

## IDENTIFICATION OF VOLATILE ORGANIC COMPOUNDS PRODUCED BY ALGAE

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### **Abstract**

The volatile organic compounds (VOC<sub>s</sub>) produced by 12 algal species belonging to different algal groups were identified. The studied species were grown for two weeks and included: *Oscillatoria agardhii* (two isolates), *Oscillatoria limnetica*, *Oscillatoria limosa*, *Microcystis aeruginosa*, *Chroococcus limneticus*, *Spirulina platensis*, *Anabaena sphaerica*, *Nostochopsis wichmannii* (blue-green algae), *Cosmarium lavae*, *Ankistrodesmis acicularis* (green algae) and *Nitzschia linearis* (diatoms). Retention indices and mass spectral data were used to identify about 100 components analyzed by GC-MS. The major abundant VOC<sub>s</sub> detected are cyclohexane, heptane, cyclopentane, dodecane, tridecane, octadecanoic acid, 9-octadecanoic acid and undecanoic acid. Fatty acids and benzene derivatives were the most compounds identified in all algal species. Most of volatile organic sulfur compounds were detected in the blue-green species. Consequently, the two isolates of *O. agardhii* emphasize the role of nitrate concentration contained in the algal media in the production of both geosmin and 2-methylisoborneol.

**Key words:** Algal bloom, Cyanobacteria, Diatoms, GC-MS, Geosmin, Green algae, Organic compound, Phytoplankton.

### **Introduction**

Eutrophication of water bodies has increased during the last century due to increase in anthropogenic inputs. Extensive phytoplankton blooms occur in eutrophic water such as rivers, reservoirs and lakes causing serious problems. Also, such problems have been reported in water supplies and drinking water treatment plants in many countries (Tellez *et al.*, 2001). Low – molecular weight organic compounds have been associated with many different species of phytoplankton, including cyanobacteria (blue-green algae), green algae and diatoms during blooms of these species in the freshwater environment (Walsh *et al.*, 1998). Therefore, a pronounced attention has been directed to investigate the chemical nature of these compounds since they have detrimental effects on water quality (Schöller *et al.*, 2002). In addition, there is evidence indicating that the production of certain volatile and terpenoide compounds provide a competitive

advantage of some phytoplankton species as allelopathic agents by inhibiting the growth of surrounding phytoplankton (Jüttner and Wurster, 1979, Fischer, 1991).

Offensive odors are noticed during the mass development of many different algal groups. During a bloom of *Asterionella formosa*, 1,3-octadiene and several octatrienes have been developed (Jüttner, 1984). Also, blooms of *Anabaena* and *Nostoc* lead to the occurrence of hydrocarbons, alcohols, aldehydes and ketones (Mohren and Jüttner, 1983, Tucker, 2000). Much interest has been focussed on the production of these organic compounds where it is regarded as the causative agents of the odor and taste problems arising during water purification and fish breeding. These compounds significantly affect the quality of raw water because they are only partially eliminated by the conventional water purification processes (McGuire *et al.*, 1981). They are known as precursors of several halogenated by-products (Hureiki *et al.*, 1994).

A key point in research on water quality is the identification and regulation of the synthesis of these nuisance compounds in different algal species. Thus, through this investigation, twelve species belonging to three-algal groups (green algae, blue-green algae and diatoms) were isolated from phytoplankton blooming. On the other hand, the study aimed to describe and identify volatile metabolites produced by these twelve species of algae.

