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THE ROLE OF PHYSICAL CHEMICAL PARAMETERS ON DIATOMS GROWTH -A REVIEW

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Abstract

Diatoms comprise a group of phototrophic microalgae with worldwide dominance in higher latitudes and have also been identified as a promising candidate for pharmaceutical, nutraceutical and biofuel production. They are one of the major elements of the marine as well as of fresh water phytoplankton. In the world's oceans, diatoms help in 40% of the primary productivity of the oceans. Diatom cultures are widely utilized for feeding shrimp larvae, zooplankton, juvenile oysters, and act as lipid sources, biofuel precursors, optical sensors in nanotechnology. The present work is a review of the different parameters such as pH, silica, temperature and amino acids which encompass their effect on diatom growth. Variable temperature influenced the diatom growth rate, cell size, biochemical composition and nutrient requirement. Alkaline pH results in the increase in triglyceride accumulation and acidic pH will result in the alteration of the nutrient uptake of diatoms. Thus, the growth study by altering different physical and chemical characteristics will provide a means to analyze and isolate biofuels, secondary metabolites, vitamins, carotenoids and fatty acids from the diatoms.

***Keywords*:** Diatoms, Silica, Growth rate, Biomineralization

Introduction

Diatom plays an important role which acts as a primary producer in various vast ecosystems which includes the artificial aquaculture ponds where they contribute in maintaining the water quality by consuming the excess of nutrients (Li *et al*., 2017). A variety of environmental factors can affect the growth as well as the cellular composition of the diatom both in the natural as well as in the artificial conditions (Juneja *et al*., 2013). The quality of water is also controlled by the diatoms by acting as bioindicators. This study is going to show the effect of various micro and macronutrient on the growth of diatom. Tested diatoms will show different lipid accumulation to the variations of the nutrients supplied to them. Optimal concentration of the nutrients is selected for a given species and then the variations are to be observed for the test samples. Extensive optimization of the macro and micronutrient concentration will also offer various benefits of the decreased material inputs and waste generation, improved biomass productivity, and overall cost saving (Ghafari *et al*., 2018). This literature survey showed the effect of environmental factors which include the light, silica, pH and the availability of nutrients as well as the special focus on the growth of the diatoms (Li *et al*., 2017). This study would be very useful to investigate whether macro and micronutrients are needed as the important parameter for controlling the growth of the diatoms (Hassler *et al*., 2012).

Diatom-Structure and Function

The most dominant groups of phytoplankton in world's ocean are diatoms which help in 40% of the primary productivity of the seas. Thus diatoms act as the major component in the carbon production as well as in the food web. The most abundant group found in the arctic-ocean are diatoms (Zhang *et al*., 2017). Diatoms are silicified algae in the range of 5-200mm in width or length. Diatoms are practically single cells, but in some cases, they show up in a nature of different forms. They have different configurations and size. The outer cell wall is made up of silica and is known as frustule. The organs of the cell are enclosed by silica cell walls. The frustules have two different parts, the outer one is known as *epitheca* and the inner one is known as *hypotheca* (Round *et al*., 1990). The frustule is covered by the mucopolysaccharide material under the natural condition. A longitudinal slot in the theca called as *raphe* is found in the one or two valve of some pennate diatoms. In case of *Nitzschia*, the raphe is continuous from pole to pole, but on the other hand, sides are separated into the two parts by the central nodule. In the central position of some pinnate diatoms which does not have raphe system, an ornamented area is known as *pseudoraphe* (Sabater, 2010). This outer layer has different roles such as it protects the cell from photo inhibition, provide more rate of uptake of nutrients, acting as a mechanical defense against grazer. Thus the content of silica is different both within and among species based upon their size, environmental factors (which include light, temperature, nutrients) and growth phase (Zhang *et al*., 2017). For the determination of the taxonomic specificity of the diatoms the following points should be considered (Round *et al*., 1990): shape of the body of the valve, the length to breadth ratio, forms of apical, axial and central areas of the cell, structure of raphe and position of raphe.

When reducing conditions are not extreme, the silica wall allows for the natural preservation in sediments. Diatoms are easy to hold and maintain. Diatoms are classified into two orders: Centrales – have the radial symmetry, valve striae arranged basically in relation to a point whereas Pennales – have bilateral symmetry, valve striae arranged in relation to a line (Sabater, 2010) (Fig 1).

