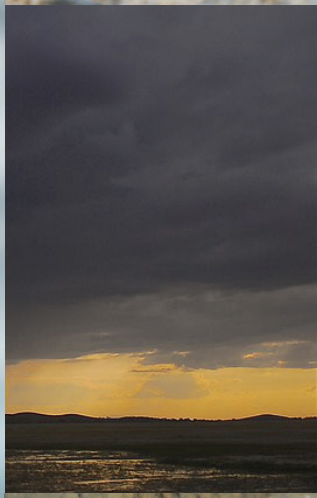
August 2020

CLIMATE SURVIVAL SOLUTIONS PVT LTD

BULLETIN

CLIMATE SURVIVAL SOLUTIONS

VOLUME 1 ISSUE 1



MICROBIOME MANAGEMENT FOR AQUAPONICS

CLIM
CHA

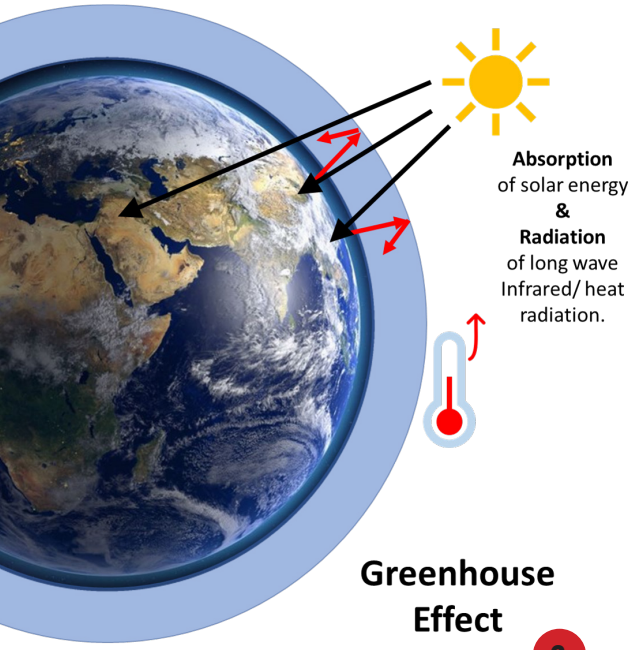
Introduction[i]

The impact of actions and activities of human on planet earth has now expanded to such a level, that few scientists call it as a new human-oriented era of geological time called the 'Anthropocene'. The working of the earth is immensely influenced by the human's activities. The movement of rocks, soil and sediments by humans globally is much more than the cumulative action of all the natural processes. Nearly half of the total trees on the earth faced the cut down. Humans have aced their anthropogenic activities so well, that there is a rise of 1°C in global temperature and around 20 cm rise in sea levels in the past 100 years. The emission of greenhouse gases (GHG) if proceeds at the same pace, would cause the global mean surface temperature to rise between 2.8°C & 5.4°C by the end of 21st century. Global sea levels would rise by 52 cm and 98 cm with substantial weather changes and more extensive climate events.

Role of greenhouse gases[i]

The temperature of the earth is dictated by the balance between the energy from the sun and the energy loss back to space. Nearly around 1/3 of the solar energy is reflected back to space and the remaining energy is absorbed by land and oceans. This absorption of energy warms the earth and ocean and they radiate as long-wave infrared or 'heat' radiation. The atmospheric gases such as water vapour,

carbon-dioxide, methane and nitrous oxide, known as GHG absorbs the heat radiation, resulting into warming of the atmosphere. This is referred to as 'greenhouse effect' and is imperative for maintaining the temperature of the earth. The absence of this effect would make the earth cooler by 35°C, resulting into the average surface temperature of earth to -20°C. These gases naturally occur in the atmosphere. But owing to human activities, such as burning of fuel, deforestation, other land-use changes have altered and increased the concentration of GHG in atmosphere.



