent treatment |

# Why this technology makes more sense now?

- Microalgae-based effluent treatment can positively contribute towards mitigation of ill-effects from *Climate Change* by the virtue of being *Sustainable*, *Circular*, and *Clean*.
  - By primarily relying on natural sunlight for photosynthesis-mediated degradation of pollutants from the effluent, this process scores high on *Sustainability*.
  - By converting the waste organic carbon, nitrogen, phosphorus, and other nutrients, present in the effluent into nutritious, high-protein algal biomass with potential for use in the food, feed and fertilizer industry, this process also scores high on *Circularity*.
  - Finally, by generating clean water and releasing pure oxygen to the environment, this is essentially a *Clean technology* option for effluent abatement.

# Typical applications for algae-based effluent treatment

1. Food processing units that produce effluent with high concentrations of organic carbon, COD, BOD, nitrogen and other metals/ salts
2. Grain-based distilleries that produce thin slops
3. Molasses-based distilleries that produce spent-wash
4. Dairy operations
5. Aquaculture operations
6. Pharmaceutical industries that produce high COD, high BOD effluent
7. Industries that produce highly acidic effluent
8. Any set-up that produces high BOD, COD, organic carbon, nitrogen or phosphorus

# About Environalgae

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- We are currently developing and demonstrating our process at pilot-scale for our customer. Its a novel, microalgae-based process that converts nutrients present in effluent from their agro-processing unit to high-value algal biomass for use as high-value feed for the aquaculture industry. Treated water generated from this process significantly exceeds the discharge specifications of the pollution control board.

- Video of our process demo at pilot-scale

  On YouTube - https://youtu.be/17b724g-i1M

  On Vimeo - https://vimeo.com/820440530/7ab9f3f906?share=copy

# About Environalgae

Team with an ideal of youth and experience

- **Ninad Gujarathi, PhD (Proprietor and Founder)**
  - Leadership experience in R&D, Techno-commercial, Manufacturing and Business roles, with proven track record of evaluating, conceptualizing, innovating, developing, scaling-up, delivering process & business solutions, and business growth.
  - Experience in conceptualizing, designing, executing, commissioning and operating some of the world's first and largest algae-based carbon capture and process effluent treatment plants.
- **Rahul Patel, PhD (Chief Technologist)**
  - Experience in developing cultivation biology process schemes, executing, commissioning and operating one of the world's first and largest algae-based carbon capture and process effluent treatment plants.
- **Makarand Phadke, PhD (Mentor)**
  - A distinguished innovator, scientist, and a senior business leader with over $35^{+}$ years of experience in water and sustainability businesses across the globe
  - Experience in establishing and leading a major algae-based renewables project that included setting up one of the world's first and largest algae-based carbon capture plant.
- **A team of THREE Biologists, FOUR Engineers and ONE supervisor** to help our customers with research, development, designing, executing, and commissioning this emerging technology

# Why Environalgae?

- As a team, we are among the very few across the world to have experience in developing, demonstrating and executing microalgae-based effluent abatement projects
- Significant experience in managing large and multi-national microalgae projects across the world
- Top management of the team are experienced R&D, technology & business leaders with illustrious corporate careers prior to establishing Environalgae
- We develop & provide customized process technology solutions for your effluent treatment needs
- We follow a *phase-gate* approach with focus on developing and **demonstrating value-addition** at each stage of the project, prior to presenting a business case for further investment by customer
- We are passionate about the environment and also about the potential of microalgae for meaningfully contributing towards resolution of some of the greatest climate challenges that mankind has ever faced

# Tentative Project Schedule for evaluating our process

| Phase | Timeline in months | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Algal bioassays at Environalgae lab<br>SCIENTIFIC FEASIBILITY ASSESSMENT | | | | | | | | | |
| Process development at Environalgae lab<br>TECHNICAL FEASIBILITY ASSESSMENT | | | | | | | | | |
| Pilot studies at Environalgae's pilot-demo site<br>OUTDOOR VALIDATION STUDIES | | | | | | | | | |
| Design and execution of the full-size ETP plant<br>DESIGN | | | | | | | | | |
| Commissioning of the full-size ETP plant<br>EXECUTION & COMMISSIONIING | | | | | | | | | |

