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Opinion

Bioremediation By Dinoflagellates

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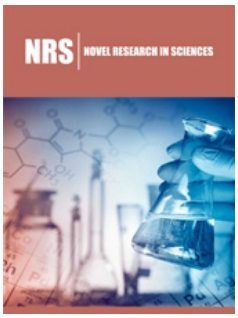

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Opinion

Dinoflagellates are the second largest group of eukaryotic algae, with 2,000 species already described to date [1] just behind the diatom group which has 100,000 species [2]. Both groups are the basis of many food chains. Besides the species diversity, dinoflagellates feature various forms, habitats and nutrition. According to Wojciechowski et al. [3] these organisms are distributed in diverse aquatic, marine, freshwater or estuarine environments and are usually dominant in the summer. Some of the species in this group can be found on ice sheets and are called cryophile. Although most species are planktonic, dinoflagellates have some representatives from marine benthic and epicontinental habitats. Zooxanthellae are also part of the group, which are symbolic species responsible for the high productivity in coral reef systems.

Despite their great diversity, dinoflagellates are widely known to produce harmful algal blooms, however only about 100 species have been shown to produce toxins [4]. Most of the toxic dinoflagellates are able of mixotrophic growth [5]. In other words, they can simultaneously photosynthesize and use organic sources of carbon for growth [6]. In the lack of light, mixotrophic species grow exclusively by heterotrophy, although in some cases the productivity may be lower than in phototrophic growth [7].

The ability to grow in mixotrophic environments gives to dinoflagellates a great potential to bioremediate eutrophic environments. The bioremediation process consists of the use of living organisms, especially microorganisms, as they have a high adaptability to environments with various characteristics, thus acting on the synthesis of environmental contaminants in less toxic forms [8]. Recent reports have shown that several microalgae strains are able to utilize nutrients from urban, industrial, and aquaculture effluents to produce biomolecules that can be improved to produce bioplastics, feed or biodiesel [9]. Effluents are waters rich in nitrogen compounds, phosphorus and organic matter, which make them suitable for use as a culture medium for dinoflagellates. In aquaculture effluents, for example, the main sources of ammonia are animal excreta and decomposition of debris, which are formed by unconsumed feed particles and animal feces which, when decomposed by heterotrophic bacteria in the mineralization process, can produce ammonia [10]. In closed cultivation systems, nitrogen uptake by microalgae and nitrification are the main processes of nitrogen cycling in aquaculture pond waters [11].

According to Schulze et al. [12] the use of microalgae in effluent treatment is considered economically and environmentally sustainable, as to remove dissolved nutrients they are able to produce valuable biomolecules offsetting water treatment costs. This is because microalgae act by improving the quality of the final effluent water through natural disinfection, as well as being able to incorporate contaminants such as heavy metals, pharmaceuticals, and endocrine disruptors [13].

Beyond of improving the water quality of environments with high nutrient loads, dinoflagellates have a high polyunsaturated fatty acid production capacity. Docosahexaenoic acid (DHA) is a polyunsaturated fatty acid belonging to the omega-3 group [14-16]. According to Yoon [17], dinoflagellates when fed with dry yeast were able to produce more docosahexaenoic acid (DHA) than when individuals were fed with *Amphidinium carterae*, which is rich in DHA and more expensive than dry yeast.

Among the main species of dinoflagellates that produce bioactive metabolites is *Karlodinium veneficum* [7,18]. This is a cosmopolitan species of temperate regions [19] producing karlotoxins, a group of toxins with potential to be used in the treatment of heart disease and some cancers [20]. *K. veneficum* is mixotrophic, being able to feed on prey as diatoms or even try to intake copepods [21] as an adaptive strategy for survival and growth in a nutrient-poor environment [19]. According to Burkholder et al. [5], in harmful algae mixotrophy combined with the allelopathic effect of toxins, can contribute to the formation and maintenance of the blooms. In addition, studies show that under conditions of lack of phosphorus and excess light, *K. veneficum* is able to reconfigure its cellular metabolic machinery and regulate dynamic protein expressions to cope with the stress caused by excess light, thus has a competitive advantage in times of global warming [22]. Therefore, *K. veneficum* proves to be an ideal species to be used for both ecological research and production of its biomolecules [21].

Due to these biological characteristics, the cultivation of dinoflagellates in effluents in order to add their biomass to feed formulation as a potential partial substitute for fishmeal, becomes very interesting for the aquaculture sector, since feed is one of the most expensive items and may reach up to 50% on intensive shrimp farms [23]. Among the ingredients used in such formulations, the application of fishmeal as the main protein source is responsible for raising the price of these products [24-26]. Thus, the use of dinoflagellates can provide a reduction in feed formulation costs without losing product quality. For this reason, new technologies, as well as the dinoflagellate culture, are being developed in order to use it as an alternative ingredient to those that are primarily intended for human consumption and may provide nutritional quality similar or superior to those traditionally used ingredients.

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