## ***Materials and Methods***

### **Isolation and purification of phytoplankton species**

Algal species were isolated from phytoplankton where annual blooms had occurred since 1995 up till now leading to unpleasant taste and odor before and after water treatment for drinking water production at Port-Said Water Works. Nine algal species belonging to blue-green algae: *Oscillatoria agardhii* (Gomont) (two isolates), *O. limnetica* (Lemm, Baitr. Kenntn), *O. limosa* (Roth, Ag), *Microcystis aeruginosa* (Kütz.), *Chroococcus limneticus* (Lemm), *Spirulina platensis* (Geitt), *Anabaena sphaerica* (Born et Flah) and *Nostochopsis wichmannii* (Weber-Van Bosse) were isolated. Two species of green algae *Cosmarium lavae*, *Ankistrodesmus falcatus* var. *acicularis* (A. Braun) and one species belong to diatoms group *Nitzschia linearis* (W. Sm.) were also successfully isolated. Algal identification has been done according to the keys of identification (Geitler, 1932, Hustedt, 1976, Komárek and Fott, 1983, Komárek and Anagnostidis, 1989). The BG<sub>II</sub> media (Carmichael, 1986) was used for algal isolation and purification. Some modifications in the nitrate concentration of the media (1.5 gm·L<sup>-1</sup>) were made according to the algal species. Two *Oscillatoria agardhii* isolates depend on the NaNO<sub>3</sub> concentration was obtained. The first isolate was achieved in the presence of 1.5 gm·L<sup>-1</sup>NaNO<sub>3</sub> while the second isolate was obtained after the NaNO<sub>3</sub> was diluted to 1/5 the original concentration. Also, *Oscillatoria limnetica* and *Spirulina* were successfully isolated after this dilution. The source of nitrogen was completely omitted from the media to obtain the

isolates of *Anabaena* and *Nostochopsis* (where it has heterocystous cells). In addition, species of green algae were isolated and purified in nitrate dilution, while *Nitzschia linearis* was flourished after the addition of  $0.05\text{mg}\cdot\text{L}^{-1}$   $\text{Na}_2\text{SiO}_3\cdot\text{H}_2\text{O}$  to the  $\text{BG}_{\text{II}}$  media.

Subsamples from the algal bloom were taken up in water and sonicated. Strains were isolated by spreading 0.1 ml of water samples into Petri dishes containing  $\text{BG}_{\text{II}}$  media (with nitrate modification) plus 1.0 % agar. Single colonies of algae were then recultivated in  $\text{BG}_{\text{II}}$  liquid media as nonaxenic batch cultures (50 ml) at  $25 \pm 2^\circ\text{C}$  and a photoperiod 24h with white fluorescent light intensity  $\cong 2500$  Lux.

#### Determination of volatile metabolites

For the detection of organic metabolites produced by algae, each unialgal purified strain was grown and cultured in one liter of  $\text{BG}_{\text{II}}$  (or its modification) liquid media. The algal cultures were grown at  $25 \pm 2^\circ\text{C}$  under continuous fluorescent light intensity  $\cong 2500$  Lux. for two weeks. Algal cells were harvested from the algal culture by centrifugation (at 10.000 r.p.m. for 20 min.) and extracted for the detection of organic compounds according to Dembitsky *et al.*, (1999). The algal cells were mixed with 10 ml MeOH-water (90:10, v/v) and heated for 50 min at  $55^\circ\text{C}$ . After cooling the solution to room temperature, 20 ml of a cold mixture of n- $\text{C}_5\text{H}_{12}$ -water (3:5, v/v) was added. The mixture was shaken for 15 min, and then cooled under ice. The  $\text{C}_5\text{H}_{12}$  and methanol-water phases were separated. The methanol-water phase was extracted three times by  $\text{CH}_2\text{Cl}_2$  (10 mlX3). Then the pentane and dichloromethane extracts were combined, dried over anhydrous sodium sulphate and evaporated under nitrogen gas at  $10^\circ\text{C}$ .

Analytical determination of organic compounds was performed by GC-MS on a Finnigan mat SSQ 7000 gas chromatograph coupled with DB-5 column (30m  $\times$  0.25 i.d. mm fused silica capillary column, film thickness = 0.25  $\mu\text{m}$ ) using He (Helium) as carrier gas ( $1\text{ mL}\cdot\text{min}^{-1}$  at  $210^\circ\text{C}$ ), 1  $\mu\text{L}$  injection size (injector temperature =  $220^\circ\text{C}$ , transfer line temperature =  $240^\circ\text{C}$ ). The column temperature was programmed from an initial temperature of  $60^\circ\text{C}$  to a final column temperature of  $240^\circ\text{C}$  at  $3^\circ\text{C}/\text{min}$ . Solvent delay was 3min. Identification of individual components were performed by a comparison of mass spectra with literature data and by a comparison of their relative retention times with those of authentic compounds or by comparison of their retention indices with literature values (Adams, 1995). The relative amounts of individual components of the extract are expressed as percent peak area relative to total peak area.