Greenhouse Effect

Causes of anthropogenic climate change[i]

There are numerous investigations and explores done supporting the fact that there has been a constant increment in the levels of carbon-dioxide in the atmosphere from the beginning of industrial revolution. One of the principal studies for measuring

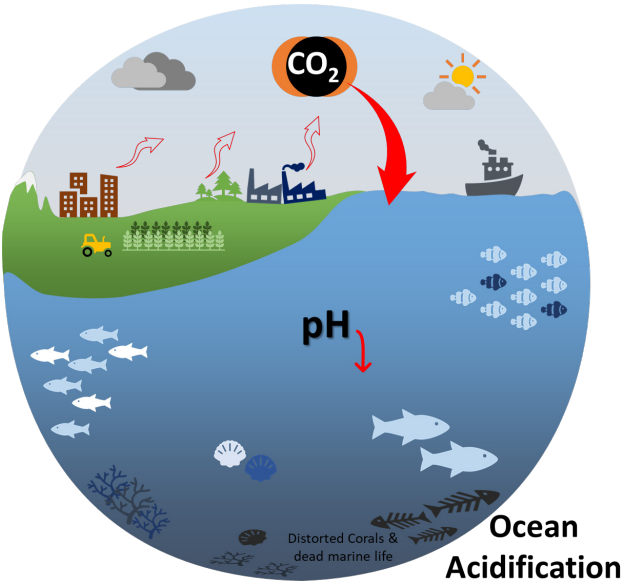
CAUSES OF ANTHROPOGENIC CLIMATE CHANGE

the carbon-dioxide concentration in the atmosphere started in 1958 at the altitude of approx. 4000 meters, on Mauna Loa mountain in Hawaii. There are significant confirmations indicating that the concentration of the carbon-dioxide has consistently increased ever since 1958. The mean concentration of carbon-dioxide which was ~316 ppmv (part per million by volume) in 1958, has escalated to ~410 ppmv now. North America, Europe and Asia emits over 90% of the global industrially produced CO_2.These emission originates from cutting down of forests for agriculture, urbanization and roads. South America, Asia and Africa emits around 90% of current day land-use change emission. In 2007, China became the biggest emitter of carbon dioxide in the world. Conversely, when considered per capita, the U.S.A emissions are four times higher than China. Since, the industrial revolution, approx. half trillion tons of carbon has been added to atmosphere, which accounts for only half of the total global emission. It appears as

out of 50% of emission absorbed by the earth, ~25% gets absorbed into the oceans and ~25% gets absorbed into the land biosphere. With the increase in global temperature and warming of ocean, there has been decrease in the uptake of carbon-dioxide by oceans. Correspondingly, if we progressively cut the forests and convert the land for farming and urbanization, there would be less vegetation to absorb CO_2 again reducing the uptake of carbon pollution.

Ocean acidification

Rise in sea-level is generally considered as the principle impact of the climatic change on marine ecosystem. Caron-dioxide in the atmosphere dissolves in the oceans. The oceans have already absorbed 1/3 of the carbon-dioxide, resulting from human activities such as burning of fossil fuels, cutting trees and urbanization. This assimilation of carbon-dioxide by oceans, causes decrease in the pH of the oceans. This is known as the 'Ocean Acidification'. Some marine organisms such as corals, foraminifera, coccoliths and shellfish comprise of shells which constitutes calcium carbonate. These carbonate shells dissolve rapidly in acidic conditions. Analyses have indicated the abatement in the

