associated oyster banks suggests that the coastal fringe of Saurashtra peninsula remained tectonically active during the late Quaternary.

1. Shackleton, N. J. and Opdyke, N. D., *Quat. Res.*, 1973, **3**, 39–55.
2. Merh, S. S., Presidential address, Proceedings of the Indian Science Congress, 1980, pp. 15–45.
3. Biswas, S. K., *Tectonophysics*, 1987, **135**, 307–327.
4. Baskaran, M., Rajagopalan, G. and Somayajulu, B. L. K., *Chem. Geol., (Isotope Geoscience Section)*, 1987, **79**, 68–82.
5. Pant, R. K. and Juyal, N., 29th IGC (Abstract), Kyoto, Japan, August 24–September 3, 1992.

ACKNOWLEDGEMENT. We are grateful to Prof. B. L. K. Somayajulu for guidance in dating of oysters.

Received 24 September 1992; revised accepted 18 February 1993

Influence of effluents on fatty acid content of a cyanobacterium

C. Manoharan and G. Subramanian*
Post Graduate Department of Botany, A. V. V. M. Sri Pushpam College (Autonomous), Poondi 613 503, India
*NFMC, Department of Botany, Bharathidasan University, Tiruchirapalli 620 024, India

Qualitative and quantitative estimations of fatty acids from a cyanobacterium *Oscillatoria pseudogeminata* var. *unigranulata* influenced by four different effluents (domestic, ossein, paper mill and tannery) were studied. The presence of 17 different fatty acids including two unidentified and six short chain (C8:0 to C13:0) along with linolenic acid (C18:3) has been established with different effluents.

In recent years, the importance of biological waste treatment systems has attracted the attention of workers world over for developing relatively efficient, low cost waste-treatment systems. The usefulness of algal systems, more particularly the cyanobacteria, is not only in treating the wastes but also in producing a variety of useful by-products from their biomass as on record[1]. To develop suitable and efficient treatment systems, it is obligatory to understand the possible interactions between effluents and the target organisms, so that manipulations to improve the treatment systems become feasible. The present work is, therefore, aimed at studying the influence of four different effluents on the fatty acid content of a cyanobacterium.

The cyanobacterium *Oscillatoria pseudogeminata* var. *unigranulata* Biswas was isolated from the sewage, made unialgal and maintained in BG11 medium[2]. The effluents from domestic, ossein, paper mill and tannery were analysed for initial physico-chemical characteristics using Standard Methods[3] (Table 1). One ml of uniform suspension of *Oscillatoria* (45 μg Chl/100 ml) was inoculated to each undiluted effluent in both sterilized and unsterilized conditions. The experiment was conducted under controlled conditions (temp. $25 \pm 2^\circ$ C) with a light intensity of 1500 lux provided from overhead cool white fluorescent tubes with an L/D cycle of 14+10 h for 15 days. The cultures were centrifuged and washed repeatedly with distilled water and analysed for fatty acid content using Hewlett Packard 5890 Gas chromatograph fitted with 10 per cent DEGS column and flame ionization detector[4]. From the peak area of fatty acids, the amount of fatty acid was calculated using respective standards from Sigma (USA).

The total fatty acid content of *Oscillatoria* with different treatments was estimated qualitatively and quantitatively as above. In all, seventeen different fatty

Table 1. Physico-chemical characteristics of effluents

Characteristics mg l^{-1}	Domestic	Ossein	Paper mill	Tannery
Colour	–	–	Darkbrown	Brownish
pH	7.35	7.65	6.75	7.45
Biochemical oxygen demand	131.20	432.00	288.00	1555.00
Chemical oxygen demand (permanganate value, 4 h)	90.00	220.00	160.00	320.00
Dissolved oxygen	2.80	–	5.37	–
Carbonate	–	–	–	–
Bicarbonate	250.00	425.00	375.00	1375.00
Free CO_2	5.50	11.00	11.00	154.00
Nitrate	0.30	132.00	0.60	8.00
Nitrite	0.003	0.01	0.08	68.00
Ammonia	25.00	80.00	1.20	45.00
Total P	2.06	1.14	0.18	1.26
Organic P	0.48	0.45	0.07	0.39
Inorganic P	1.58	0.69	0.11	0.87
Sodium	80.00	73.00	94.00	820.00
Potassium	20.00	24.00	32.00	58.00
Sulphate	77.00	25.00	90.00	362.00
Calcium	34.00	1804.00	164.00	640.00
Magnesium	23.15	48.70	26.80	528.00
Chloride	150.86	4260.00	710.00	6213.00

Table 2. *Qualitative and quantitative analysis of total fatty acids in Oscillatoria (μg mg⁻¹ dry wt)*

