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Phycoremediation technique using for the treatment of Dairy Effluent

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Abstract: The degradation of the environment poses an ever-greater threat to human health, with the danger being compounded in urban areas with high concentrations of industrial activity. The addition of industrial pollutants has resulted in a significant decline in the quality of the water supply, which is a significant challenge for large industrial communities. Both the quality of the water and the aquatic life in it are negatively impacted when effluents are discharged into larger bodies of water without proper regulation. By altering the worldwide cycles of elements or by introducing chemicals, industrial effluents, pesticides, and so on into the environment, human beings are able to affect the environment and even the entire eco-sphere. A biosphere that has undergone such transformation poses a danger to the continued existence of humans on this planet. As a result of the presence of biodegradable components, the effluent from the dairy is primarily organic. Because of the high concentration of nutrients in these effluents, microalgae may be able to grow in them. In addition to the production of potentially valuable biomass that can be used for a variety of purposes, such as the production of biogas and biofuels, composting, animal feed, aquaculture, and the production of chemicals, microalgae culture in wastewater treatment offers a contemporary solution for tertiary wastewater treatment.

Keywords: Effluent Treatment, Phycoremediation, Pollution, Dairy

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INTRODUCTION

Water is one of the most precious resources we have on Earth. Some have compared it to the planet's blood since life and human civilization simply could not exist without it. One of the worst ecological disasters in human history has been brought on by pollution and the poisoned environment it has created. The rise in human population has resulted in a corresponding rise in water contamination. Concerns about the nature and quantity of rubbish created and flushed into water systems prompted the implementation of new regional water quality rules.

Because of the tremendous expansion of several businesses throughout the course of the last century, boundless resources were available, leading to a dramatic rise in the quantity of hazardous effluent that seeped into waterways and aquifers. Climate change, sinking land and ocean levels, melting ice caps, rising sea temperatures, and damaged photochemical ozone layers are only some of the problems caused by environmental degradation brought on by manufacturing emissions of a wide range of chemicals. [1]

Organic matter is a major contributor to the foul odour and high concentrations of COD and BOD in the wastewater produced by dairy industries. It also contains trace organics, suspended solids, and soluble organics, all of which contribute to the emission of gases, the impairment of taste and odour, the enhancement of turbidity and colour, and the promotion of eutrophication. Organic nitrogen sources including proteins, urea, and nucleic acids may also be present in dairy effluent, although milk protein is the primary source. Poly active phosphorus and orthoactive phosphorus (po3-4) are two of the most common inorganic phosphorus types (po3 -4). (p2o4). The salt, chloride, potassium, calcium, magnesium, copper, cobalt, and nickel levels in dairy effluent are all rather high. [2]

Environmentalpollution

In recent years, surface water contamination has emerged as one of the world's most pressing environmental problems. We used to have an endless amount of land and resources, but the explosion of new industries over the past century has led to a dramatic increase in the pollution of water supplies and aquifers with dangerous effluent. Discharge of these compounds, known as persistent organic pollutants (POPs), from industries has caused environmental pollution, which in turn has caused climatic changes, decreased ground and ocean water levels, melting ice caps, global warming, and depletion of the ozone layer due to photochemical oxidation, among other effects. Because of this, ecologists are paying increased attention to pollution's consequences.

Multiple sectors generate large amounts of wastewater as a byproduct of their activities across the world. There have been a number of studies conducted to determine how severe the pollution of freshwater is that results from the discharge of industrial effluent. The government and environmentalists have been challenged with developing practical, financially feasible, and sustainable methods of treating and recycling wastewater. [3]

Water Pollution and Microalgae

Microalgae are the major producers in all aquatic environments, and their waste products have a considerable impact on water quality in a number of ways. For starters, increasing the nitrogen content of water through organic effluent may cause some species of microalgae to thrive, resulting in widespread surface growths or "blooms" that lower water quality and restrict its use. Microalgae that thrived in water polluted with organic wastes are essential to the "self-purification of water bodies."

It's generally agreed that microalgae are an important element of the water purification process. As a result, several articles have detailed the application of microalgae for recovering nutrients from trash. [4]

Wastewater and its Treatment

Wastewater refers to the unused water that is produced by commercial, industrial, governmental, and similar establishments. Wastewater can enter the environment from two different types of sources, called "point" and "non-point" sources, respectively. Pipelines that carry sewage to bodies of water are examples of point sources. Non-point sources, on the other hand, refer to wastewater that comes from a wide variety of diffuse origins, such as storm water runoff from parking lots or farmland.