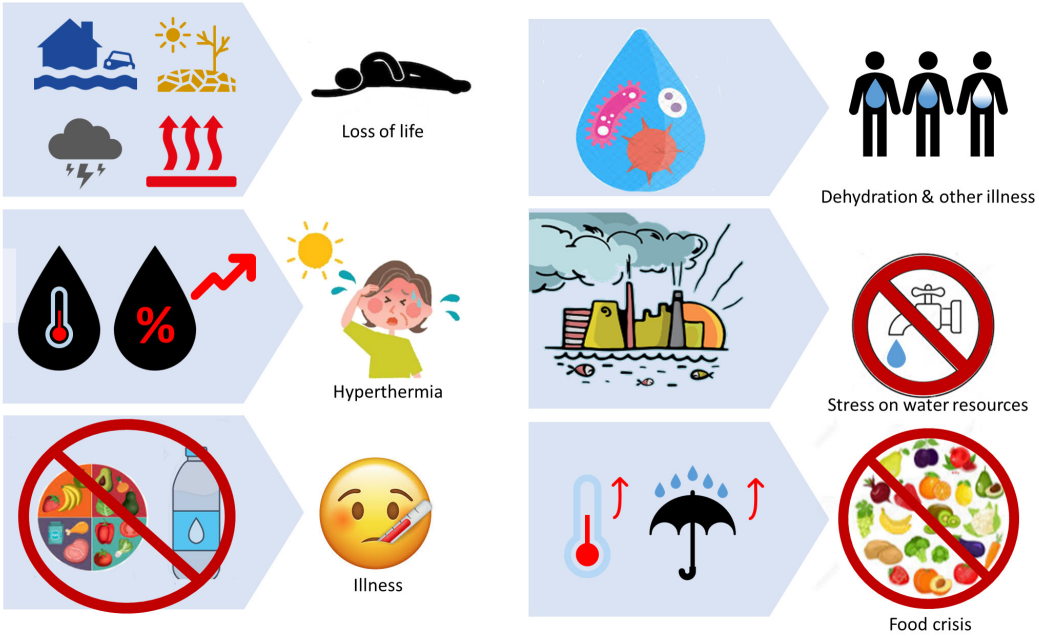


development pace of marine species and distorted shells into acidic condition This phenomenon also alters the cycling of nutrients and several other elements and components in the ocean, and adversely impact the marine ecosystem and food web.

Health and climate change[i]

Climate change can possibly hamper the health of humans. Several potential health impact of climate change are alluded beneath:

- Climate change would increase the deaths due to severe heat waves, drought, floods and storms.
- Increased cases of hyperthermia due to the elevated temperature and humidity. The likely influenced populace would be the ones working outside routinely, such as construction workers and farm workers.
- Higher levels of insecurity regarding the food and water.



- Increased threat to acquire fresh drinking water.
- Lack of water causes health problems like dehydration and number of other diseases caused due to drinking of parasite contaminated water.
- Increase pollution poses great stress on the water resources.
- Adverse impact on health due to affordable food crisis caused by the changes in temperature and precipitation.

Solutions[ii]

Several potential solutions of climate changed have been investigated, researched, practiced and developed, some of which are recorded under:

- Innovation and introduction of new technologies in electricity generation.
- In order to curb the emission of GHG, Indian Government have implemented a policy, whereby every household and industries are restricted on emission of carbon IV oxide gas.
- Reforestation- highest priority of Indian government to mitigate the global climate change. For e.g. Indian government has set aside around 0.8 million hectare of land development for forests annually. This effort is clubbed with forest conservation strategies, forest improvement and management.
- Expansion, advancement and utilization of renewable sources of energy.

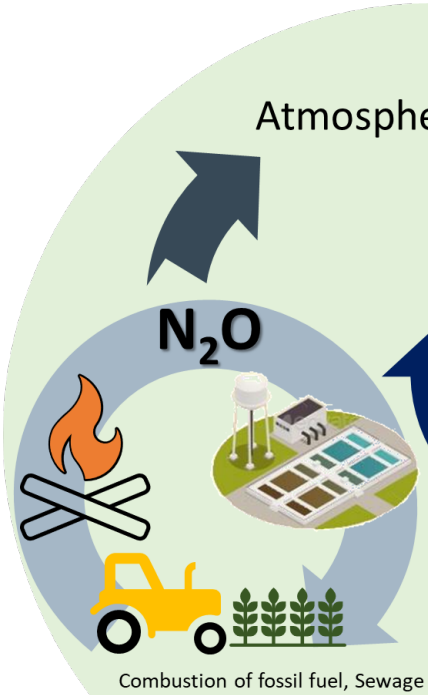
Role of microbes in climate sustainability[iii]

The soil is teeming with a large array of microorganisms. These microorganisms offer a significant role in curbing the climatic change. Generally, climatic change focuses on the life at macroscopic scale, but the microorganisms and their metabolic activities are equally influenced. As the temperature increases due to global warming, the activity of microbes responsible for breaking down of the carbon-based components in soil also increases. This further results into higher respiration rate, which causes higher production of carbon-dioxide. Laboratory experiments shows that with every 5-10°C increase in temperature, the respiration rate of soil microbes doubles, which in turn contributes to carbon-dioxide emission.

The soil flora is vital to many of the ecological processes like nutrient cycling, degradation of organic components, consumption and generation of trace metals and transformation of metals. Microbes contribution in consumption and production of greenhouse gases like, carbon dioxide, methane, nitrous oxide and nitric oxide is imperative.

