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MICROALGAE CULTIVATION: AN OVERVIEW

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ABSTRACT

The paper reports regarding Microalgae, that grow in aquatic environments, area unit easy microscopic heterotrophic and/or plant life chemical action organisms, starting from animate thing to multi-cellular in type. In distinction to aquatic plants, microalgae don't have real embryos, roots, stems or leaves. They're ready to use water, sunlight, and dioxide to synthesize biomass through chemical change,

KEY WORDS : *Microalgae Heterotrophic & CO_2.*

INTRODUCTION:

The artificial biomass will be born-again into biodiesel, fertiliser and different helpful merchandise. Over forty, completely different species of microalgae are known (Fuentes- Grunewald et al. 2009), and most of them have a high content of lipids, accounting for between twenty and five hundredth of their total biomass (Chisti 2007). the general reaction method will be summarized as follows:

$6CO_2 + 12H_2O + photons = C_6H_{12}O_6 + 6O_2 + 6H_2O$

Apart from daylight and carbonic acid gas, water, N and phosphorus square measure the 3 major inputs for protoctist growth. Major nutrients like N and P alone contribute to regarding 10–20% of protoctist biomass (Benemann 1996). further as macro-ingredients as well as N, P, Mg, Na, Ca, and K, micro-ingredients like Mo, Mn, B, Co, Fe and zinc are needed. In general, the expansion of microalgae goes through four parts (Figure 1): lag phase, exponential part, stationary part.

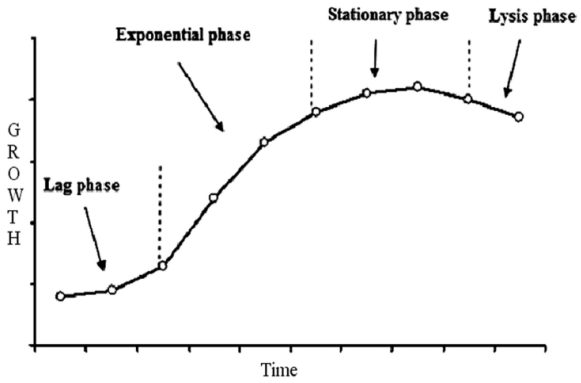

Figure 1. Algae growth phases

Culture parameters

Specific environmental conditions, that vary between microalgae species, are needed so as to with success cultivate microalgae. Factors that influence microalgae growth embrace (Mata et al. 2010): abiotic factors like intensity level, temperature, O_2, CO_2, pH, salinity, nutrients (N, P, K, etc.) and toxins; organic phenomenon factors like microorganism, fungi, viruses, and competition for abiotic matters with different microalgae species; operational factors like intermixture and stirring degree, dimension and depth, dilution rate, harvest frequency, and addition of hydrogen carbonate. The widely most vital factors are represented within the following sections.

Light

Light is that the energy input supply for the chemical action of microalgae. Light weight accessibility and intensity is one amongst the key parameters impacting the expansion performance of microalgae culture. Once the sunshine intensity is at a reasonably low level, for example, below the compensation purpose, there's no internet growth (Long et al. 1994; Alabi et al. 2009; Ye et al. 2012). Once the compensation purpose, because the candlepower will increase, the expansion will increase till the sunshine saturation wherever the chemical action rate is that the most. Once now, no increase in rate can seem once increasing the sunshine intensity, since it'll cause photoinhibition (Henley 1993; Ye et al. 2012). When the microalgae culture concentration is low, each microalgal cell will capture the sunshine. The microalgal cells may lack self-shading, that may cause photoinhibition (Alabi et al. 2009). To avoid this, the sunshine intensity shouldn't be too high. once the microalgae culture concentration is high, it's unacceptable for the sunshine to penetrate deeply into the culture; additionally, solely the highest layer will absorb the obtainable lightweight, deed the remainder within the dark – this is often referred to as over-shading. The highest layer may face lightweight saturation and inhibition, since most microalgae reach lightweight saturation at around 2 hundredth of star candlepower (Pulz 2001; Torzillo 2003). Correct mixture is one resolution to those problems, permitting the cells to maneuver around, so expeditiously increasing chemical action.