Traditional, widespread, and costly, ponds are used to treat wastewater. All costs associated with water treatment, sludge processing, and disposal will be covered by this bid. Making a marketable good out of wastewater treatment would boost the treatment's profitability and likely encourage greater recycling in society. [5]

Need for Industrial Wastewater Treatment Plants

The potential health hazards associated with discharging untreated wastewater necessitate further treatment. Wastewater treatment plants are subject to environmental inspection to help and improve the protection of the environment and the general population. Since the pollution generated by industrial enterprises has a severe influence on the environment and human health, the industrial sector considers wastewater treatment as an enforced requirement that it utilises only when forced to. It is especially important to do so when the effects of the wastewater on the receiving watercourse are readily apparent.

Companies may have to invest a lot of time and money into research and trial projects to find an affordable method of treating their wastewater. If you plan your actions in advance, you'll save yourself some time. On the other hand, if industries didn't adequately prepare to save costs associated with wastewater treatment, they could have to shut down if an urgent solution wasn't found quickly enough. [6]

PHYSICAL UNIT OPERATIONS

Treatment methods that primarily involve the use of physical force are referred to as physical unit procedures. Because the bulk of these procedures were directly created from man's early observations of nature, they were the first ones to be used for the treatment of wastewater. Activities such as screening, mixing, flocculation, sedimentation, flotation, filtration, and gas transfer are examples of typical unit activities. [7]

Chemical unit processes

Chemical unit treatments are a type of treatment method in which pollutants are eliminated or transformed by the use of chemicals or other chemical processes. Precipitation, adsorption, and disinfection are frequently cited as examples of wastewater treatment processes. In chemical precipitation, a chemical precipitate that settles out of solution is created and then treated. Settled precipitate typically contains both components that were present in the wastewater before it settled (including those that may have interacted with the additional chemicals) and components that were present in the wastewater before it settled (including those that may have been pulled from the wastewater). Adsorption is a process that may be used to remove certain molecules from wastewater on solid surfaces by taking use of the attractive attractions between substances. [8]

Biological unit processes

When organisms are utilised to degrade contaminants, the treatment methods are known as biological unit processes. The primary goal of biological treatment is the removal of biodegradable organic components (colloidal or dissolved) from wastewater. These chemicals are essentially broken down into gases that may disperse into the atmosphere and into living cell tissue, where they can be flushed out through natural processes like evaporation and sedimentation. Wastewater can usually be treated biologically, and nutrient removal (nitrogen and phosphorus) is part of that process with the correct environmental conditions.

Current methods of wastewater treatment

The primary problems with the current approaches to wastewater treatment are:

- Multiple wastewater treatment processes generate sludge, which must be hauled off-site for disposal. The cost of treating and disposing of this sludge might be the most costly aspect of operating a wastewater treatment plant.
- However, most wastewater treatment technologies are not flexible enough to accommodate daily, seasonal, or long-term shifts in the wastewater's composition. A wastewater treatment procedure that is effective during one time of the year may not be as effective during another.
- Many wastewater treatment methods need substantial amounts of energy that is not readily available in countries with low per capita energy usage.
- The tremendous cost of their upkeep and maintenance, which includes the production of large quantities of sludge, makes them unfeasible in many locations (solid waste material).

Because of these issues, the research and development of a new wastewater treatment method is urgently needed. This method must be effective, cost-effective, and ecologically benign. [9]

Utilizing biotechnology to reduce pollution

Biotechnology has the potential to be employed in the assessment of ecosystem health, the development of environmentally friendly manufacturing and disposal technologies, and the transformation of pollutants into innocuous substances. Keeping in mind the urgent need for more efficient environmental biotechnological processes, scientists have devised a method called bioremediation to rehabilitate areas impacted by pollution or other ways owing to ecosystem mismanagement. Excavating contaminated areas and transporting the debris to landfills or capping and enclosing the polluted zones are some of the more conventional approaches to site rehabilitation. A more effective technique than these standard methods would be to eliminate the toxins totally, if at all possible, or to convert them into substances that are innocuous to humans.

Bioremediation

Bioremediation refers to any process that uses microorganisms or their enzymes to return a polluted area to its original condition. It is not always simple to cure toxins by bioremediation since some toxins, especially heavy metals like cadmium and lead, are not easily digested or gathered by organisms. According to the Environmental Protection Agency, bioremediation is "the use of living organisms to mitigate or eliminate environmental risks caused by accumulations of toxic chemicals or other hazardous wastes." Bioremediation is a strategy that utilises natural biological processes to remove or render certain poisons harmless. Therefore, it uses low-tech, low-cost procedures that are popular with the locals and can be carried out right there. However, it may not always be acceptable due to the limited range of pollutants against which it is effective, the extended time frames required, and the possibility of unacceptable residual contamination levels. Since bioremediation appears to be a practical replacement for standard cleaning methods, study in this field is essential.[10]

METHODS OF BIOREMEDIATION

Bioremediation techniques can be roughly classified as either ex situ or in situ. In contrast to ex situ technologies, which need transporting the contaminated material to a new place, in situ procedures may treat the material right where it is. They've proven to be more effective than standard procedures, and they may be done right there in the patient's home. It's not only that they're cheaper, but that they eliminate trash for good without leaving behind any responsibility. Since it may be used in tandem with other physical or chemical therapeutic techniques, it enjoys more public acceptance.