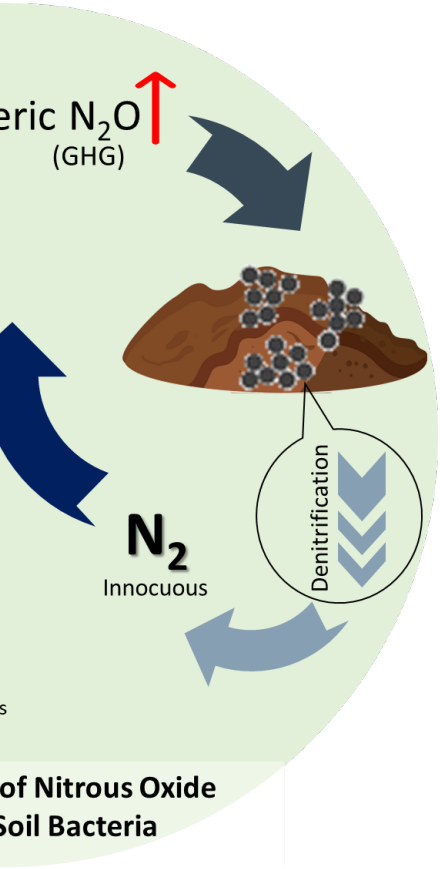
Consumption of nitrous oxide[iii]

A greenhouse gas, nitrous oxide (N_2O), is said to have 300-folds greater global warming potential than carbon-dioxide



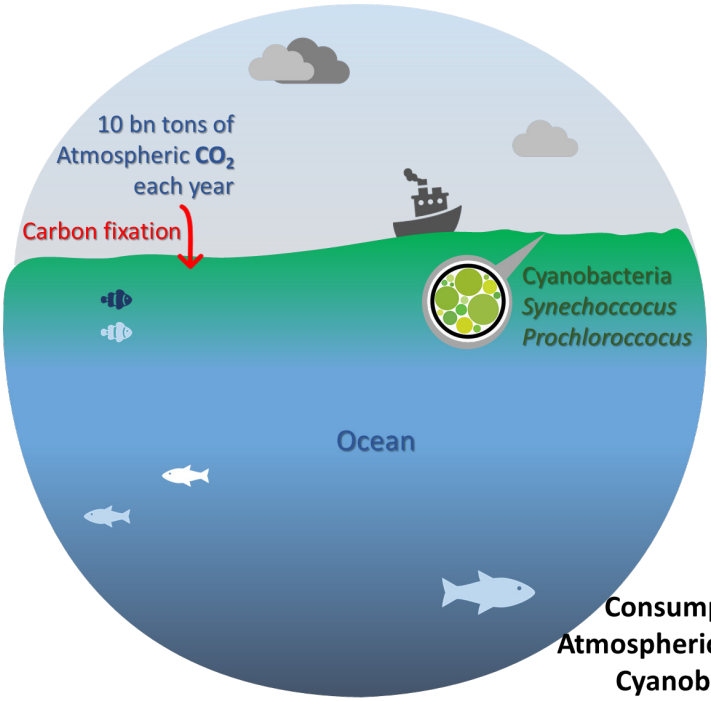
Consumption
(N_2O) by S

(though occurs as only a fraction of carbon-dioxide) and decimates the ozone layer[ix]. The N_2O fundamentally, enters the atmosphere through agricultural practices, sewage treatment and combustion of fossil fuels. A group of microorganisms known as denitrifying bacteria converts this nitrous oxide into innocuous nitrogen gas as a part of nitrogen cycle. This step of denitrification is least oxygen tolerant. The enzyme responsible for the consumption of nitrous oxide is bacterial nitrous oxide reductase and is a subjective to extensive research. The enzyme nitrous oxide reductase is encoded by *nosZ* gene. *Paracoccus denitrificans* (a gram negative bacteria, with coccus morphology and non-motile) is thought to remove nitrous oxide[vi]. Thus, characterization, isolation and utilization of this microbe will aid to mitigate emissions.



Consumption of Carbon from air[iii]

Prochlorococcus and *Synechococcus* – unicellular cyanobacteria present abundantly in marine environment. *Prochlorococcus* and *Synechococcus* size varies from 0.5 to 0.7 µm and 0.8 to 1.5 µm respectively. They are estimated for responsible of roughly 25% of the net productivity of ocean. *Prochlorococcus* is generally confined to open ocean between 45°N and 40°S. *Synechococcus* has broader geographical distribution including subpolar and coastal regions[iv]. It is estimated and investigated that these microbes remove 10 billion tons of carbon from the air each year,