Cell cycle of diatom

In the diatoms, the diploid forms are dominant over the haploid form which means that they mostly exhibit the diplontic lifecycle (Edlund and Stoermer, 1997). Asexual reproduction (Fig. 2(a)) is the mostly followed by diatoms in the form of vegetative reproduction. In this form of reproduction from the parent cell the daughter cell is formed by the process of mitosis. The parent valve is called as the epivalve, inside of which the hypovalve is formed. So the daughter cell contains the valve from the parent as epivalve and newly synthesized daughter cell as hypovalve. The one daughter cell from the parent epivalve have the same size as that of the parent cell while the other synthesized daughter cell from hypovalve is slightly smaller in size as compared to that of the parent cell. Thus, with the successive division in the population, the cell size decreases. With the reduction in the cell size the cell dimensions also change. The entire range in which the population's size and shape changes that is known as Size Dimeinution Series (D'Alelio *et al.*, 2009). The regaining of the maximum size in the diatoms is done during the formation of the auxospore- a specialized cell called as perizonium. It is the other type of reproduction, called as sexual reproduction (Fig. 2 (b)). In the sexual reproduction the fusion of male and female gametes takes place, followed by the meiosis and which lead to the formation of the auxospore (D'Alelio *et al.*, 2009). The expansion of the auxospore will decide the basis of the shape of the each diatom species. Auxospore is having the silica band on it rather than having the rigid silica cell wall. This will then allow the auxospore to expand to its maximum size and after reaching its maximum size the frustules are produced by the expanded shape of the auxospore. In case of the adverse conditions such as lack of nutrients and very low temperature, the diatoms from the resting cells. The process of reproduction among the diatoms is mostly asexual as compared to the sexual. It has also been seen that in cases in which auxosporulation has not been occurring directly, the changes in the shape and size of cells (vegetative cells) does not occur (Mann and Round, 1988).

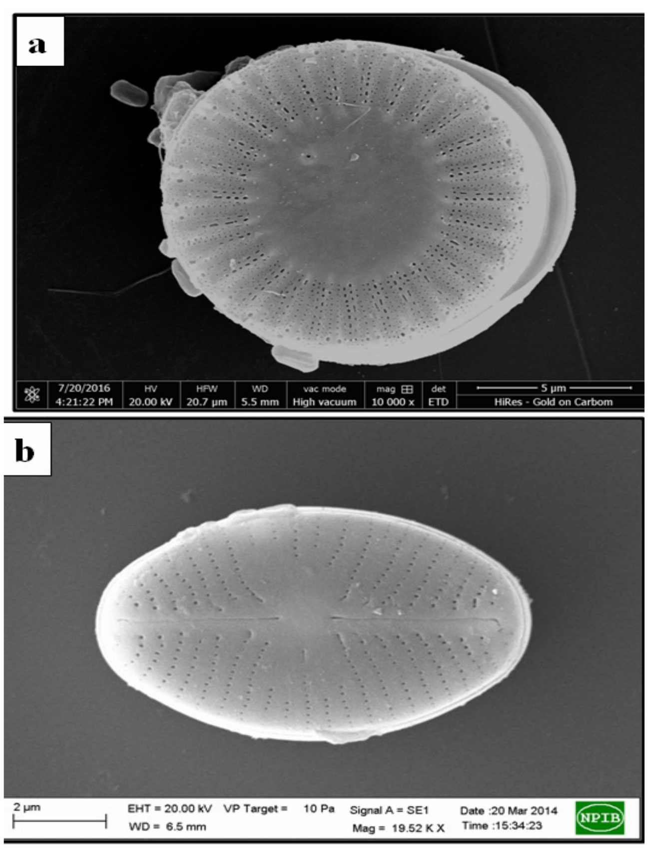

Fig. 1: Scanning electron micrographs of different diatom species. (1) *Cyclotella meneghiniana* (order-centrale) (2) *Diadesmis confervacea* (order-pennale) (Kumar *et al.*, 2018)

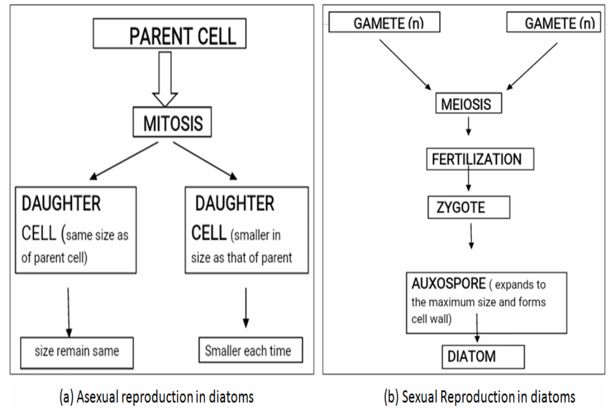

Fig. 2: Diagrammatic representation of life cycle of diatoms (a) asexual reproduction in diatoms and (b) sexual reproduction in diatoms.

