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CULTURES OF THE SELECTED STRAINS OF ALGAE ON DOMESTIC SEWAGE

The possibility of the development of different genera of *Chlorophytae* in raw domestic sewage has been investigated. The cultures of 21 selected strains were conducted in domestic sewage, both pure and diluted with synthetic Uspienski's medium, the latter being used as the control. The development of algae was estimated basing on the increment of their dry weight and protein content. It appeared that the particular strains differed both in dry weight and protein content, and that raw domestic sewage was the most advantageous medium for the development of algae. The highest increments in dry weight and protein content were stated in strain No. 394.

1. INTRODUCTION

The possibility of an intense culture of algae in mineral media stated in fifties gave rise to further investigations on the algal cultures on treated wastewater. The results obtained, namely an intense growth of algae due to utilization of some components of wastewater have allowed us to expect that this method can find its practical application [1], [2], [5]. The culture of algae in some kinds of wastewater, on the one hand, could be a cheap source of protein and, on another hand, by purifying wastewater and thus preventing the eutrophication of receivers could compete with conventional methods of biological treatment with activated sludge.

The purpose of the present work was to show the possibilities of algae growth in domestic sewage and to select such a strain which not only would be characterized by a fast increment in its biomass but also guarantee substantial amounts of proteins.

2. MATERIAL AND METHODS

The investigations were performed on a group of 21 algal strains. Scientific centres which provided us with these strains are listed in tab. 1.

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Table 1

Genera and species of algae taken for investigations and their origin

No. of strain	Genus and species of algal strains		Origin
1	*Ankistrodesmus acicularis*		Institute of Botany of the Wrocław University
2	*Chlorella pyrenoidosa*	366	Experimental Department of Animal Breeding at Zator near Kraków
3	*Chlorella pyrenoidosa*		Institute of Botany of the Wrocław University
4	*Chlorella* sp.	373	Experimental Department of Animal Breeding at Zator near Kraków
5	*Chlorella* sp.	394	
6	*Chlorella* sp.	594	
7	*Chlorella* sp.	620	Czechoslovakian Academy of Botany, Ustav-Hydrobotanicke Oddelani, Trebon
8	*Chlorella* sp.	820	
9	*Chlorella keslerii*		
10	*Scenedesmus acuminoatus*	633	
11	*Scenedesmus acutus*	103	
12	*Scenedesmus acutus*	126	Experimental Department of Animal Breeding at Zator near Kraków
13	*Scenedesmus* sp.	407	
14	*Scenedesmus* sp.	449	
15	*Scenedesmus* sp.	516	
16	*Scenedesmus* sp.	863	Czechoslovakian Academy of Botany, Ustav-Hydrobotanicke Oddelani, Trebon
17	*Scenedesmus* sp.	1408	
18	*Scenedesmus quadricauda*		
19	*Scenedesmus* sp.	610	Experimental Department of Animal Breeding at Zator near Kraków
20	*Scenedesmus* sp.		Institute of Botany of the Wrocław University
21	*Selenastrum capricornutum*		Institute of Environment Management, Poznań

The culture of algae was conducted in domestic sewage coming from intermediate pumping station "Szczytniki" in Wrocław. Raw domestic sewage, after its sedimentation and filtration through a soft filter paper, was used as a nutrient solution for algal culture. The investigations were conducted in three different variants:

1) in mineral medium according to Uspienski (control medium),

2) in raw domestic sewage diluted with the Uspienski medium in 1:2 ratio,

3) in non-diluted wastewater.

Culture of algae lasting for 7 days conducted under stationary conditions in 100 cm^3 flat-bottomed flasks at 293 K ± 2 K (20°C ± 2°C) and at illumination of 1500 lux, employing glow-tube lamps for 12 h in 24 h. The density of inoculum measured at the wavelength of 720 nm amounted to about 0.25 units of extinction.

The growth of culture was estimated basing on the measurements of dry weight and soluble protein content. Dry weight was determined by taking from the culture flask a 10 cm^3 sample, which was centrifuged, washed with distilled water and dried to a constant weight at 378 K (105°C). Soluble protein was determined according to the methods described by ZAWADZKA [6]. 10 cm^3 sample of algal culture was centrifuged and the obtained biomass treated with 2 cm^3 of hot trichloroacetic acid and extracted in hot water bath for 1 min. Thereupon the filtrate was centrifuged again, supernatant removed, and 2 cm^3 of 1 M NaOH were added to the precipitate. The samples were placed in hot water bath for 10 min. After cooling, they were completed with 1 M NaOH to the volume of 5 cm^3. Thereupon they were centrifuged and protein in supernatant was determined by the LOWRY method [4].