### Results and Discussion

Numerous biogenic compounds from phytoplankton species are well documented (Esterbauer, 1982, Jüttner, 1984, Jüttner *et al.*, 1986). A series of volatile metabolites have been identified by means of GC-MS in the extracts of twelve algal species isolated from phytoplankton bloom. The composition of

hydrocarbons and volatile metabolites is presented in Table (1). Hundred of hydrocarbons and metabolites (Table 1) were identified in the different algal species. The biogenic hydrocarbons were represented exclusively by straight chain components, which were characterized, as pentadecane and heptadecane. Tellez *et al.*, (2001) stated that heptadecane has been found to be a common major volatile component in many cyanobacterial species.

The second most abundant compounds (detected through this study) in the isolated cyanobacterial species are thiophane derivatives and other organic sulphur compounds (VSOC<sub>s</sub>) with numbers C12, C14 and C25. Several reports deal with volatile sulphur compounds as the second most abundant ones associated with many cyanobacterial species (Yasuhara and Fuwa, 1982, Rezanca *et al.* 1982, Tsuchiya and Matsumoto, 1988, Hayes *et al.* 1989, Dembitsky *et al.* 1999, Tellez *et al.*, 2001).

In addition, polysulfides occur in cyanobacterial culture have been correlated with rapid post bloom bacterial decomposition (Hayes *et al.* 1989). Also, Bechard and Rayburn (1979) reported that the analyses of young and old cultures of *Oedogonium* and *Spirogyra* indicated H<sub>2</sub>S, DMS and DMDS occurred only in senescent cultures. In addition, the obtained results indicated that other compounds found in the volatile extraction of different algal species include p-xylene (0.541%), ethylbenzene (0.591%), benzaldehyde (0.591%) and benzothiazole (0.737%). Some studies (Henatsch and Jüttner, 1983, Sugiura *et al.*, 1998) indicated that benzothiazole derivatives are pyrolytic products of cyanobacteria.

Many aromatic compounds were found in all algal species and most of these compounds are ester derivatives of benzenedicarboxylic acid, benzoic acid, dimethylphthalate, tetraphthalic, methylvinyl ester and phenanthrene carboxylic acid ester derivatives (Table 1). Evans, (1994) and Badawy *et al.*(1999) reported the presence of several fatty acids with carbon range C12 to C22 were isolated from ponds dominated by *Oscillatoria* species. Jüttner (1981) found that Chrysophyceae exhibit large amounts of unsaturated fatty acids including linoleic acid and arachidonic acid which make up nearly 60% of the total fatty acids in *Ochromonas danica*. Also, Table (1) showed that several nitrogenous compounds were identified with peaks of diphenylamine, hydrazine, 1-diphenyl, glycine N-methyl-N-(1-oxododecyl) and hydrazine nitrophenol.

The two isolates of *O. agardhii* revealed the effective role of nitrate concentration in the production of geosmin and 2-methylisoborneol (MIB) by cyanobacterial species. The dilution of nitrate concentration to 1/5 original value (1.5 gm/L) led to a pronounced production of geosmin and MIB by the second *O. agardhii* isolate (Fig.1). Meanwhile, there is no detection to both compounds with the first *O. agardhii* isolate. Naes *et al.*, (1988) reported that in culture of *O. brevis*, geosmin production increased relative to carotenoid content in the N-limited situation. On the other hand, Rashash *et al.*, (1995) concluded that

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nitrogen and phosphorus control in surface waters represents most logical approach for lessening the potential odor problems associated with MIB and geosmin produced by *Phormidium calcicola*.

