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Environmental impact assessment of *Chlorella vulgaris* employed in phycoremediation of effluent from a leather-processing chemical industry

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Abstract

In this study, *Chlorella vulgaris,* the micro alga used for the phycoremediation of effluent from a leather-processing chemical industry, was assessed for environmental impact. This was carried out by conducting plant and fish growth experiments using the biomass separated from phycoremediated water. The micro alga supported plant (*Cyamopsis tetragonoloba*) growth, which was more than that supported by control and hence the alga could very well be used as a bio-fertilizer. Fish (*Oreochromis mossambicus*) growth study revealed that *C. vulgaris* resulted in excellent gain in fish weight and could be used a cheaper source of feed. Thus, the micro alga was not only effective in effluent treatment, but also safe to the environment.

Key words:

Environmental impact assessment, *Chlorella vulgaris, Cyamopsis tetragonoloba*, *Oreochromis mossambicus*, phycoremediation.

1. Introduction

Environmental impact assessment (EIA) is the evaluation of the effects likely to arise from a major project (or other action) significantly affecting the environment. It is a systematic process for considering possible impacts prior to a decision being taken on whether or not a technology should be implemented. EIA requires, *inter alia*, the publication of an EIA report describing the probable significant environmental impacts in detail. Consultation and public participation are integral to this evaluation. EIA is thus an anticipatory, participatory environmental management tool.

The most immediate purpose of EIA, arising directly from these functions, is to study the likely environmental consequences of the method. This is with the aim of ensuring that development only proceeds in an acceptable manner. To fulfill this objective, EIA provides mechanisms for development proposals to be amended wherever necessary for amelioration of adverse impacts, if any. Although EIA may lead to the abandonment of certain proposals, its focus is more strongly on the mitigation of any harmful environmental impacts likely to arise. In addition to these 'proximate aims' (Sadler, 1996), EIA is increasingly being positioned within a broader context of sustainability and its original, substantive aim of contributing to more sustainable forms of development is being rediscovered (Glasson *et al*., 2005).

EIA has been given legal and institutional force in many other parts of the world, and it is now practiced in more than 100 countries (Petts, 1999; Wood, 2003), including many developing and transitional economies (Lee and George, 2000). Although it has been adapted to different contexts and circumstances, its basic intentions and core elements are widely agreed.

In this study, an attempt was made to assess the environmental impact of a microalga, *Chlorella vulgaris*, which was employed in the phycoremediation of effluent from a leather-processing chemical industry. In general, the benefits of microalgae outweigh and outnumber the harmful effects. They have an unusual breadth of nutritional quality when compared with conventional plants and consist of a broad spectrum of nutritious compounds such as peptides, carbohydrates, lipids, vitamins, pigments, minerals, polyunsaturated fatty acids (PUFAs), and other valuable trace elements. Now-a-days, there are numerous commercial applications of microalgae. For example, (i) microalgae can be used to enhance the nutritional value of food and animal feed due to their chemical composition and (ii) they play a crucial role in aquaculture. The high protein content of various microalgal species is one of the main reasons to consider them as an unconventional source of protein (Soletto *et al*., 2005). In addition, the amino acid pattern of almost all algae compares favorably with that of other food proteins. As the cells are capable of synthesizing all amino acids, they can provide the essential ones to humans and animals (Guil-Guerrero *et al*., 2004). Microalgae also represent a valuable source of nearly all essential vitamins (e.g., A, B1, B2, B6, B12, C, E, nicotinate, biotin, folic acid, and pantothenic acid) (Becker, 2004).

Therefore, the aim was to study the EIA of the green microalga, *C. vulgaris*, which was isolated from the effluent of a leather-processing chemical industry (a multinational company, which is one of the world's leading suppliers of leather-processing products), situated at Ranipet, Tamil Nadu, India**.** The effluent, apart from various inorganic and organic compounds, contains heavy metals, viz. lead, chromium, cadmium, copper, zinc and nickel. Hence, the microalga, after using for treating the effluent in the pilot-scale pond, was tested for environmental safety credentials. This was carried out by conducting plant and fish growth experiments using the biomass separated from phycoremediated water.