3. RESULTS

Results obtained for cultures of algae grown in mineral medium are presented in tab. 2. As it may be seen, the individual strains did not develop uniformly producing after 7 days different amounts of biomass (expressed as dry weight). In 21 strains, the increment in dry

Table 2

Development of algae grown in the Uspienski medium

No. of strain	Dry weight of algae mg/100 cm^3			Protein content in algal biomass mg/100 cm^3		
	Initial t_0	Final t_7	Increment t_7-t_0	Initial b_0	Final b_7	Increment b_7-b_0
1	1.67	7.50	5.83	0.92	1.020	0.1
2	1.25	7.33	6.08	0.06	0.300	0.24
3	1.42	18.06	16.64	0.72	0.920	0.20
4	1.07	18.25	17.18	0.35	0.400	0.05
5	3.61	30.76	27.15	0.185	2.693	2.508
6	3.91	33.56	29.649	0.068	0.226	2.158
7	1.71	16.56	14.85	0.25	0.300	0.05
8	1.10	11.66	10.56	0.46	0.553	0.093
9	3.35	11.50	8.15	0.22	0.380	0.16
10	2.23	9.00	6.77	0.17	1.006	0.836
11	4.22	33.33	29.11	0.66	0.986	0.326
12	1.34	2.00	0.66	0.55	0.813	0.263
13	2.99	26.13	23.13	0.176	1.702	1.526
14	3.89	15.66	11.77	0.051	0.440	0.389
15	3.67	25.46	21.79	0.38	1.480	1.10
16	4.89	16.00	11.11	0.68	0.753	0.073
17	4.30	6.90	2.60	0.44	0.520	0.080
18	1.29	11.03	9.74	0.38	0.506	0.12
19	4.40	17.65	13.25	0.046	1.103	1.06
20	1.68	9.76	9.592	0.62	0.813	0.19
21	1.39	9.10	7.71	0.30	0.500	0.20

Table 3

Development of algae grown in domestic sewage diluted in 1:2 ratio with the Uspienski medium

No. of strain	Dry weight of algae mg/100 cm^3			Protein content in algal biomass mg/100 cm^3		
	Initial t_0	Final t_7	Increment t_7-t_0	Initial b_0	Final b_7	Increment b_7-b_0
1	1.67	18.85	17.18	0.920	1.380	0.46
2	1.42	22.16	20.74	0.720	1.693	0.973
3	1.25	14.76	13.51	0.060	1.086	1.026
4	1.07	15.16	24.09	0.350	0.760	0.410
5	3.61	60.96	57.35	0.185	3.153	2.968
6	3.91	48.90	44.99	0.068	3.000	2.932
7	1.71	21.76	20.05	0.250	1.073	0.823
8	1.10	19.96	18.86	0.460	1.013	0.553
9	3.35	14.0	10.65	0.220	1.046	0.826
10	2.23	31.60	29.37	0.170	1.520	1.350
11	4.22	35.90	31.68	0.660	1.213	0.553
12	1.34	17.10	15.76	0.550	1.680	1.130
13	2.99	51.83	48.84	0.176	2.926	2.750
14	3.89	26.50	22.61	0.051	1.030	0.979
15	3.67	61.06	57.39	0.380	3.860	2.706
16	4.89	36.83	31.94	0.680	1.266	0.586
17	4.30	26.33	22.03	0.440	1.260	0.820
18	1.29	15.60	14.31	0.360	1.080	0.700
19	4.40	42.66	38.26	0.046	1.120	1.074
20	1.68	10.23	10.062	0.620	1.100	0.480
21	1.39	19.03	17.64	0.300	1.146	0.846

weight with respect to the initial one ranged from 0.66 to 29.64 mg per 100 cm^3 of the culture. Substantial differences in protein contents have been also stated in algae grown in mineral medium. The increment in protein content in biomass of algal cultures (100 cm^3) ranged from 0.05 to 2.508 mg. The highest protein content and high dry weight were stated for the strain 394.

The results of investigations on the possibility of algal cultures in domestic sewage diluted in 1:2 ratio with mineral nutrient solution are given in tab. 3. A special attention should be paid to the fact that the development of algae in domestic sewage was much better than that under natural conditions. After 7 days of culture both biomass and protein content were much higher. So, in 100 cm^3 of the culture, the increment in dry weight ranged from 10.65 to 57.35 mg and that in protein content varied between 0.41 and 2.96 mg.

The best results were obtained in the third experimental series, in which algae were grown in non-diluted domestic sewage. The results are given in tab. 4. As it may be seen, in the last day of culture dry weight increased from about 7.0 mg to 59 mg, and protein content from about 0.3 mg to 3.0 mg (per 100 cm^3 of culture).

