BLUE-GREEN ALGAL TAXA IN RELATION TO DIFFERENT FACTORS
Most of the samples were collected from different habitats of various places. The pH of these varied from 5.1 to 9.1. All the samples have a pH range above 7.1 except those at Kittur, Arikoppa and Kanavihonnapur that have slightly acidic samples (pH 5.1, 6.3 and 6.6 respectively). Generally it appears that soils with higher pH have a larger number of heterocystous blue-green algae.

Tunnel wall and rock wall samples of Castle rock have pH varying from 6.2 to 9.1. Higher pH favours more heterocystous forms (3.19 species per sample). The pH range from 6.3 to 8.5 of paddy field and sugarcane field soils collected in Holehosur, Nuggikeri, Kanavihonnapur, Arikoppa, M.K. Hubli, Kittur and Nayakanahulakatti have moderately high percentage of heterocystous algae (47.61 to 70.83%). Banana field soil samples of Sogal and Munavalli (pH 7.7 and 7.8) also favours more number of heterocystous forms with 1.2 to 3 species per sample.

Water samples at Nuggikeri and Londa have pH varying from 7.1 to 8.1 and have high percent of heterocystous algae with 50 to 70.17%. Interesting enough, the paddy field soils at Arikoppa and Kanavihonnapur shows a reverse relation i.e., the higher number of heterocystous algae (3 species per sample)
is coupled with the slightly acidic nature of soils with pH 6.3 and 6.4. This may be due to high rainfall and higher content of organic carbon present in these soils while, Kurgund which has a pH of 7.2 lacks in the growth of heterocystous algae (0.75 species per sample).

Generally with a few exceptions, all the heterocystous BGA are found in greater numbers in habitats that have higher pH.

Electrical conductivity:

It appears that higher electrical conductivity favour the heterocystous algae. Different samples collected at Nuggikeri, Castle rock, Kanavihonnapur, Sogal and Arikoppa have high electrical conductivity (263683.2 to 871680.8 micromhos) with higher number of heterocystous members (3 to 4 species per sample). While the samples at M.K. Hubli, Ambargatti, Nayakanahulakatti, Londa and Kittur have electrical conductivity ranging from 39361.8 to 327016.2 micromhos and have moderately high number of heterocystous populations (2.2 to 2.83 species per sample). This may be due to high organic carbon and nitrogen in these samples.

Electrical conductivity of Nayanagar, Hosur, Dharwad and Kurgund have low range from 19612.8 to 72049.8 micromhos and therefore lack the growth of heterocystous algae (0.75 to 1.8 species per sample). Apparently, it may be concluded that
higher electrical conductivity of different samples support higher number of heterocystous population.

**Phosphate:**

The phosphate content in all the samples does not seem to vary considerably as compared to the average occurrence of heterocystous algae. Even though in banana field soils of Sogal, tunnel wall of Castle rock and lake water of Nuggikeri, phosphate content in the high range 0.020 to 0.034% appears to favour abundance growth of heterocystous algae (3 to 4 species per sample). While, sugarcane field soils of Belavadi, banana field soils of Munavalli and water samples of Londa have phosphate values varying from 0.014 to 0.030% and the heterocystous algae in them vary from a minimum number with 1.2 to 2.4 species per sample. This suggests that phosphate alone does not appear to restrict the heterocystous population.

The sugarcane field soils of Anigol and paddy field soils of Kanavihonnapur has a greater number of heterocystous forms in spite of its lowest phosphate content (0.0002%). The bark samples have phosphate content varying between 0.008 to 0.011% and the heterocystous population in them vary considerably 2.2 species per sample. In all other samples that have phosphate value ranging from 0.0001 to 0.0008% possess least percent (37.50%) of heterocystous algae.
Organic carbon:

Moderately high organic carbon content appears to favour greater number of heterocystous algae. Different samples of Nayakanahulakatti (paddy field soils), Sogal (banana field soils), Kanavihonnapur (paddy field soils) and Castle rock soil samples with higher organic carbon (2.41, 2.17, 2.25 and 2.14% respectively) show a high number of heterocystous algae (2.5 to 3.19 species per sample). However, the paddy field soils of Nuggikeri in spite of their 1.51% organic carbon have moderately high number of heterocystous forms with 4 species per soil.