2. Methodology

2.1 Effect of *C. vulgaris* on plants (seed germination study)

Experiments were conducted to study the effect of *C. vulgaris* on the growth pattern of *Cyamopsis tetragonoloba* (cluster beans). The seeds were soaked in 3 mL of *C. vulgaris* culture (biomass separated after phycoremediation and resuspended in medium) overnight. Another set of seeds were soaked overnight in tap water and this served as the control. The following day, these seeds were planted at an optimum depth in plastic containers filled with about three-fourth with soil. The containers were sprayed with water on a regular basis and this was carried out for about a week. Then the total length, shoot length and root length of control as well as treated plants were measured and compared.

2.2 Effect of *C. vulgaris* on fish

In this experiment, the effect of *C. vulgaris* was tested on the growth of fish. Fifteen fishes (*Oreochromis mossambicus*) each were grown in three tanks with 20 L of water and the tanks were sufficiently aerated. All the three tanks were of dimension 50 cm (length) x 25 cm (width) x 25 cm (height). Tank 1 was fed with 0.5 g. of commercial fish feed, tank 2 with 0.5 g of sun-dried powder of *C. vulgaris* and tank 3 with 0.25 g commercial fish feed + 0.25 g *C. vulgaris*. The average lengths of the fish were measured after 21 days and their average weights measured once in 3 days for 21 days.

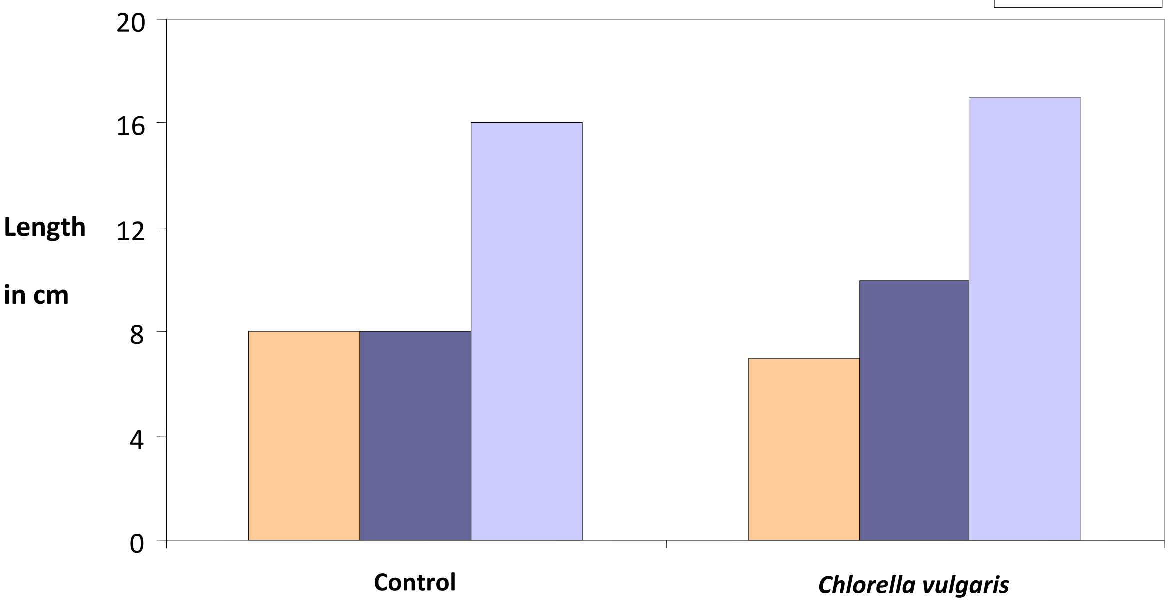
2.3 Statistical analysis

All data are expressed as mean ± standard deviation (SD). All analyses were carried out in triplicate and the difference between treatments was analysed by one-way ANOVA.

3. Results and Discussion

After treatment with the microalgal culture, the total length, shoot length and root length of *Cyamopsis tetragonoloba* were measured and compared with those of the control plants. The results showed that the treatment with *C. vulgaris* cells improved the germination of seeds tested (Fig. 1), i.e., the total length was more by nearly 6% in microlaga-treated plants when compared with that of control.

