COSTS OF MICROALGAE PRODUCTION GROWING ON SEWAGE AND DRAINAGE WATER IN AQUACULTURE

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Abstract

Microalgae feeds are currently used in relatively small amounts in aquaculture, mainaly for the production of larvae, juvenile and adult fish, as well as for raising the zooplankton required for feeding of juvenile animals.

The operating costs for outdoor cultivation of microalgae were LE 34.76/ton live algae in sewage and drainage water. While the oven dry biomass *Chlorella vulgaris* and *Scenedesmus. bijuga* by cultivated on sewage water were LE 58.15 & 51.87/kg dry biomass respectively but on the drainage water were LE 54.65 & 50.12/kg dry algae, respectively. The microalgae production by wastewater and drainage water can reduce the costs for algae production 14.2% cheaper than by clean processes. In this study the labor cost represented the major count of the total operating costs (46.03%), followed by electricity (20.13%).

Introduction

A few years ago, microalgae have been increasingly produced for commercial purposes which include human and animal consumption, bioactive compounds for medicine, fuel production, biofertilizers, and as live feeds for the cultivation of filter feeding organisms. Currently, microalgal biomass production is economically feasible only when product values are relatively high, such as special chemicals and pigments, or when the microalgae play a critical role in aquaculture production (Spectorova *et al.*, 1997).

The main constraintion microbial production for aquaculture is the cost. The best US estimate gives a cost of greater than $US 50 kg-1 of dry algal biomass (Fulks & Main, 1991).

The cost is extremely high when compared with the costs of other commercial large-scale algal producers. The production costs of algae such as *Spirulina*, *Dunaliella* and *Chlorella* are of $US 15-20/kg dry algae (Borowitzka, 1992and Tanticharoen *et al.*, 1993).

Agriculture is superior to microalgal cultivation because of much lower capital costs and its ability to derive CO_2 from the atmosphere. On the other hand microalgae can use poor drainage soils and saline or low quality waters, generally unsuitable for agriculture and stites exist where climate, topography, water (most importantly), low cost (approximately equals $ 100/metric ton) and CO_2 are available for microalgae production (Benemann *et al.*, 1987). The treatment of liquid wastes with algae-bacteria systems is the most promising microalgal technology. It yields proteinaceous microbial biomass as a

(ISSN: 1110-8649)

comparatively inexpensive byproduct of the operation of high-rate algal ponds (Soeder, 1980).

Microalgae play an important role in the treatment of wastewater in the self purification of streams and natural standing waters as well as in stabilization ponds or oxidation ponds or lagoons (Dor, 1975).

Massive cultivation of *Spirulina* in waste-effluent media could improve the prospects for industrial production of this biomass, considering that the culture medium is an important factor in the production cost of the algal product. The biomass obtained from intensive cultivation of *Spirulina* in these wastewater media could be used as a pigment-protein supplement in animal feed as raw material for certain chemicals (Ayala & Vargas, 1987)

Schulz *et al.* (1985) found that the production cost of *Scenedesmus* will decrease from 7.56 US $/kg at a plant of 10 hectare. The investment costs are reduced from 241 US $/m^2 to 27.50 US $/m^2 net. Cultivation area, depreciation and maintenance of the equipment, remuneration, consumption of CO_2 and electric energy are the most important cost factors.

The objective of the present study was to estimate the costs of algae production cultivated on sewage and drainage water at Abbassa- Sharkia-Egypt.

Materials and Methods

An isolate of *Chlorella vulgaris* & *Scenedesmus bijuga* from Nile water samples according to Pascher (1915) was sampled. The microalgae were subcultured in a solid Bold's basal medium (BBM) (Bischaff & Bold, 1963). The medium was sterilized after the addition of 15-20 g L-1 of agar and then poured in Petri dishes. Algae inoculum previously cultured on slants were introduced to the surface of the solid medium. The cultures were allowed to grow in the algae culture room at 25 °C and 14/10 light-dark cycle (5000 lux). After each period, parts of the cultures were aseptically transferred into tubes containing the same solid medium and left to grow after which, the purity of the cultures was examined by bacteria free test.