The samples collected from tunnel wall and rock wall at Castle rock have range of organic carbon between 1.02 to 1.21% and have abundance growth of heterocystous algae 3.19 species per sample. Bark samples collected from Kittur have optimum content of organic carbon (7.44 to 8.04%) and the heterocystous populations in them very considerably and an average of 2.2 species per sample. The sugarcane field soil samples collected at Holehosur 2.14% and Belavadi 1.69% have least number (1.8 species per sample) of heterocystous algae. While paddy field soils at Ambargatti (0.97%), Dharwad (1.89%) and Kittur (1.92%) have low organic carbon with low number of heterocystous forms (1 to 2.2 species per sample). The organic carbon ranges between 1.35 to 1.77% in sugarcane field soils.
at Anigol, Hosur and Kurgund which have a reduced (0.75 to 1.6 species per sample); except at Anigol.

Apparently, it may be concluded that moderately high organic carbon values support higher percentage of heterocystous blue-green algae except at few places.

**Sodium:**

Low concentration of sodium seem to favour higher average of heterocystous algae. The paddy field soils collected at Nuggikeri, Kanavihonnapur, Arikoppa, M.K. Hubli, Ambargatti and Nayakanahulekatt with low sodium content between 0.015 to 0.059% and have higher number of heterocystous algae which in these soils range between 2.5 to 4 species per soil. However, paddy field soils collected at Kittur and Nayanagar have a similar range of sodium value as that of former groups of soils, but have moderately high number of heterocystous forms (1.33 to 7.2 species) per soil.

The sugarcane field soils at Anigol, M.K. Hubli, Holenhosur and Belavadi have sodium content varying from 0.015 to 0.039% and have moderately high number of heterocystous populations in the range between 1.8 to 3 species per soil. While, water samples collected at Londa and Nuggikeri with high concentration of sodium (0.360 to 0.896%) favour greater number of heterocystous population (2.4 to 4 species per sample). Bark samples of Kittur which in spite of maximum
sodium value (0.221 to 0.480%) have 2.2 species of heterocystous algae per sample. It appears that heterocystous algae do not tolerate higher sodium content and in addition, these samples have also high potassium and phosphate. In all these cases sodium is in a combined state with chloride, unless it is applied as manure in some soils. All these factors together might have restricted the growth of heterocystous blue-green algae.

**Nitrogen**:

High nitrogen content in the range of 0.038 to 0.768% appears to tolerate a higher number of heterocystous algae. Different habitat samples of tunnel walls at Castle rock have nitrogen varying between 0.0740 to 0.1255% and support a luxuriant growth of heterocystous population (4 species per sample). While, rock wall samples at Castle rock are poorer in nitrogen (0.0002 to 0.0004%) and favour moderately low percentage of heterocystous algae (47.67%).

Water samples collected at Puggikeri and Londa have high nitrogen content (0.2700 to 0.3400%) correspondingly and therefore have higher number of heterocystous forms (2, 4 and 4 species per sample respectively). However, bark samples of Kittur have nitrogen varying from 0.0450 to 0.0932% and support moderately high number of heterocystous algae (68.76%). Banana field soil samples at Munavalli and Sogal have
moderately high nitrogen content (0.695 to 0.672% respectively) with considera b l e range (1.2 to 3 species per sample) of heterocystous algae.

The paddy field soil samples of Nuggikeri, Kanavi-honnnapur, Arikoppa, M.K. Hubli and Nayakanahulakatti have nitrogen varying between 0.0606 to 1295% with high number of heterocystous algae (2.5 to 4 species per samples). While, paddy field soils at Kittur, Holehosur, Nayanagar, Ambargatti and Dharwad have high nitrogen content (0.0470 to 0.1090%) with low number of heterocystous forms (0.75 to 2.6 species) per soil. The sugarcane field soils of Anigol, Hosur, M.K. Hubli, Holehosur, Belavadi and Kurgund have moderately high number (0.75 to 3 species per soil) of heterocystous population.

However, it may be assumed that higher concentrations of nitrogen favour higher concentrations of heterocystous blue-green algae.

Calcium:

The average calcium content of all the habitats varies from 0.0315 to 0.160% its optimum values produce high number of heterocystous algae.

The bark samples collected at Kittur have maximum calcium content (1.5800 to 1.8100%) and have low number of
heterocystous algae (2.2 species per sample). While, tunnel wall, rock wall and soil samples collected at Castle rock having moderately high calcium content (0.2405 to 0.8817%) favour greater number of heterocystous algae with 3.19 species per sample. The sugarcane field soils at Anigol, Hosur, M.K. Hubli and Holehosur have calcium content ranging between 0.0101 to 0.0606% and have higher percentage (42.10 to 70.83%) of heterocystous algae except at Kurgund and Belavadi.