Silica organic compound derivatives were detected in culture of *Nitzschia linearis* (Table 1). The predominant silica compounds with carbon numbers in the range C3 to C17 are trimethyl, butyl trimethyl, 2-(methoxyethyl) trimethyl, 2-trimethylsilyl, ethyl trimethyl, Acetophenone, glucopyranose,  $\alpha$ -1-mannopyranoside, chloromethylene and 1,7-octadiene-1,8-diyl.

**Table (1): Volatile organic compounds identified from twelve phytoplankton species.**

Chemical name	Molecular Formula	R. T.	M. W.	%
-Ethane,1,1-dinitro-	C <sub>2</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>	3.05	120	5.972
-1,3,4-Thiadiazol-2(3H)-thione	C <sub>2</sub> H <sub>3</sub> N <sub>3</sub> S <sub>2</sub>	3.1	133	70.508
-Butanoic acid	C <sub>5</sub> H <sub>10</sub> O <sub>3</sub>	3.13	118	1.834
-2-propanol,1-isopropoxy-2-methyl	C <sub>7</sub> H <sub>16</sub> O <sub>2</sub>	3.13	132	1.834
-1,3,4-Thiadiazol,1-2-amine,-5-methyl	C <sub>3</sub> H <sub>5</sub> N <sub>3</sub> S	3.13	115	1.834
- Pentanoic acid	C <sub>7</sub> H <sub>14</sub> O <sub>2</sub>	3.13	130	1.834
-Thiophene,tetrahydro-2,5-dimethyl	C <sub>6</sub> H <sub>12</sub> S	3.13	116	1.834
-1,2,4-Trithiolane,3,3,5,5-tetramethyl	C <sub>6</sub> H <sub>12</sub> S <sub>3</sub>	3.13	180	1.834
- Acetamide	C <sub>13</sub> H <sub>22</sub> N <sub>2</sub> O <sub>2</sub>	3.18	118	20.94
- Butyltrimethyl	C <sub>7</sub> H <sub>18</sub> Si	3.41	130	0.101
- Methyl 3-o-methyl	C <sub>7</sub> H <sub>14</sub> O <sub>5</sub>	3.41	178	0.101
- L-glucose	C <sub>7</sub> H <sub>17</sub> O <sub>5</sub>	3.41	178	0.101
-1,3,5-Trithiane2,2,4,4,6,6-hexamethyl	C <sub>9</sub> H <sub>18</sub> S <sub>3</sub>	3.41	222	0.101
- 1-propanol	C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>	4.02	90	26.449
-4-o-Acetyl-2,5-di-o-methyl-3,6-dideoxy-d-gluconitrile	C <sub>10</sub> H <sub>17</sub> NO <sub>4</sub>	4.20	215	0.056
- 4-Thiepanone	C <sub>10</sub> H <sub>18</sub> O <sub>2</sub> S	4.27	202	0.293
-Disulfide,bis[1-methylthioethyl ]	C <sub>6</sub> H <sub>14</sub> S <sub>4</sub>	4.41	214	0.171
- Ethanethionide	C <sub>2</sub> H <sub>5</sub> NS	4.41	75	0.171
- Carbamic acid	C <sub>3</sub> H <sub>7</sub> NO <sub>3</sub>	4.47	105	24.715
- Bicyclo[3.2.1]octan-2-one	C <sub>11</sub> H <sub>16</sub> O	4.53	164	4.312
- 1,4-oxathian-2-one	C <sub>4</sub> H <sub>6</sub> O <sub>2</sub> S	5.14	118	0.510
- Silane,butytrimethyl	C <sub>7</sub> H <sub>18</sub> Si	5.31	130	3.520
-Silane,(2-methoxyethyltrimethyl)	C <sub>6</sub> H <sub>16</sub> OSi	5.31	132	3.520
- Thiourea (N,N-dimethyl)	C <sub>3</sub> H <sub>8</sub> N <sub>2</sub> S	5.32	104	0.195
- Hydrazine	C <sub>3</sub> H <sub>10</sub> N <sub>2</sub>	5.51	74	1.528
- Cycloserine	C <sub>3</sub> H <sub>6</sub> N <sub>2</sub> O <sub>2</sub>	5.51	102	1.528
- DL-Valine	C <sub>5</sub> H <sub>11</sub> NO <sub>2</sub>	5.58	117	1.127
- Cyclohexane	C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>	5.58	158	1.127
-Ethanol,2-(trimethylsilyl)	C <sub>5</sub> H <sub>14</sub> OSi	6.40	118	0.175