Fig 1. Effect of *Chlorella vulgaris* on germination of cluster beans



The average lengths of the fish were measured after 21 days (Table 1) and their average weights measured once in 3 days for 21 days and tabulated (Table 2). When fed with the microalga alone, the average increase in length of the fish was 22.5%, with commercial feed, it was 9.9%, and in combination of both, it was 14.8%. The difference between commercial and *C. vulgaris* feeds was statistically significant. Similar trend was observed in weight gain measurements also. When microalgae was used as a feed, the increase in weight gain was nearly 76%, whereas commercial feed exhibited 37% increase and combination type resulted in moderate weight gains (Fig. 2). The difference in weight gains was statistically significant between all the three groups.

Table 1: Effect of *Chlorella vulgaris* on the growth of *Oreochromis mossambicus* – Measurement of lengths after 21 days

S. No.	Type of fish feed	Average total length (cm)	
		Initial	Final
1	Commercial fish feed (Group I[b])	3.8 ± 0.2646	4.18 ± 0.1312
2	*Chlorella vulgaris* (Group II[a])	4.0 ± 0.15	4.9 ± 0.05
3	Commercial fish feed + *Chlorella vulgaris* (Group III[ab])	4.05 ± 0.1323	4.65 ± 0.0866

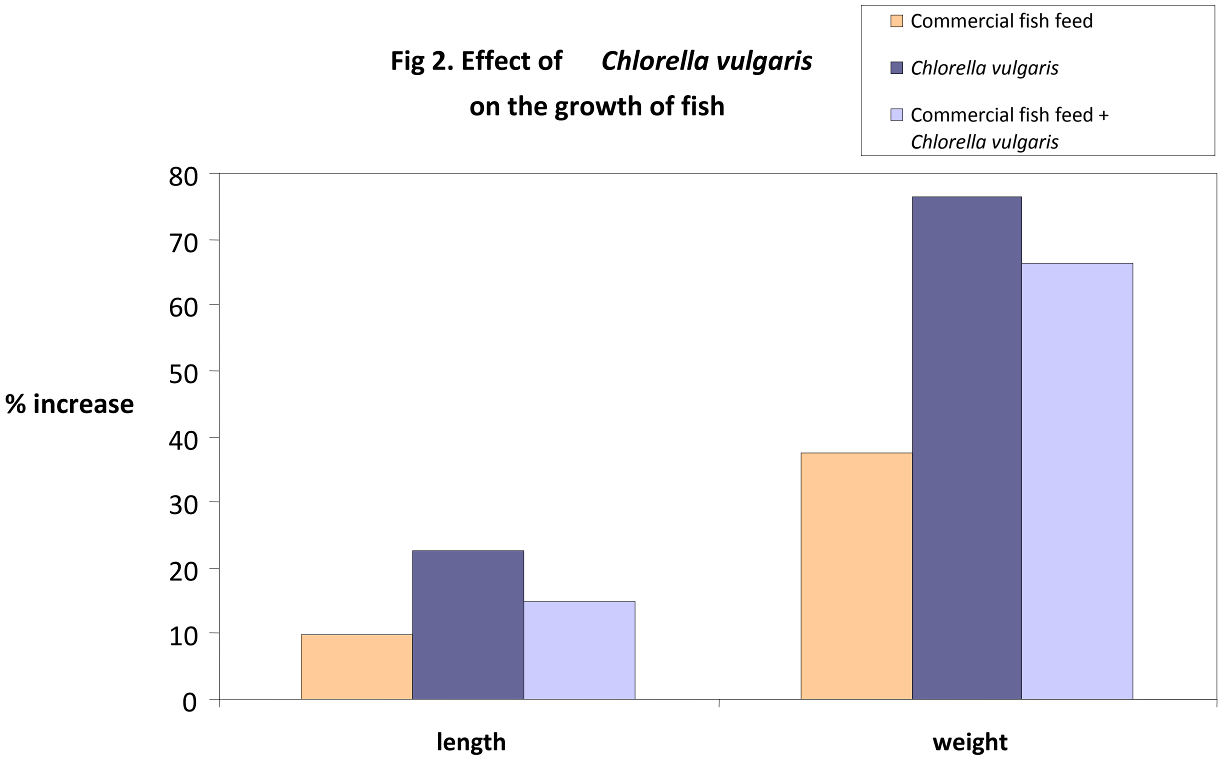
All values are presented as mean ± SD of triplicate analyses. Groups represented with the same alphabets are not statistically significant as analyzed by one-way ANOVA (5% level); LSD.