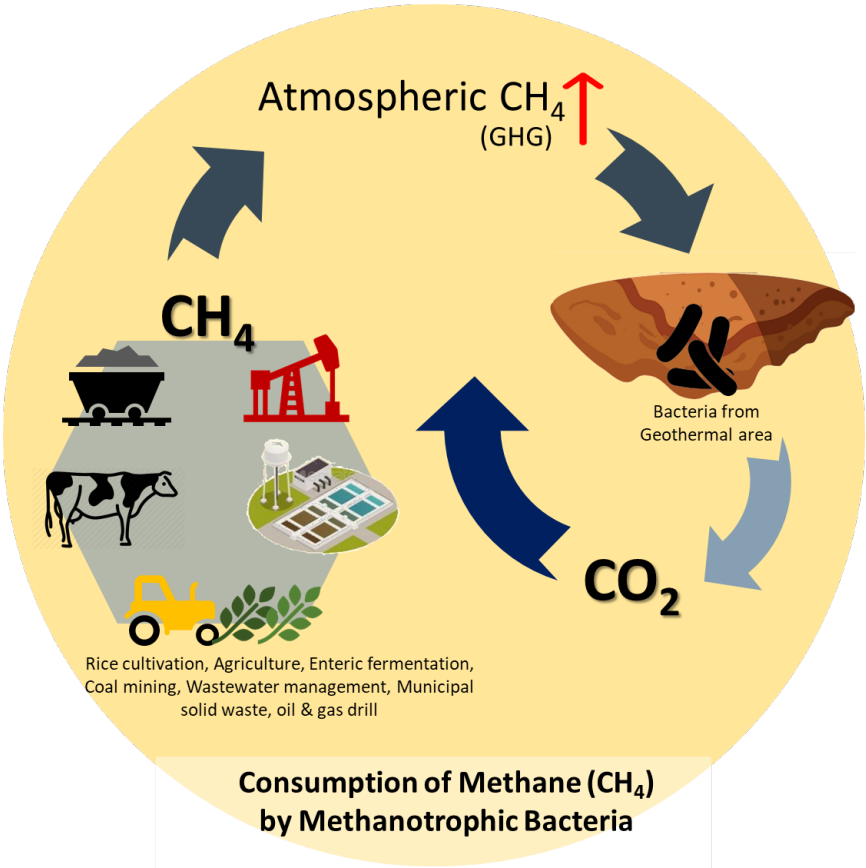


Consumption of Atmospheric Carbon By Cyanobacteria

which accounts for two third of total carbon-fixation that occurs in ocean. The successful utilization of these microbes and their proficiencies would eventually reduce the global climate change.

Consumption of methane[iii]

Methane is another potent greenhouse gas. It traps around 20-folds' greater heat as compared to the same volume of carbon-dioxide. This implies that, it warms the climate 20 times more than carbon-dioxide. The sources of methane emissions are rice cultivation, agricultural practices, enteric fermentation, coal mining, waste water management, municipal solid waste management and oil and gas drilling. A novel bacterium, *Methylokorus infernorum* discovered by scientist is referred to consume methane gas as the sole source of carbon and energy. The methane is converted into carbon-dioxide by these microbes. It is observed that this bacterium can utilize a massive amount of methane, around 11kg/year. *Methylokorus infernorum* is found principally in geothermal Area-Hells Gate, Rotorua at the depth of 30 cm below the ground. In

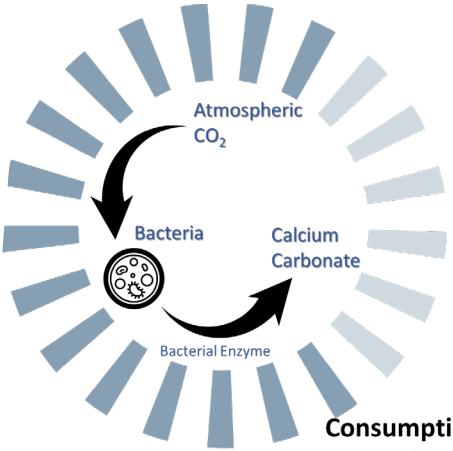


Consumption of Methane (CH_4) by Methanotrophic Bacteria

general, the "methanotrophic bacteria" can consume one carbon compounds, predominantly methane, methanol, methylated amines, dimethyl sulphide and methyl halides. By utilization of Stable Isotope Probing method, investigators have succeeded in discovering which microbes are active in environment. One of the methylotrophic bacteria, known as *Methylobacillus,* is the earth's most significant carbon recycler. They recycle carbon containing compounds such as methane, methanol, methylated amines. The natural habitat of these microbes includes marine and fresh water ecosystem.