Temperature

Temperature is another key limiting factor, especially for outdoor cultivation systems. Generally, microalgal growth increases exponentially as temperature increase to an optimal level, after which the growth rate declines. Temperatures below the optimal range and above freezing will not kill microalgae, and many microalgae can easily tolerate temperatures up to 15°C lower than their optimal (Mata et al. 2010). Keeping cultures at temperatures above the optimal will result in total culture loss (Alabi et al. 2009). Generally, temperature must remain within 20 to 30°C to achieve ideal growth (Chisti 2007). In outdoor systems, overheating issues might occur, and thus water-cooling systems should be considered to make sure the temperature will not exceed the optimal range.

Nutrients

Generally, the composition of microalgae is CH1.7O0.4N0.15P0.0094 (Oswald 1988). Thus, the macronutrients ought to contain chemical element and phosphorus (silicon is additionally needed for seawater algae). additionally, trace metals, such as, Fe, Mg, Mn, B, Mo, K, Co and Zn, also are required. The nutrients used may be provided within the type of straightforward, simply offered agricultural fertilizers. However, vital prices are going to be incurred here. Several studies have reportable that N or P deficiency or limitation throughout microalgae cultivation will improve the lipide accumulation and transformation for many species (Khozin-Goldberg and Cohen 2006; Hu et al. 2008; Devi and Mohan 2012; Feng et al. 2012). In follow, microalgae square measure civilized fully media with enough nutrients within the early stages, whereas in later stages nutrient deficiency or limitation has to be designed to enhance the lipide content. Ito et al. (2012) found that chemical element deficiency conditions may cause a decrease in amino acids in protoctist cells to 1/20 the number or less, whereas the quantities of neutral lipids hyperbolic greatly. Devi

and Mohan (2012) advised that the hold on carbohydrates from the expansion part would possibly channel towards the formation of triacylglycerides (TAGs), resulting in economical composition for biodiesel production. Recently most forms of effluent are tested for microalgae cultivation. The N and P removal primarily results from the uptake of microalgal cells throughout growth (Su et al. 2011). Moreover, microorganisms (if existing in microalgae culture) may contribute to the nutrient degradability. Ammonia (NH4+), nitrate and radical may be degraded via nitrification (Eq. (1)) and denitrification (Eq. (2)) by some special bacterium (Zhu et al. 2011a), as shown within the following equations (Eq. (1) and atomic weight. (2) is capable atomic weight. (3)). Inorganic chemical element within the type of nitrate once nitrification may be absorbed by protoctist cells or continues to be degraded into gas chemical element. For phosphorus reduction, physical and chemical reactions like absorption, activity and alluviation or precipitation play a awfully necessary role (Ruiz-Marin et al. 2010). Phosphate may be degraded to some extent through microbic activities (Kim et al. 2005; Oehmen et al. 2007). additionally, if the hydrogen ion concentration of microalgae culture will increase, it'll additionally contribute to the P removal via P precipitation (Ruiz-Marin et al. 2010). Metal ions like atomic number 20, metal and iron will react with phosphate and calm down. for instance, Eq. (4) shows that phosphate reacts with ionic atomic number 20 and is removed as a solid.

$$NH_4^+ + 2O_2 + 2HCO_3^- \rightarrow NO_3^- + 3H_2O + 2CO_2 \quad (1)$$

$$5C + 4NO_3^- + 2H_2O \rightarrow CO_2 + 4HCO_3^- + 2N_2 \quad (2)$$

$$4NH_4^+ + 8O_2 + 5C + 4HCO_3 \rightarrow 2N_2 + 10H_2O + 9CO_2 \quad (3)$$

$$10\ Ca^{2+} + 6\ PO_4^{3-} + 2\ OH^- \leftrightarrow Ca_{10}(PO_4)*6(OH)_2 \downarrow \quad (4)$$