Treatment	C8:0	C9:0	C10:0	C11:0	C12:0	C13:0	C14:0	C15:0	C16:0	C16:1	C17:0	C18.0	C18:1	C18:2	C18:3	U1	U12	Total
C	1.2	27.0	108.0	5.8	5.80	5.00	4.5	0.90	1.5	0.50	1.6	1.00	–	1.30	0.70	+		164.0
DU	2.59	28.56	58.69	4.3	3.60	2.70	2.12	0.48	0.78	0.21	0.66	0.37	0.26	1.52	3.83	+		110.8
DS	0.95	21.82	40.97	1.64	3.60	2.90	2.50	0.50	2.00	0.20	1.50	0.40	–	0.70	0.50	+		80.5
O4	1.10	15.90	22.80	26.20	2.80	2.40	2.10	0.40	0.70	0.10	0.10	0.40	–	0.40	1.00	+		76.4
OS	0.40	0.60	28.00	11.75	1.30	1.20	1.30	0.30	0.50	–	0.40	0.20	–	0.60	1.30	+		47.85
PU	1.20	39.00	37.40	32.60	2.50	3.90	2.90	0.60	0.90	0.30	0.90	0.50	–	0.80	1.80	+		125.3
PS	10.70	21.80	23.13	38.69	4.00	5.40	2.30	0.50	0.70	0.40	0.80	0.50	–	0.30	0.60	+		109.82
TU	0.40	1.10	17.90	21.70	0.90	0.80	0.70	0.10	0.20	0.10	0.40	0.20	–	0.20	1.80	+	+	46.5
TS	0.70	5.30	14.00	29.40	2.00	1.80	1.60	0.30	0.60	0.10	0.50	0.30	–	0.60	0.80	+		57.6

C, Control; U, unsterilized; S, sterilized; D, domestic sewage; O, ossein factory effluent; P, paper mill effluent; T, tannery effluent; UI, unidentified.

acids, including two unidentified ones, were treated in different treatments. Fifteen different fatty acids were common to all treatments except for *Oscillatoria* grown in unsterilized domestic sewage, that showed additional presence of oleic acid (C18:1). *Oscillatoria* grown in unsterilized tannery effluent, showed additional unidentified fatty acid peak (Table 2). Compared to control, there was an overall reduction in the total fatty acid content for all treatments, while a few fatty acids alone were in excess in some (Table 2). The total fatty acid content was highly reduced with ossein and tannery effluents (Table 2). With unsterilized domestic sewage, although there was a general reduction in levels of all the fatty acids compared to control, there was indication for oleic acid (C18:1) and more than a five-fold increase in linolenic acid (C18:3). With sterilized domestic sewage, however, these changes were not observed.

In general, there was a greater reduction of unsaturated and short chain fatty acids and slight increase in some long chain fatty acids with sterilized compared to unsterilized domestic sewage. A similar trend was observed with other effluents also. In general, the reduction in overall fatty acid content was greater with sterilized than unsterilized effluents. Except with domestic sewage, in all other treatments, there was a considerable increase in undecanoic acid (C11:0) content compared to control (Table 2). With both sterilized or unsterilized ossein effluent and unsterilized paper mill as well as tannery effluents, there was nearly a three-fold increase in linolenic acid (C18:3). The presence of an additional unidentified fatty acid was noticed only with the unsterilized tannery effluent (Table 2).

The influence of environmental factors including light on the fatty acid composition is also known[5]. Reports on a variety of long chain saturated and unsaturated fatty acids in cyanobacteria including *Oscillatoria limnetica* have appeared[6] where most of these pertain to long chain fatty acids[5,6]. The presence of substantial amounts of short chain fatty acids among the total fatty acid content in the present case, could be attributed to the accumulation of free fatty acid under effluent stress. Considerable and significant changes in the levels of fatty acids have been reported in cyanobacteria following light and dark incubations[5]. In view of this, the observed changes in levels of different fatty acid as influenced by different effluents, are quite conceivable (Table 1). Attempts are desired to select suitable strains of cyanobacteria minimally influenced by the adverse conditions posed by effluents that, in turn, could be deployed for removing pollutants maximally.

1. Subramanian, G. and Shanmugasundaram, S., *Indian J. Environ. Health*, 1986, **28**, 250–253.
2. Rippka, R., Duruelles, J., Waterbury, J. B., Herdman, M. and Stanier, R. Y., *J. Gen. Microbiol.*, 1979, **111**, 1–61.

3. *Standard Methods for the Examination of Water and Wastes*, 14th edn., American Public Health Association, Washington, DC 1976, pp. 1–85.
4. Niller, L. and Berger, T., *Gas Chromatography Application Note*, 1985, pp. 228–241.
5. Al-Hasan, R. H., Ali, A. M. and Radwan, S. S., *J. Gen. Microbiol.*, 1989, **135**, 865–872.
6. Jahnke, L. L., Lee, B., Sweeney, M. J. and Klein, H. P., *Arch. Microbiol*, 1989, **152**, 215–217.