Consumption of carbon-dioxide[iii]

Certain microbes have been discovered lately, which converts the atmospheric carbon-dioxide into calcium carbonate. These microbes utilize an enzyme for carrying out their metabolic pathway. It's being investigated and worked upon for setting up a



Consumption of Atmospheric CO_2

situation like chamber in an industrial facility wherein this enzyme (responsible for the utilization of the carbon-dioxide) can be added to degrade the carbon-dioxide before it is discharged in the atmosphere. The harmful greenhouse gas carbon-dioxide would be converted to calcium carbonate. This discovery can be a great breakthrough in curbing the climatic crisis.

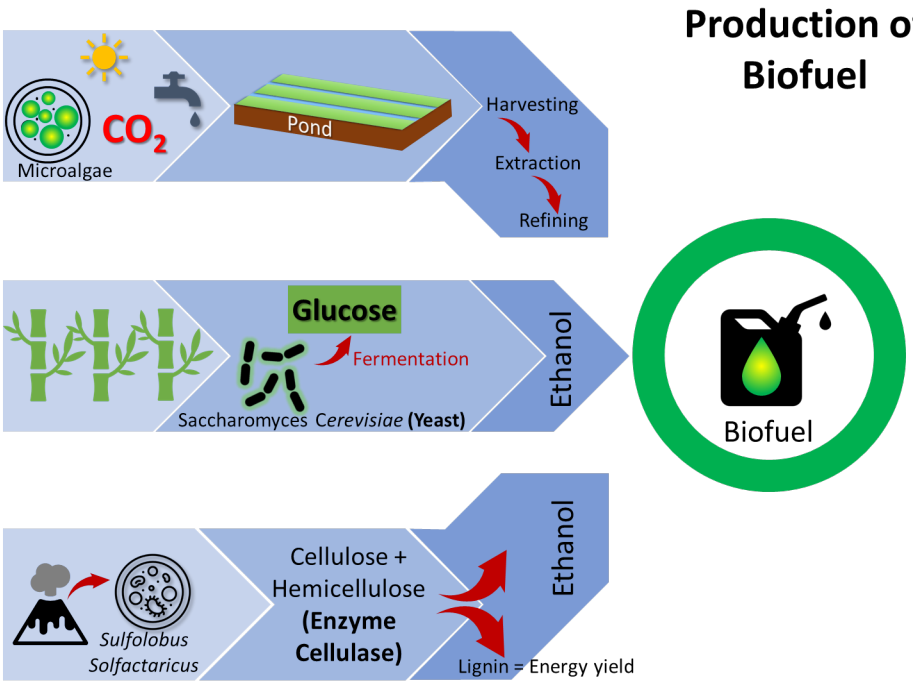
Biofuels[iii]

Utilization of bio-fuels additionally creates a path for reducing the greenhouse emission by fossil fuels. Bio-fuels such as bioethanol causes little or no carbon-dioxide. Bioethanol is a diverse fuel and can be blended with gasoline in different proportions and used as flexible-fuel vehicles[v]. An archaeon, *Sulfolobus solfactaricus,* isolated from volcanic pool near Mount Vesuvius in Italy, illustrates high capability of producing cellulase enzyme when genetically modified. The cellulase enzyme facilitates the conversion of cellulose and hemi-cellulose into ethanol (utilized as bio-fuel). The process also generates lignin as a by-product and utilized for production of energy. The edible plant parts such as sugar cane; beet root or corn kernel are used. Production of bio-ethanol by yeast – *Saccharomyces cerevisiae* using edible part of plant (sugarcane) is well studied and researched.

Biofuels are also generated by the utilization of microalgae. Algal based biofuel-biodiesel offers several advantages and few are mentioned below:

- Cost competitive.
- No additional land requirement (as in case of biofuel from biomass feedstock).
- Minimal water use.
- Mitigation of atmospheric carbon-dioxide.