**Table (1) continue**

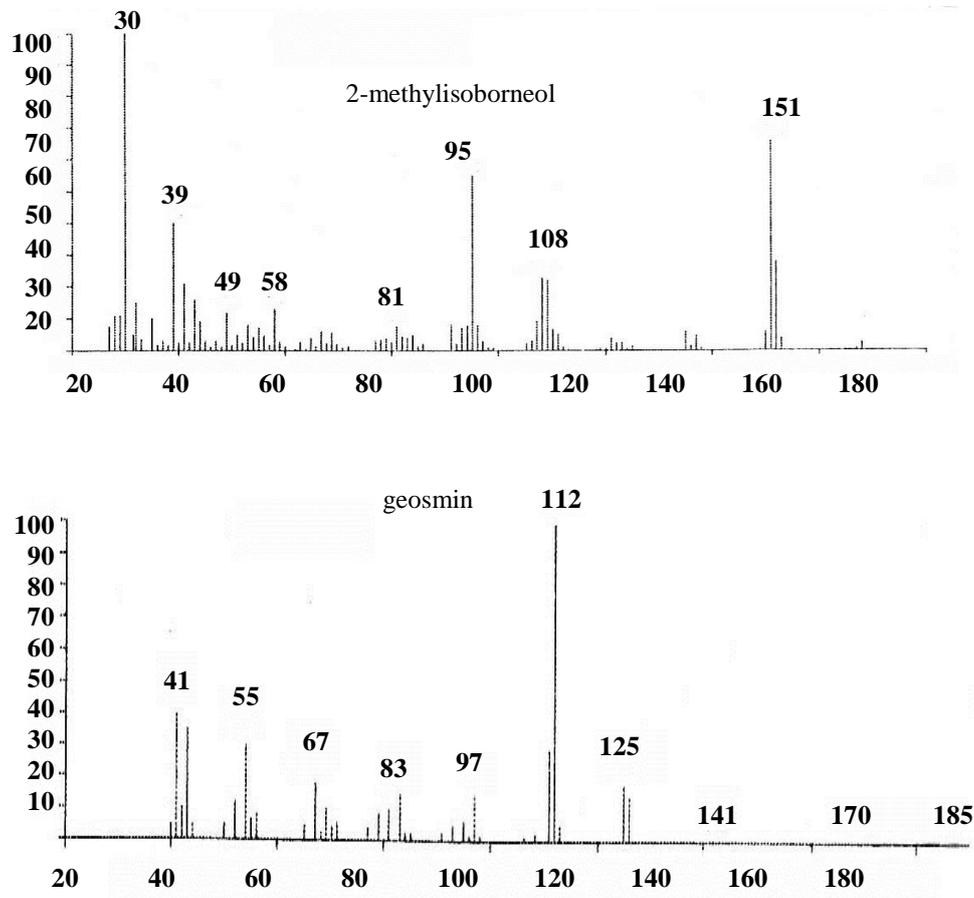
-Octatriacontanoic acid	C <sub>41</sub> H <sub>82</sub> O <sub>2</sub>	6.40	606	0.175
- Borane	C <sub>2</sub> H <sub>7</sub> O <sub>2</sub> B	6.40	74	0.175
- Thiirane	C <sub>3</sub> H <sub>6</sub> S	6.40	74	0.175
- Ethanethioamide	C <sub>2</sub> H <sub>5</sub> NS	6.40	75	0.175
- Silane,ethyltrimethyl	C <sub>5</sub> H <sub>14</sub> Si	7.40	102	0.256
- Silane,trimethyl	C <sub>3</sub> H <sub>10</sub> Si	7.40	74	0.256
- Heptane	C <sub>14</sub> H <sub>30</sub> O	10.07	214	2.819
- 1-Dotriacontanol	C <sub>32</sub> H <sub>66</sub> O <sub>2</sub>	13.38	466	0.176
- Anethole	C <sub>10</sub> H <sub>12</sub> O	14.39	148	0.935
-Benzaldehyde,2,4,6-trimethyl	C <sub>10</sub> H <sub>12</sub> O	14.39	148	0.935
- Benzene,1-methoxy-4-(1propenyl)	C <sub>10</sub> H <sub>12</sub> O	14.58	148	0.591
-Benzene, ethenyl (methoxymethyl)	C <sub>10</sub> H <sub>12</sub> O	14.58	148	0.591
- Benzaldehyde	C <sub>10</sub> H <sub>12</sub> O	14.58	148	0.591
- 2-Isopropylbenzaldehyde	C <sub>10</sub> H <sub>12</sub> O	14.58	148	0.591
-Benzo[b]thiophene,6-methyl	C <sub>9</sub> H <sub>8</sub> S	14.58	148	0.591
-Benzene,1,2-dimethoxy-4-(2-propenyl)	C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>	18.16	178	0.335
- Benzoic acid	C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>	18.16	178	0.335
- Benzene propanoic acid	C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>	18.16	178	0.335
- Phenol 3,5-bis(1-methylethyl)	C <sub>17</sub> H <sub>27</sub> NO <sub>2</sub>	19.47	277	0.737
- Butylated hydroxytoluene	C <sub>15</sub> H <sub>24</sub> O	19.47	220	0.737