Effects of Physical, chemical parameters on diatom growth

(i) Effect of pH and growth rate

Different species of diatoms may vary their growth at different pH. It was observed that the growth of *P.australis*, *Pseudo-nitzschia* sp., *P. calliantha, P. fraudulenta*, *P. multiseries*, *P. pungens*, *P. seriata*, *P. granii* and *P. cf. turgidula* stopped at 8.7-9.1 pH value, whereas the growth of two diatom sp. (*P. delicatissima* and *N. navis-varingica*) was higher at pH 9.3-9.8 (Lundholm *et al.*, 2004). *Skeletonema costatum* is one of the common species of diatoms found in the coastal water in the Atlantic. It has the appearance of a chain of 3-15 cells because the cells remain attached to each other even after cell division. This species is easy to obtain and cultivate. It is mostly used in aquaculture (Taraldsvik and Myklestad, 2000). At different pH value, marine diatom *Skeletonema costatum* was cultivated. At a pH of 6.5-8.5 the growth rate was constant and at pH >9 the growth rate was declined. It may be caused due to the decrease in the rate of important biochemical reactions, which also induce the changes in the properties of the cell membrane (Taraldsvik and Myklestad, 2000).

(ii) Effect of carbon production and concentration of amino acid

It was determined that there is a rapid reduction in the organic carbon production due to fluctuations in the pH. At pH 6.5-8.5 the organic production was 5.3 mg/L and at pH 9.0-9.4, it was decreased to 2 mg/L to 1mg/L (Taraldsvik and Myklestad, 2000). β-1-3 linked glucan also decreased from pH 6.5, it was 7.1 mg/L and at pH 9.4 it was 0.2mg/L. The cellular concentration of amino acid varies from the concentration of 62-8mM at a pH range of 8.0-9.4. At pH 9.4 the concentration of glutamine was below detection limit (Lundholm *et al.*, 2004).

(iii) Effect of temperature on diatoms

Several researches were done on the biological control of biosilification (Patwardhan and Clarson, 2002; Brzezinski, 2008; Fu *et al.*, 2019; Vrieling *et al.*, 2007). When a marine diatom *Thalassiosira pseudomonas* was grown on the different temperature [14ºC, 18Cº, and 23Cº] (Javaheri *et al.*, 2015) and, it was seen that at different temperature, the different kind of dependent growth phases was seen. After that the morphology was seen with the help of scanning electron microscopy. The different pattern which was seen are as follows- Silicon rich- mesh like and Silicon less- tree like. It is seen that cells which are grown at 14ºC and 18ºC is more actively dividing in silicon limited condition by developing a tree like pattern (Javaheri *et al*., 2015).

Biomineralization : The silica is distributed in a well defined mannered. The frustule of the diatom is made up of silica (Kleitz *et al*., 2001; Losic *et al*., 2007). The dissolution of SiO_2 depends upon the certain factors which include- temperature, concentration of dissolved silica, and the activity of the bacteria. Diatom adapts itself to the environmental changes (Hildebrand, 2008). If the silica supply is less the cell cycle does not stop, but it limits the growth of the cell. This slowing down of the cell cycle does have certain benefits from the breakup of the silicate from the frustules of the neighboring diatoms. In case of the silicon limited environment, it has been observed that the amount of the silification per cell decreases, which results in the thin cell walls (Javaheri *et al*., 2015). By assessing the effect of temperature changes on the diatoms, it further leads to generate the data of changes occur in the shape, size, biomass and growth rate (Montagnes and Franklin, 2001).

(iv) Effect of silica variations on diatoms

Effect of variation of silica has been studied in the field of taxonomy, physiology, ecology and geochemistry. The content of silica is different among species to species (Conley *et al*., 1989; Paasche, 1973). All these variations can occur during the time of the cell division and with the effect of other factors also such as growth rate, light, nutrient limitation, and temperature. In the case of marine and freshwater diatoms, there has been seen the physiological difference in the utilization of the dissolved silica. It has also been seen that the pennate diatoms of the freshwater is having slightly more heavily silicified as to that of freshwater centrales diatoms (Conley *et al*., 1989). Tuchman (Tuchman *et al*., 1984) found that the cells of *Cyclotella meneghinia* Kutz from the culture, having the highest concentration of NaCl probably of 660-400 mg l^{-1} Cl had lower silica content to that of cells, which are grown at low concentration of NaCl even when the initial concentration of the dissolved silica was same. Previous study of Olsen and Paasche (Olsen and Paasche, 1986) it has been reported that it is not known that whether the salinity effect on silification are due to the direct effect of salt and osmotic pressure is not known (Conley *et al*., 1989). There is the significant variation in the dissolved silicon concentration, when the biological uptake of the dissolved silicon is done by organism and is transformed into the Biogenic Amorphous Silica (BSI). It was seen that the uptake of the silicon is irregular, that is, it can sometimes fluctuate during the time period. The dissolved silicon consumption is more that is, it is 90% during the growth of diatom (Hughes *et al*., 2011).

Conclusion

Diatoms are the major group of phytoplankton's. They are used in many applications such as dye sensitized solar cell, photovoltaic cells, biomonitoring, ante-mortem and post-mortem analysis etc. They can be grown in the artificial environment by providing all the necessary requirements. From the literature review, it is studied that the diatoms required a perfect culture conditions such as light and dark, silica, vitamins and other constituents for their proper and healthy growth.

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