# Some Preliminary Estimates on investment and environmental benefits from a generic Effluent Treatment Plant

CAPEX and OPEX numbers worked out in the Indian context

# Preliminary workout on expected Financials

| | | |
|---|---|---|
| Effluent generation rate | 300 | $m^3$/day |
| COD of incoming effluent | 3,000 | mg/L i.e. g/$m^3$ |
| COD consumption | 150 | g COD/ m2-day |
| Algae ponds footprint area required for treatment | 1.5 | acres |
| | | |
| CAPITAL REQUIRED | | |
| Lab, R&D and Pilot scale expenses | ₹ 3,300,000 | |
| Algae ponds (excluding cost of land) | ₹ 4,545,000 | |
| Downstream processing system | ₹ 8,500,000 | |
| CONSULTING - Technology engineering commissioning | ₹ 10,000,000 | |
| **Total capital** | **₹ 27,345,000** | |
| Plant life in years (Depreciation) | 10 | years |
| | | |
| OPERATING COSTS | | |
| Electrical | ₹ 2,227,500 | per year |
| Nutrient costs & Chemical costs | ₹ 712,800 | per year |
| Manpower to operate the plant | ₹ 3,400,000 | per year |
| Maintenance costs | ₹ 652,250 | per year |
| **Total operating expense per year** | **₹ 6,992,550** | **per year** |
| | | |
| Algae produced per year (on dry basis) | 59 | MT/year |
| Algae produced per year (on fresh weight basis) | 594 | MT/year |
| Value as aquaculture feed/ organic fertilizer | ₹ 35 | per wet kg algae |
| **Revenue from algae per year** | **₹ 20,790,000** | **per year** |
| | | |
| **Total revenue from operations** after cost accounting | **₹ 8,328,450** | **Per year** |
| Rate of return on Investment (ROI) | **30%** | per year |
| Payback period | **3.3** | years |

- PS – Significant additional cost savings can be realized by the customer on account of reduction in NaOH usage as this process operates even better in acidic conditions (pH 4-5)

# *Sustainable* & *Clean* Process with high *Circularity* of Carbon

| | | |
|---|---|---|
| **$CO_2$ equivalent Emissions Reduction (SUSTAINABLE PROCESS)** | | |
| Electricity consumed in the microalgal process | 297,000 | kWh/year |
| (Carbon foot-print of electricity in India) | 0.85 | $kgCO_2/kWh$ |
| Carbon emissions because of electricity consumed in the microalgal process | 252 | MT/year |
| Total COD treated | 297 | MT/year |
| $CO_2$ emissions avoided by not allowing that COD to be converted to $CO_2$ | 408 | MT/ year |
| **Net $CO_2$ emissions reduction** | **156** | **MT/year** |
| | | |
| **$O_2$ released from the process because of microalgal photosynthesis (CLEAN TECHNOLOGY)** | | |
| Assumed $O_2$ generation rate | 80% | of Max |
| Max $O_2$ generation rate (theoretical; from literature) | 0.00573 | moles $O_2$/ g-hour |
| biomass concentration in the ponds | 0.5 | g/L |
| $O_2$ productivity (assumed) | 0.002292 | moles $O_2$/ L-hour |
| | 0.073344 | g $O_2$/L-hour |
| **$O_2$ generation** (and release in to the environment) **expected** | 132.0 | kg/hour |
| | 1,056 | kg/day |
| | **349** | **MT/year** |
| | | |
| **Renewable microalgal biomass wet-cake generated from the process (CIRCULARITY OF CARBON)** | **~600** | **MT/year** |