- 5-methyl-5-hexen-3-ol	C <sub>7</sub> H <sub>14</sub> O	20.51	114	0.526
- 1,2,6-Hexanetriol	C <sub>6</sub> H <sub>14</sub> O <sub>3</sub>	20.51	134	0.526
- Asarone	C <sub>12</sub> H <sub>16</sub> O <sub>3</sub>	21.02	208	0.321
- Acetic acid	C <sub>13</sub> H <sub>18</sub> O <sub>3</sub>	21.20	222	0.293
- Methanol	C <sub>13</sub> H <sub>18</sub> O <sub>3</sub>	21.20	222	0.293
- Benzene,1,2,4-trimethoxy-5-(1-propenyl)	C <sub>12</sub> H <sub>16</sub> O <sub>3</sub>	21.45	208	0.178
- 3-(4-methoxyphenyl)propionic acid ethyl ester	C <sub>12</sub> H <sub>16</sub> O <sub>3</sub>	21.45	208	0.178
- Acetophenone	C <sub>11</sub> H <sub>16</sub> O <sub>2</sub> Si	21.45	208	0.178
-2-Allyl-3-ethoxy-4-methoxy phenol	C <sub>12</sub> H <sub>16</sub> O <sub>3</sub>	21.45	208	0.178
- Hydrocinnamic acid	C <sub>12</sub> H <sub>16</sub> O <sub>3</sub>	21.45	208	0.178
- 4-undecene	C <sub>12</sub> H <sub>24</sub>	22.21	168	14.511
- Cyclopentane	C <sub>12</sub> H <sub>24</sub>	22.21	168	14.511
- Dodecane	C <sub>12</sub> H <sub>25</sub> F	22.40	188	42.207
- Tridecane	C <sub>28</sub> H <sub>58</sub>	22.40	394	42.207
-Methyl-16-methoxy heptadecanoate	C <sub>19</sub> H <sub>38</sub> O <sub>3</sub>	25.46	314	1.054
- 2-Naphthalenol,8-amino	C <sub>10</sub> H <sub>9</sub> NO	25.46	159	1.054
- D-Ribo-hexose,2,6-di deoxy-3-o-methyl	C <sub>7</sub> H <sub>14</sub> O <sub>4</sub>	25.46	162	1.054
- Butylated hydroxytoluene	C <sub>15</sub> H <sub>24</sub> O	26.54	220	0.364
- 1,4-Benzenediol	C <sub>14</sub> H <sub>22</sub> O <sub>2</sub>	26.54	222	0.364
- Didodecyl phthalate	C <sub>32</sub> H <sub>54</sub> O <sub>4</sub>	27.16	502	0.682