The algal stock culture for indoor culture was prepared by growing algal cells in Erlenmeyer flasks (125 ml) to glass bottle (1 litre) into gallon jars (2.5 litres) next to glass carboys (20 litres) with BBM. Cells of BBM-grown *Chlorella vulgaris* and *Scenedesmus bijuga* were inoculated into a glass aquarium (100 litres) containing about 5 liter of inoculum to obtain an initial cell density of about 2.2 x 10^5 cells ml^{-1} (0.2g dry weight litre^{-1} and 1.19 mg l^{-1} pigment content for *C. vulgaris* and with 2.6 x 10^5 cells l^{-1} (0.27g dry weight litre^{-1} and 1.66 mg l^{-1} chlorophyll "a" content) for *S. bijuga*, respectively.

A 2-m^2 oblong concrete algal cultivation tank with associated filtration system containing two Aqua-pure dirt/rust filtered, pumping and circulated systems operated by a 1.5 horsepower (h.p.) pump was constricted next to the chlorination tank of the sewage and drainage water. Sewage and drainage water from the chlorination tank was pumped through the filtration system and then into the cultivation tank. Approximately 1.2 ton of sewage and drainage water was used to fill the cultivation tank. The algae cultures required about 5-6 days of cultivation to reached a maximum density as in Table (1). The cost of inculum was LE 6/L as referred previously (Dawah, 2000). Equipment and materials were depreciated using the straight-line method (Shang, 1981).

Table 1: Final density, chlorophyll "a" content, dry weight and yield of algae biomass of *C. vulgaris* and *S. bijuga* after cultivation for 6 day in sewage and drainage water.

	Sewage water		Drainage water	
Species⇒ / Parameter ⇓	*C. vulgaris*	*S. bijuga*	*C. vulgaris*	*S. bijuga*
Density (x 10^6 cell ml $^{-1}$)	5.80	5.11	6.10	5.22
Chlorophyll "a" (mg l $^{-1}$)	4.71	4.85	4.76	4.96
Dry weight (g l $^{-1}$)	0.70	0.80	0.75	0.83
biomass yield (g ton-1)	700	800	750	830

Initial (0 day): Density x 10^6 cell ml $^{-1}$ = 0.2, chlorophyll "a" (mg l $^{-1}$) = 1.11 and dry weight g l $^{-1}$ = 0.2 for *C. vulgaris* and density x 10^6 cell ml $^{-1}$ = 0.24, chlorophyll "a" (mg l $^{-1}$) = 1.6 and dry weight g l $^{-1}$ = 0.26 for *S. bijuga*.The costs of producing Bold's Basal medium (BBM) were LE 38.65/l and the operating costs of producing 1 ton of microalgae by clean processes were LE 40.53 / ton live algae (Dawah, 2000).

Results and Discussion

Single-cell technique was used for purification of inoculum. Initial and final population densities and the yield of the biomass of C. *vulgaris* and S. *bijuga* are shown in Table (1). The asset requirement for the production of microalgae was LE 14905.8 as shown previously in (Dawah, 2000).

Table (2) shows the cost of producing 1 ton of the above two microorganisms cultivated in sewage and drainage water. Operating costs were LE 34.76 / ton of live algae.

Table 2. Cost of producing live microalgae (Pound/ton)

Item	Quantity	Unit cost (LE)	Total	% of total
Inoculum	50 ml	0.006 /ml	0.30	
Bold's basal medium	10 ml	0.039 /ml	0.39	⇑ Nutrient
Agar	5 g	0.125 /g	0.625	⇓ 2.90
Clorox	1 l	1.50 /l	1.50	
Electricity	100 kwh	0.07 /kwh	7.00	20.13
Labor	16 h	1.0 /h	16.0	46.03
Depreciation			8.94	
Total operating cost/ton			34.76	

Fig. (1) shows the high cost of labor in the mass cultivation by waste processes which represent approximately 46.03% from the total operating costs, followed by the electricity, which recorded about 20.13% from the total costs. While the nutrients had the minimum cost (about 2.9% from the total costs). De Pauw and Persoone (1988), also Helm et al. (1979) reported that the following cost-breakdowns for culturing algae by the bloom induction technique : labor (50-85%), pumping (4-24 %), nutrients (4-20 %) and mixing (5-8 %) of the total production costs.