Table 2: Effect of *Chlorella vulgaris* on the growth of fish (*Oreochromis mossambicus*) – Growth measurement

Day	**Average weight of fish in grams**		
	Commercial fish feed (Group III[c])	***Chlorella vulgaris* (Group I[a])**	**Commercial fish feed + *Chlorella vulgaris* (Group II[b])**
0	1.17 ± 0.0087	1.19 ± 0.01	1.16 ± 0.0229
3	1.18 ± 0.005	1.20 ± 0.005	1.17 ± 0.0087
6	1.20 ± 0.01	1.24 ± 0.0132	1.19 ± 0.005
9	1.32 ± 0.02	1.59 ± 0.0265	1.59 ± 0.01
12	1.40 ± 0.0218	1.73 ± 0.0132	1.65 ± 0.015
15	1.51 ± 0.0132	1.80 ± 0.0397	1.73 ± 0.0132
18	1.59 ± 0.0087	1.90 ± 0.018	1.85 ± 0.025
21	1.61 ± 0.0218	2.10 ± 0.025	1.93 ± 0.0087

All values are presented as mean ± SD of triplicate analyses. Groups represented with the same alphabets are not statistically significant as analyzed by one-way ANOVA (5% level); LSD.

Fig 2. Effect of *Chlorella vulgaris* on the growth of fish



Future studies should compare the environmental conditions that might prevail without EIA with those with EIA so as to evaluate the effectiveness of EIA. The various aspects of environmental quality that might be improved as a result of EIA and even more elusive are the concepts of sustainable development and sustainability, which are increasingly being adopted as the fundamental goals of EIA. In this study, the phycoremediation technology using *C. vulgaris* was assessed for environmental impact. The microalgal supported plant growth was more than that of control and hence the alga could very well be used as a bio-fertilizer. Fish growth study revealed that *C. vulgaris* resulted in excellent gain in fish weight and could be used a cheaper source of feed. Thus, the microalga was not only effective in effluent treatment, but also safe to the environment. Thus, EIA carried out in this study to examine the safety credentials of the microalga proves that the organism can be used in implementing phycoremediation technology which in turn implies that both the organism and technology are safe.

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References

Becker, E.W. (2004). Microalgae in human and animal nutrition, In *Handbook of microalgal culture*, ed. A. Richmond, pp. 312-351. Blackwell, Oxford.

Glasson, J., Therivel, R. & Chadwick, A. (2005). *Introduction to environmental impact assessment.* Third ed. London: Routledge.

Guil-Guerrero, J. L., Navarro-Juárez, R., López-Martínez, J. C., Campra-Madrid, P., & Rebolloso-Fuentes, M.M. (2004). Functional properties of the biomass of three microalgal species. *J. Food Eng.*, 65, 511-517.

Lee, N. & George, C. editors. (2000). *Environmental assessment in developing and transitional countries*, Chichester, Wiley.

Petts, J. editor. (1999). *Handbook of environmental impact assessment*, Blackwell, Oxford.

Sadler, B. (1996). Environmental assessment in a changing world: evaluating practice to improve performance. *Final report of the international study of the effectiveness of environmental assessment*, Canadian Environmental Assessment Agency and International Association for Impact Assessment. Ministry of Supply and Services, Ottawa.

Soletto, D., Binaghi, L., Lodi, A., Carvalho, J. C. M., and Converti, A. (2005). Batch and fed-batch cultivations of *Spirulina platensis* using ammonium sulphate and urea as nitrogen sources. *Aquaculture*, 243, 217-224.

Wood, C.M. (2003). *Environmental impact assessment: a comparative review*. second ed. Harlow: Prentice Hall.