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Table (1) continue

- Glucopyranose	C <sub>17</sub> H <sub>40</sub> O <sub>6</sub> Si <sub>3</sub>	27.42	424	0.541
- α-1-mannopyranoside	C <sub>16</sub> H <sub>38</sub> O <sub>5</sub> Si <sub>3</sub>	27.42	394	0.541
- Xylonic acid	C <sub>14</sub> H <sub>32</sub> O <sub>5</sub> Si <sub>3</sub>	27.42	364	0.541
- Dibutyl phthalate	C <sub>16</sub> H <sub>22</sub> O <sub>4</sub>	27.35	278	2.481
- Hexadecanoic acid	C <sub>22</sub> H <sub>42</sub> O <sub>2</sub>	27.48	338	4.683
- 6H-Dibeno(b,d)pyran-1-ol	C <sub>22</sub> H <sub>32</sub> O <sub>2</sub>	27.56	328	12.106
-1H-Indole-2-carboxylic acid	C <sub>18</sub> H <sub>31</sub> NO <sub>3</sub> Si <sub>3</sub>	27.56	393	12.106
- Nonadecanoic(trimethyl silyl ester)	C <sub>22</sub> H <sub>46</sub> O <sub>2</sub> Si	27.56	370	12.106
- Glycine,N-methyl-N-(1-oxododecyl)-	C <sub>15</sub> H <sub>29</sub> NO <sub>3</sub>	27.59	271	1.628
- Isopropyl palmitate	C <sub>19</sub> H <sub>38</sub> O <sub>2</sub>	27.59	298	1.628
-Undecanoic acid,11-Chlorotrimethylsil ester	C <sub>14</sub> H <sub>29</sub> O <sub>2</sub> SiCl	28.07	292	5.855
- Didodecyl phthalate	C <sub>32</sub> H <sub>54</sub> O <sub>4</sub>	28.50	502	0.144
- Pentadecanoic acid, methyl ester	C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>	29.02	256	0.865
- Octadecanoic acid	C <sub>32</sub> H <sub>64</sub> O <sub>2</sub>	30.40	480	0.340
-1-Dotriacontanol	C <sub>32</sub> H <sub>66</sub> O	30.40	466	0.340
-(Chloromethylene)bis(trimethyl-	C <sub>7</sub> H <sub>19</sub> SiCl	31.22	194	0.092
-1,7-octadiene-1,8-diylbis[ trimethyl	C <sub>14</sub> H <sub>30</sub> Si <sub>2</sub>	31.22	254	0.092
-(2-ethyl hexyl) phthalate	C <sub>24</sub> H <sub>38</sub> O <sub>4</sub>	32.09	390	0.140
- Hexanedioic acid	C <sub>14</sub> H <sub>26</sub> O <sub>4</sub>	33.19	258	28.044
- Di-n-octyl phthalate	C <sub>24</sub> H <sub>38</sub> O <sub>4</sub>	34.57	390	2.716
-3',8',8'-trimethoxy-3-pi eridyl-2,2'	C <sub>28</sub> H <sub>25</sub> NO <sub>7</sub>	35.07	487	5.258
-Undecanoic acid,11-fluorotrimethylsilyl ester	C <sub>14</sub> H <sub>29</sub> O <sub>2</sub> FSi	35.16	276	0.993
- Cholest-5-en-22-one	C <sub>33</sub> H <sub>60</sub> O <sub>3</sub> Si <sub>2</sub>	36.16	560	0.352
- Triacontanoic acid	C <sub>31</sub> H <sub>62</sub> O <sub>2</sub>	36.16	252	0.352
- 1,2-Benzenedicarboxylic acid	C <sub>34</sub> H <sub>58</sub> O <sub>4</sub>	36.16	418	0.352
- 4H-1-Benzopyran-4-one	C <sub>24</sub> H <sub>30</sub> O <sub>16</sub>	36.32	610	0.468
-9-(2',2'-Dimethyl propanoil drazono)-3,6-dichloro-2,7-bis	C <sub>30</sub> H <sub>42</sub> N <sub>4</sub> O <sub>3</sub> Cl <sub>2</sub>	38.03	576	0.334
- 9-octadecenoic acid	C <sub>35</sub> H <sub>70</sub> O <sub>2</sub>	40.45	534	0.055
- 1-propanone	C <sub>12</sub> H <sub>22</sub> O	41.34	182	0.080
-Decane,5,6-bis(2,2-dimethyl propylidene)	C <sub>20</sub> H <sub>38</sub>	41.12	278	0.355
- Methylergonovine maleate	C <sub>20</sub> H <sub>25</sub> N <sub>3</sub> O <sub>2</sub>	41.12	339	0.355