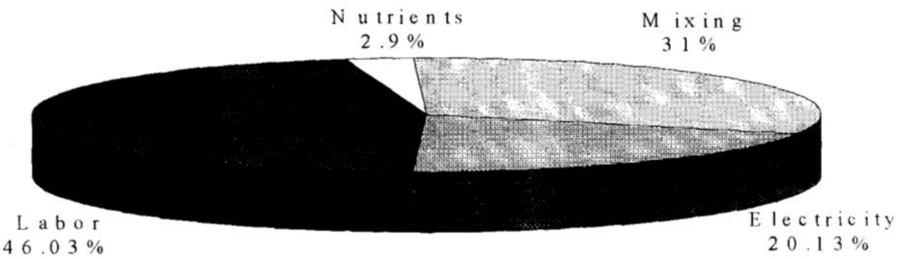

Fig. 1: Percentage of labor, electricity, nutreints and mixing costs of the total operating costs

The cost of production of 1 ton live algae on sewage and drainage water is about 14.2% cheaper than by clean processes. The wastewater treatment by algae is approximately 38% cheaper than by activated sludge (Shelef *et al* 1978b)

Shelef *et al.* (1978a) recommended that intensive algal wastewater treatment system advantaged by lower energy requirement for oxygenation, essentially no sludge accumulation, combination of biological and advanced treatment (nutrient stripping, virtual absence of pathogenic bacteria and viruses in the effluent, recovery of odour problems.

The cost of operating 1-kg oven dry biomass of microalgae cultivated on sewage and drainage water was shown in Table (3). The producing 1-kg oven dry biomass of microalgae required 6 kwh from electricity and 8 hours from labor.

Table 3. Cost of operating 1-kg oven dry biomass microalgae.

Species	Yield/ton live algae	quantity (ton)	Total cost (LE)	Total operating cost / kg
Sewage water				
C. vulgaris	700	1.43	49.70	58.12
S. bijuga	800	1.25	43.45	51.87
Drainage water				
C. vulgaris	750	1.33	46.23	54.65
S. bijuga	830	1.20	41.70	50.12

The total cost of electricity and labors required for producing 1kg dry biomass algae was LE 8.42

The limitations to greater use of microalgae feeds are both technical and economic in some cases the problem is how to mass culture desirable species. In others the cost of production must be reduced (Benemann, 1992).

The availabilty of low cost algal concentrates would also allow the blending of these concentrates to produce nutritionally superior feeds (Borowitzka, 1997).

The production of microalgae such as *C. Vulgaris* and *S. Bijuga* on secondarily treated sewage and drainage water can reduce the economics for production of microalgae by clean processes.

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تكاليف إنتاج الطحالب على مياه الصرف الصحى والزراعى فى المزارع السمكية

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يتم استخدام العلائق المكونة من الطحالب الدقيقة بكميات صغيرة نسبيا فى الاستزراع السمكى فى الوقت الحالى بصورة اساسية فى انتاج اليرقات والاصبعيات والاسماك الكبيرة أو البالغة كما يستخدم أيضا فى تنمية الاحتياجات المطلوبة من الهائمات الحيوانية اللازمة لتغذية اليرقات.

وقد تم تقدير تكاليف زراعة الطحالب فى مرحلة الاستزراع المفتوح وكانت ٣٤,٦٧ جنيه مصرى/طن طحالب حية المرباة على مياه الصرف الصحى والزراعى بينما كانت تكاليف ثمن كلوريلا فولجارس وسينيدسمس بيوجا المرباة على مياه الصرف الصحى المجففة كانت ٥١,٨٧,٥٨,١٥ جنيه مصرى لكل كجم طحالب جافة على التوالى بينما كانت التكاليف للطحالب المرباة على مياه الصرف الزراعى ٥٠,١٢,٥٤,٦٥ جنيه مصرى/كجم طحالب جافة على التوالى.

ان انتاج الطحالب على مياه الصرف الصحى والزراعى يقلل من تكاليف انتاج الطحالب بـ ١٤,٢ % أرخص من استخدام الماء النقى. وكانت تكاليف العمالة الكم الأعظم من عملية التكلفة (٤٦,٠٣ %) ثم استخدام الكهرباء ٢٠,١٣ %.