CO_2 addition and O_2 removal

The microalgal biomass contains a high proportion of carbon, around 45–50% (Alabi et al. 2009). CO_2, plus acetic acid, sugar, etc., is the carbon source for photosynthesis. Algal growth limitation might occur if algal culture is supplied only from air, which only contains 0.033% CO_2. Extra CO_2 can be blended with air and injected into algae cultures via gas addition facilities (Mata et al. 2010). CO_2 is expensive, so the use of it can increase the costs. In practice, air can be introduced into a deep level underwater via air stones to improve the efficiency of CO_2. Another method is to introduce CO_2-rich industrial flue gas into the cultures.

During photosynthesis, CO_2 is used and O_2 is generated. If O_2 cannot be emitted into the air and its concentration exceeds saturation, it will cause photo-oxidative damage to chlorophyll reaction centers, thus inhibiting the process of photosynthesis and reducing biomass productivity (Alabi et al. 2009). In open algae systems, this phenomenon will not happen, since there is an interface between atmosphere and medium and O_2 can be emitted easily and freely. Nonetheless, as to the closed systems such as closed PBRs, additional facilities such as gas exchangers are required (Mata et al. 2010).

Mixing

As already discussed above when the culture concentration is high, the light cannot penetrate, thus reducing biomass productivity. Therefore, mixing is necessary to make sure all algal cells are suspended with identical access to light. Mixing is also useful to mix nutrients and help the cells' uptake of these nutrients. Additionally, mixing can also make gas exchange more efficient.

pH and salinity

Usually, suitable pH value for algae culture is 6–8 (Zeng et al. 2011). However, different sources of media have different pH values. Also, influenced by CO_2, the pH values are changeable during cultivation. However, algae species seem to be more tolerant of the broad range of pH values. Lam and Lee (2012) cultivated *Chlorella vulgaris* in media with pH values of 3, 4, 5, 6, 7, 8 and 9, and came to the conclusion that

there was no great difference in the growth characteristics of the algae. Of course, the tolerance ability of is species-dependent.

Due to evaporation, salinity might increase during algae production. Too high a degree of salinity is harmful for algae cells since it might change their shape and structure due to the water pressure between media and cells (Mata et al. 2010).

Culture vessels

Microalgae can be manually cultivated. In total, it has been found that more than 50,000 microalgae species exist; only about 30,000 species, however, have been studied and analyzed until now (Richmond 2004). From a technological point of view the most practical and mature way to cultivate microalgae is to use ponds and photobioreactors (Chisti 2007).

Biomass harvest and drying

Microalgae concentrations are always low, and their size is only a few micrometers (1 to 30 µm), which makes the harvesting and further concentration of algae difficult and therefore expensive (FAO 2009). It has been suggested that harvesting including drying contributes 20–30% of the total biomass production costs (Mata et al. 2010). The harvesting cost could be significantly reduced by optimizing various processes; however, current studies are not conclusive enough to propose such optimal harvesting processes. Thus, further R&D efforts are still required.

Basically, most common harvesting methods include sedimentation, filtration, flotation and centrifugation, sometimes with an additional flocculation step or a combination of flocculation–flotation (Mata et al. 2010). The aim of harvesting is to obtain slurry with at least 2–7% of total solid matters (SEI 2009); the microalgae can achieve up to 20% of total solid matters when using centrifugation (US Department of Energy 2010).

CONCLUSION

After harvesting the next step is dewatering and drying. Drying needs lots of energy and thus is the economic bottleneck of the entire process. The most common methods include spray-drying, drum-drying, freeze-drying and sun-drying (Mata et al. 2010). Sun-drying is cheap, but it is geography-dependent and will require extra space and considerable time.

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