R. T.: Retention time; M. W.: Molecular weight; %: The percentage of each compound



**Figure (1):** Mass spectra of geosmin and 2-methylisoborneol associated with *Oscillatoria agardhii* isolated on nitrate dilution to 1/5 original concentration of BG<sub>11</sub> media.

### **Conclusions**

In conclusion, the strict correlation of certain species with the occurrence of volatile compounds has important practical consequence for water treatment. During water purification processes, cells of the phytoplankton are largely damaged and maximum values of liberation of these compounds can be expected. To predict the load with odor compounds, in most cases it would be easier to follow the development of a Cyanobacterium or alga known to be noxious rather than to perform a sophisticated analysis of trace amounts of volatile compounds.

If the growth of a noxious organism is detected, specific treatments of the raw water can be elaborated to eliminate nuisance odor substances and prevent complaints from customers.

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## انتاج المواد العضوية المتطايرة بواسطة الطحالب

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قسم بحوث تلوث المياه-المركز القومي للبحوث-الدقى-القاهرة

تهدف هذه الدراسة الى فصل و التعرف على المواد العضوية المتطايرة و المنتجة بواسطة 12 جنس من اجناس الطحالب المعزولة من احد التجمعات الطحلبية و التى تنتمى الى ثلاث مجاميع طحلبية و هى:

*Oscillatoria agardhii* (two isolates), *Oscillatoria limnetica*, *Oscillatoria limosa*, *Microcystis aeruginosa*, *Chroococcus limneticus*, *Spirulina platensis*, *Anabaena sphaerica*, *Nostochopsis wichmannii* (blue-green algae), *Cosmarium lavae*, *Ankistrodesmus acicularis* (green algae) and *Nitzschia linearis* (diatoms).

و ذلك بعد تنمية كل جنس منهم على حدا فى الوسط الغذائى المناسب له لمدة اسبوعان. هذا و قد تم باستخدام جهاز الكروماتوجراف الغازى GC-MS التعرف على 100 مركب عضوى من هذه المركبات. من اهم النتائج المتحصل عليها ان كل من مركبات cyclohexane, heptane, cyclopentane, dodecane, tridecane, octadecanoic acid, 9-octadecanoic acid and undecanoic acid. هى من المواد العضوية المتطايرة الاكثر تواجدا بالاضافة الى الاحماض الدهنية و مشتقات البنزين. اما المواد العضوية الكبريتية فقد وجد انها اكثر المواد العضوية شيوعا فى اجناس الطحالب التى تنتمى الى مجموعة الطحالب الخضراء المزرقه. كما اوضحت الدراسة العلاقة الوثيقة بين تركيز عنصر النترات فى الوسط الغذائى للطحالب و قدرة بعض انواع الطحالب على افراز المواد العضوية التى تسبب تغير فى طعم و رائحة المياه مثل مركبات Geosmin and 2-methylisoborneol.