Several species of microalgae, such as *Botryococcus braunii,*



Nannochloropsis sp, Dunaliella primolecta, Chlorella sp, and Crythecodinium cohnii have a high yielding capacity of hydrocarbons and lipids. The capability of oil product varies greatly among the microalgae, for e.g. *Chlorella* accounts for 50 % of the lipids while *B. braunii* produces as high as 80 % of lipids. The biodiesel productivity of microalgae with low, medium and high oil content is recorded to 51,927 kg biodiesel/ha/year, 86,515 kg biodiesel/ha/year and 121,104 kg biodiesel/ha/year respectively[vii]. Several disadvantages of micro algal-biofuel include the following:

- Low production of biomass.
- Low content of lipids in algal cells.
- Costly harvesting process due to small sized cells.

These disadvantages can be overcome, by improvising the harvesting techniques, drying and genetically modifying the metabolic pathway of microalgae to facilitate high production of lipids.

Adapting with the impacts of climate change[viii]

Micro-organisms helps plants to cope-up with the changing climatic conditions by following means:

- Soil microbes can restore the soil degraded by climate change.
- They can help plants tolerate hot temperatures and drought caused by climate change, for e.g. recent studies suggest that soil microbes can help the plants like rice, pepper and wheat to tolerate drought.
- Soil microbes are thought to increase the plant defence mechanism which protects them from pest, whose populace has expanded due to climate change.
- The overall health of the plant under the stressful climatic crisis is maintained by soil microbes, ensuring sustainability and productivity of the farms.

Conclusion

Reduction in the climate change and its holistic solution is the need of the hour. Solutions to climate change and mitigate the climate crisis are followed and practised comprehensively. Out of several significant solutions to curb the emission of GHG, microbes play a vital role. It is clear that microbes can have a massive influence on future climate change scenarios and ecosystem-level responses to climate change. Microorganisms can prove to be a highly effective factor in mitigating the emission of greenhouse gases, and facilitates to predict the future climate changes at global scale.

References

i Maslin, M. (2019, April 24). Climate change:essential knowledge for developing holistic solutions to our climate crisis.

ii Shah, J. M. Climate change: Challenges and solutions.

iii Gupta, C., Prakash, D., & Gupta, S. (2014). Role of microbes in combatting global warming. International Journal of Pharmaceutical Sciences Letters.

iv Berube, P. M., Biller, S. J., Hackl, T., & Hogle, S. L. (2018, September 04). Single cell genomes of Prochlorococcus, Synechococcus , and sympatric microbes from diverse marine environment. Scientific Data.

v Our changing earth our changing climate. (1997, September). U.S. Deparment of Energy.

vi Puiu, T. (2018, October 29). Scientist find that soil bacteria can devour potent green house gas. Retrieved from zmescience.com.

vii Srikant Reddy Medipally, M.Yusoff, F., & Shariff, M. (2016). Microalgae as Sustainable Renewable Energy Feedstock for Biofuel Production.

viii Ngumbi, E. (2015, April 30). Turning to bacteria to fight the effect of cliamte change

ix David Richardson, & Moulton , V. Understanding nitrous oxide emission from denitrifying bacteria: integrating chemostat and soil studies. UK Research and Innovation.

Climate Survival Solutions Pvt. Ltd. is a consultancy, engineering, and solutions development enterprise dedicated to helping us all navigate the climate crisis.

Our Consulting Services include:

Climate Impact Assessments – to help your organization and its operations understand how they will be affected both in the near and long term by the climate crisis.

Using a strategic analysis approach backed by our unique climate science database, we will work with you to understand how your organization, its industry, and its supply chain will need to evolve as temperatures rise, extreme weather events worsen, and conditions such as drought and floods will change the world we live in.

Adaptation and Mitigation Planning – to help your team develop concrete workable alternatives to support your sustainability and climate survival objectives.

Climate Crisis Education – to educate your team on how the climate crisis came to be and what it means to your organization's future.

Our Product and Systems Offerings current in development include:

Climate-Resilient Housing and Office Construction Solutions

Greywater Recycling Solutions

Passive and Low-Energy Cooling and Heating Systems

Low-Carbon Construction Technologies

Advanced Agricultural Growing Systems, including Aquaponics

Renewable Energy Alternatives

Zero Emissions Transportation

Tech Parks and More

Climate Survival Solutions is currently developing integrated tech parks and home/business habitats which will showcase the full range of product and solutions needed to live and thrive in a world dominated by the climate crisis. New Kalapa Tech Park and Habitat (India) is currently in the planning stages and will be deployed in early installations in the very near future.

Want to Know More? Please contact us at info@climatesurvivalsolutions.in or visit our website at http://www.climatesurvivalsolutions.in.