Received 29 September 1992; revised accepted 18 February 1993

Evaluation of sex pheromone components of rice leaf folder, *Cnaphalocrocis medinalis* Guenee

A. Ganeswara Rao, K. Krishnaiah*, D. R. Hall, A. Cork** and D. D. R. Reddy**
Andhra Pradesh Agricultural University, AICRP on Biological Control of Crop Pests, College of Agriculture, Hyderabad 500 030, India
*Directorate of Rice Research, Hyderabad 500 030, India
** Natural Resources Institute, Kent ME4 4TB, UK

Different blends of (Z)–13–18:AC, (Z)–11–16:AC and (Z)–13–18:OH were evaluated for the pheromonal activity to rice leaf folder, *Cnaphalocrocis medinalis* under field conditions. Mixture of (Z)–13–18:AC and (Z)–11–16:AC in the ratio of 10:1 was pheromonally active and captured relatively larger number of male moths than traps baited with two Virgin females. Addition of (Z)–13–18:OH to the mixture reduced the trap capture. Polythene vial dispensers were superior to rubber septa.

RICE leaf folder, *Cnaphalocrocis medinalis* Guenee has recently emerged as a major pest in all the intensively rice-growing areas[1]. Chemical control, so far, has been the main method of controlling the pest. Insect sex pheromones have promised to render the insecticide more effective by helping in timing the insecticide application, besides acting as practical means of direct control[2,3].

Studies made to identify the pheromone components of *C. medinalis* through electroantennographic (EAG) and gaschromatographic (GC) analyses with ovipositor washings of Virgin females at Overseas Development Administration, Natural Resources Institute, Kent, UK indicated that a mixture containing (Z)–13–octadecenylacetate (Z–13–18:AC) and (Z)–11–hexadecenylacetate (Z–11–16:AC) at approximately 100:5–10 ratio were pheromonally active to male moths of *C. medinalis*. (Z)–13–octadecenol (Z–13–18:OH) was also found associated with pheromonal activity (Hall, D. R., pers. commun.). Based on these results, samples of the blends consisting of variable quantities (0, 10, 50, 100, 500 μg) of (Z)–11–16:AC, each mixed with 1000 μg of (Z)–13–18:AC dispensed in rubber septa, were evaluated in field trials organized in Medchal area (Operational Research Project site of Directorate of Rice Research) during wet (*kharif*) and dry (*rabi*) seasons of 1991–92 and the results are presented here.

The pheromone blends dispensed in rubber septa containing 1 mg mixture were baited in delta sticky traps during wet season. The traps were positioned at crop canopy level in rice fields infested by leaf folder (*C. medinalis*) synchronizing with the moth emergence at 20 m apart. The trial had four replicates spaced at 100 m. The trap captures were collected and counted daily for over 10 days. The trap positions were interchanged after each count. Based on the results of EAG and GC analyses and of the first season field trials, pheromone blends consisting of variable quantities (50, 100, 200, 300 μg) of (Z)–11–16:AC mixed with fixed quantity (1000 μg) of (Z)–13–18:AC along with a single treatment consisting of all three components (Z–13–18:AC, Z–11–16:AC and Z–13–18:OH) in 1000:100:100 ratio dispensed in rubber septa and polythene vials were evaluated during dry season.

Mixture of (Z)–13–18:AC and (Z)–11–16:AC recorded consistent trap captures while (Z)–13–18:AC either alone or in combination with (Z)–13–18:OH failed to do so, thus indicating the former mixture to be the probable pheromone of *C. medinalis*. These results also indicated that probable proportion of (Z)–11–16:AC in the mixture to be around 50 to 100 μg from the consistent larger catches than with other combinations. Similar observation was recorded in dry season of 1992 wherein the trap captures were significantly larger with 50–100 μg of (Z)–11–16:AC than with other combinations. These observations were in conformity with EAG–GC analytical results wherein the quantity of (Z)–11–16:AC was estimated at 5–10% of the (Z)–13–18:AC in the pheromone mixture (Hall, D. R., pers. commun.). Number of male moths with pheromone dispensers was greater than with one and two virgin female moth baits.

Addition of (Z)–13–18:OH to the best blend (i.e. Z–13–18:AC and Z–11–16:AC in 1000:100 ratio) significantly reduced the trap capture, indicating an inhibitory role of the chemical component at this level. Results of these trials reveal that the pheromone composition of *C. medinalis* contains a mixture of (Z)–13–18:AC and (Z)–11–16:AC in the ratio of 100:5 to 10 respectively.

Among the dispensers evaluated polythene vial was superior to rubber septum with the significantly larger trap captures with all the treatment combinations evaluated.

1. Kalode, M. B., Pasalu, I. C., Krishnaiah, N. V. and Bentur, J. S., National seminar on changing pest situation in the current agriculture scenario of India, June 11–16, 1988, Indian Agricultural Research Institute, New Delhi.