Because the organic wastes are biologically degraded under regulated circumstances to concentration levels below those specified by regulatory agencies, bioremediation has emerged as one of the most significant and successful remediation approaches.

There are two primary subfields within bioengineering. The first type of phycoremediation for pollution degradation, bio-stimulation, involves encouraging the growth of macro- or micro-flora in the affected area. Several methods exist for doing this, including the incorporation of electron donors, electron acceptors, microelements, and chelating agents. The second type is commonly referred to as "bio-augmentation." This method is frequently utilised when a suitable pollutant-degrading microorganism cannot be found naturally in the environment. It involves injecting a specific bacterial strain, or strains, into a potentially infected area.[11]

Wastewater as a substrate for microalgae cultures

Wastewater treatment with microalgae is an environmentally benign way to lower nitrogen and phosphorus levels, and it has been utilised in high-rate ponds for almost 50 years.

Microalgae mass culture shows promise for the removal of nitrogenous and phosphoric compounds, two of the most prevalent pollutant and eutrophication contributors. Recent research has focused on a number of techniques and microbial species that show promise for improving the efficacy and sustainability of such bio therapy. High-value proteins for animal feed and pharmaceutically relevant chemicals can be produced at low cost by cultivating photosynthetic bacteria on adequately treated wastewater. The cultivation of microalgae in wastewater serves two purposes: the removal of organic and inorganic pollutants and the generation of biomass.

Phycoremediation

Microalgae or macroalgae are used to biotransform or remove contaminants like nutrients and xenobiotics from wastewater, as well as carbon dioxide from the air, a process known as phycoremediation. Oswald et al. provided one of the first examples of using microalgae in wastewater treatment more than 50 years ago. Use of microalgae in the treatment of municipal wastewater has been the subject of study and experimentation for quite some time. In order to develop a microalgae system that removes nutrients more efficiently, additional research is required in several important areas. The system's direct and indirect phosphorus and nitrogen removal capacities are impacted by the expansion of microalgae. Therefore, substantial micro algal production is required for effective nutrient removal. At the same time, a methodology for effectively extracting nutrients from the soil and a manner of harvesting that does not break the bank are both essential. For this reason, numerous studies and in-depth discussions of the various immobilisation techniques and their applications have been conducted on the use of immobilised cells and filamentous microalgae with high auto flocculation capabilities. [12]

Phycoremediation as a technology

Because of their powerful bioremediation properties, microalgae are already being used by many wastewater treatment facilities. Advanced Integrated Wastewater Pond Systems are one such technology that is now available on the market (AIWPS). Facultative ponds, which are relatively deep and favour surface development of microalgae, and high-rate algal ponds (HRAPs), which are shallow and rely on mechanical mixing for maximum microalgal production and removal of biological oxygen need, are the two most common designs. HRAPs are used to treat waste from pig farms, and are the most cost-effective reactors for handling liquid waste and harnessing solar energy.

Microalgae often play a substantial part in the treatment of household wastewater in maturation ponds or of small to medium-sized municipal wastewater in facultative or aerobic ponds. By using the carbon dioxide produced during bacterial respiration as fuel, anaerobic bacteria aid in the removal of nutrients, pathogens, and heavy metals while also providing oxygen to heterotrophic aerobic bacteria, allowing the latter to mineralize organic pollutants. Photosynthetic aeration is fascinating because it has the potential to reduce operational expenses and the risks of pollutant volatilization during mechanical aeration. Recent studies suggest that some microalgae may be capable of aerobically degrading certain dangerous contaminants. It is well known that certain species of microalgae, such as Chlorella, Ankistrodesmus, and Scenedesmus, are capable of degrading organic contaminants and have been used successfully to clean up paper mill and olive oil factory wastewater in the past.