Table 4

Development of algae grown in raw domestic sewage

No. of strain	Dry weight of algae mg/100 cm^3			Protein content in algal biomass mg/100 cm^3		
	Initial t_0	Final t_7	Increment t_7-t_0	Initial b_0	Final b_7	Increment b_7-b_0
1	1.67	22.46	20.79	0.92	1.40	0.480
2	1.42	18.83	17.41	0.72	1.593	0.873
3	1.25	9.30	8.05	0.06	1.026	0.966
4	1.07	16.75	15.68	0.35	0.706	0.356
5	3.61	58.06	54.45	0.185	3.166	2.981
6	3.91	47.26	43.35	0.068	2.533	2.464
7	1.71	19.65	17.94	0.25	1.150	0.900
8	1.10	13.00	11.90	0.46	0.840	0.380
9	3.35	10.10	6.75	0.22	0.906	0.686
10	2.23	16.60	13.93	0.17	1.853	1.683
11	4.22	35.33	31.11	0.66	1.293	0.633
12	1.34	14.75	13.41	0.55	1.500	0.950
13	2.99	51.50	48.51	0.76	2.833	2.659
14	3.89	37.80	33.91	0.651	0.740	0.689
15	3.67	62.56	58.89	0.38	3.166	2.786
16	4.89	32.50	27.61	0.68	1.246	0.566
17	4.30	23.00	18.70	0.44	1.640	1.200
18	1.29	10.50	9.21	0.38	1.313	0.930
19	4.40	33.16	28.76	0.046	1.406	0.360
20	1.68	15.17	15.00	0.62	0.946	0.320
21	1.39	15.50	14.11	0.30	1.240	0.940

From the comparison of the obtained results it follows that the algae grown in undiluted domestic sewage, and the strain 394 of *Chlorella* sp. gave the best effects.

4. FINAL REMARKS

The conducted experiments have shown that the algae of genera *Ankistrodesmus*, *Chlorella*, *Scenedesmus*, and *Selenastrum* may be grown in domestic sewage. It appeared that in the case of domestic sewage the activated sludge pretreatment is not required. The comparison of cultures conducted in three different series shows that the highest dry weight and the protein content were obtained from the culture in non-diluted domestic sewage. It has been also stated that the examined strains differed in this respect from one another. Thus, the strain *Chlorella* sp. 394 appeared to be the most efficient. The obtained results show that the preliminary selection and choice of strain most adequate to the given kind of domestic sewage is advisable. The degree to which the domestic sewage was purified will be estimated in the next paper.

5. CONCLUSIONS

1. The culture of algae in domestic sewage is possible.

2. Of 21 strains, *Chlorella* sp. 394 gave the best growth effects, i.e., increment in dry weight and protein content.

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MOŻLIWOŚĆ HODOWLI WYBRANYCH SZCZEPÓW GLONÓW NA ŚCIEKACH BYTOWO-GOSPODARCZYCH

Badano możliwość rozwoju różnych rodzajów glonów z gromady zielenic na surowych ściekach bytowo-gospodarczych. Prowadzono hodowlę wybranych 21 szczepów na podłożu kontrolnym według Uspieńskiego oraz na rozcieńczonych i nierozcieńczonych tym podłożem ściekach bytowo-gospodarczych. Rozwój glonów oceniono oznaczając przyrost ich suchej masy i zawartość białka. Uzyskane wyniki wykazały, że poszczególne glony różniły się znacznie wartością suchej masy i zawartością białka. Wykazano, że hodowla glonów na nierozcieńczonych ściekach daje najlepsze wyniki. Największy przyrost suchej masy i zawartości białka uzyskano dla szczepu *Chlorella* sp. 394.

ВОЗМОЖНОСТИ РАЗВЕДЕНИЯ ИЗБРАННЫХ СТАММОВ ВОДОРОСЛЕЙ НА БЫТОВО-ХОЗЯЙСТВЕННЫХ СТОЧНЫХ ВОДАХ

Исследованы возможности развития разных видов водорослей из класса синезеленых водорослей на сырых бытово-хозяйственных сточных водах. Разводили избранные 21 стаммов на контрольном основании по Успенскому, а также на разбавленных и неразбавленных этим основанием сточных водах. Развитие водорослей оценивали, обозначая привес их сухой массы и содержание белков. Полученные результаты обнаружили, что отдельные водоросли значительно отличались качеством сухой массы и содержанием белков. Обнаружили, что разведение водорослей на неразбавленных сточных водах дает наилучшие результаты. Самый высокий привес сухой массы и содержания белков получили для стамма *chlorella* sp. 394.