These examples show that microalgae may help degrade environmental contaminants in two ways: either by undergoing a direct transformation of the pollutant in question or by increasing the degradation capacity of the microbial population present. Value-added goods may be easily crafted from the biomass left over after wastewater treatment. This biomass may be utilised for a variety of purposes, such as animal feed supplements, the manufacture of biofuel, the extraction of value-added products like carotenoids or other bio-molecules, and many more.[13]

MICROALGAE ROLE IN EFFLUENT REMEDIATION

Since microalgae are effective bioremediation agents, they are being used in many wastewater treatment facilities. There are now available technologies such as the Advanced Integrated Wastewater Pond System (AIWPS). High-rate algal ponds (HRAPs) are the most common type of algal pond, and they are shallow and reliant on mechanical mixing to achieve maximum microalgal production and eliminate biological oxygen requirement. Facultative ponds, on the other hand, are deeper and promote the development of microalgae at the water's surface. HRAP reactors, used for treating pig farm waste, are the most cost-effective method of controlling liquid waste and harnessing solar energy.

Typically, microalgae play a key role in the treatment of home wastewater in maturation ponds and small to medium-sized municipal wastewater in facultative or aerobic ponds. They use the carbon dioxide (CO2) produced during bacterial respiration as fuel, which helps remove nutrients, pathogens, and heavy metals while also providing oxygen to heterotrophic aerobic bacteria, which mineralizes organic pollutants. Photosynthetic aeration is an exciting option for mechanical aeration since it can reduce running costs and the risks of pollutant volatilization. Recent research suggests that microalgae may be capable of aerobically degrading a variety of harmful contaminants. It is well-known that microalgae may degrade organic contaminants; Chlorella, Ankistrodesmus, and Scenedesmus species have been successfully used to clean up paper mill and olive oil factory wastewater in the past. This process, known as phycoremediation, makes use of both macro- and microalgae.[14]

i. Nutrients Removal by microalgae

Natural water's capacity to self-purify organic contaminants thanks in large part to microalgae. Heavy metals, pesticides, organic toxins, inorganic toxins, and viruses are just some of the pollutants that microalgae have been proven to absorb or use from the water they are in. Microalgae have been shown to have the potential for effective use in wastewater treatment due to their bioaccumulation abilities.

Microalgae have the potential to be used efficiently for the extraction of large quantities of nutrients due to their high protein (45-60% of microalgae dry weight), nucleic acid, and phospholipid synthesis needs for nitrogen and phosphorus. Because photosynthesis raises pH, NH3 stripping or NH3 precipitation might theoretically increase nutrient removal.

ii. Organic pollutants Removal

Increasing the growth of cells in the presence of contaminants is one technique to test microalgae for their potential to biodegrade organic waste. The achlorophyllous alga Protothecazopfii used as a model organism for these research because of its ability to break down the petroleum hydrocarbons present in Louisiana crude and motor oils. An inducible catabolic mechanism was identified as the cause of the deterioration. They also discovered that aniline, a byproduct of azo colour degradation, was broken down by the microalgae. A further investigation found that the dietaryly flexible chrysophyteOchromonasdanica could grow heterotrophically on either phenol or p-cresol as the sole source of carbon up to doses of 4 mM. However, wastewater may be cleaned using a combination of microalgae and bacteria.

Microalgae's ability to produce oxygen through photosynthesis minimises the amount of mechanical aeration needed for wastewater treatment, which is especially helpful when volatile contaminants need to be biodegraded aerobically yet shouldn't evaporate. However, it is more plausible that CO2 reduction and biofuel generation might be integrated with the microalgae-bacterial treatment of wastewater.

ENVIRONMENTAL IMPACT ASSESSMENT

An environmental impact assessment is a thorough analysis of how a major project (or other activity) can affect the surrounding environment (EIA). It is standard practise to carefully evaluate the implications of a proposal before determining whether or not to move forward with it. An EIA report detailing the most probable main environmental impacts is required. There will be both open and closed discussions as part of this evaluation. To manage the environment in a proactive and inclusive manner, EIA is a useful tool.

From these activities, EIA draws its fundamental purpose, which is to educate decision-makers on the environmental consequences of their actions. By using these measures, we can guarantee that only desirable growth will occur. To do this, EIA suggests modifying the processes for development proposals as required to lessen the impact of any unintended consequences. While EIA may lead to the rejection of certain proposals, its primary goal is to mitigate any unintended ecological consequences. There are presently over 100 countries that employ EIA, with many of them being developing and transitional economies that have legislated and institutionally supported its use. [15]

CONCLUSION

Algae are used in a process called phytoremediation, in which nutrients and xenobiotics (such as drugs that are not naturally occurring in the human body) are removed from wastewater and waste carbon dioxide (CO2) is converted into a usable form. It would seem that algae would be the perfect organism to utilise in laboratory remediation investigations due to its ease of growth, adaptability, and manipulation. Finding algae strains capable of efficiently and cheaply removing the pollution from the environment is the ultimate aim of this research. The potential of algal groups to rapidly, efficiently, and effectively decolorize the dairy effluent and to be employed as an alternative to more costly materials has been investigated in light of the worldwide recognition for the removal of environmental pollutants using less expensive biological means.

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