The banana field samples at Sogal and Munavalli having calcium percent (0.0113 to 0.0180%) also favour greater number of heterocystous population (1.2 to 3 species per sample). However, paddy field soils at Nuggikeri, Kanavihonnapur, Arikoppa and M.K. Hubli having low calcium content varying from 0.0250 to 0.0928% have optimum number of heterocystous algae (2.83 to 4 species per sample). Whereas paddy field soils at Holehosur, Kittur, Nayakanahulakatti, Nayanagar, Ambargatti, Kurgund and Dharwad though these places with low calcium content (0.0660 to 0.0200%) have moderately low number of heterocystous algae with more than 0.75 species per sample.

It is, therefore obvious to come to certain conclusion that low calcium content favours heterocystous blue-green algae.

Magnesium:

The soil and tunnel wall samples collected at Castle rock having high magnesium content (0.0170 to 0.2200%) show
higher number of heterocystous algae (3.19 species per sample). The banana field samples collected at Sogal and Munavalli have magnesium values ranging between 0.0030 to 0.0045% and have moderately greater percentage of heterocystous forms (50 to 78.94%).

The samples collected from water at Nuggikeri and Londa with magnesium content 0.0120 to 0.0800% have abundance growth of heterocystous forms (2.4 to 4 species per sample). However, bark samples of Kittur have magnesium value ranging between 0.0083 to 0.0659% have smaller number of heterocystous algae (2.2 species per sample). The paddy field soils at Nuggikeri, Kanavihonnnapur, Arikoppa, M.K. Hubli and Nayakanahulakatti having magnesium content in the range 0.0018 to 0.0100% have optimum growth of heterocystous forms (47.61 to 70.83%). While, all other places at Holehosur, Ambargatti, Nayanagar and Dharwad have magnesium content (0.0024 to 0.300%) and have low number of heterocystous algae (1 to 2.83 species per sample).

Sugarcane field soils at Anigol, Hosur and M.K. Hubli have magnesium content ranging between 0.0045 to 0.0270% and have moderately high number of heterocystous algae with 2.83 to 3 species per species per sample and only Belavadi soils with nil magnesium show low number of heterocystous (1.8 species per sample) algae. While, other sugarcane field soils at Holehosur and Kurgund have magnesium content varying from 0.0036
to. 0.0066% and have low number of heterocystous algae with 0.75 to 1.8 species per sample.

One may obviously come to the conclusion that moderately high concentration of magnesium in different samples favour higher averages of heterocystous algae.

**Potassium**

Very low concentrations of potassium in the range of 0.0140% indicate the growth of heterocystous blue-green algae. The paddy field soil samples at Kanavihonnapur, Arikoppa, Nugqikeri, M.K. Hubli and Nayakanahulakatti have potassium content (0.0165 to 0.0430%) and favour abundant growth of heterocystous algae (47 to 70%). However, paddy field soils at Holehosur, Kittur, Nayanagar, Ambargatti and Dharwad have low potassium content with more than 0.0170% and have greater number of heterocystous forms with 1 to 1.8 species per sample.

The samples from sugarcane field soils at Anigol and M.K. Hubli with potassium content (0.0355 and 0.0380% respectively) have moderately high number of heterocystous algae (57.70 to 70.83%). While, sugarcane field soils at Hosur, Belavadi and Holehosur with potassium content 0.0140 to 0.0345% have moderately high number of heterocystous forms (42.10 to 69.23%). However, samples from banana field soil at Sogal and Munavalli with potassium in the range between 0.0195 to 0.0330% have high number of heterocystous algae (1.7 to 3 species per sample).
The bark samples of Kittur have high potassium content (1.2500 to 1.4800%) and have low number of heterocystous algae with 2.2 species per sample. A distinct relation of potassium alone does not favour or restrict the heterocystous algae. It can be seen in the samples from tunnel wall and rock wall of Castle rock though these samples with high potassium content in this place (1.1200 to 2.8000%) have moderately high number of heterocystous algae (4 species) per sample. It might be because of low phosphate at some places, and high organic carbon.

Water samples at Londa and Nuggikeri have slightly high potassium content (0.1600 to 0.4800%) and have moderately high number of heterocystous algae ranging upto 4 species per sample.

Iron:

The samples from tunnel wall, rock wall and soils of Castle rock having optimum range from 1.012 to 4.313% of Iron content favour more heterocystous algae with 3.19 species per sample. This might be due to high nitrogen and organic carbon, in addition the continuous trickling of water. The samples collected from bark at Kittur have Iron content (0.071 to 0.078%) and have good percentage of heterocystous forms (68.76%). On the other hand, water samples collected at Londa and Nuggikeri having low Iron content 0.012 to 0.062% show greater number of heterocystous forms (50 to 70.17%).
Iron content in the range between 0.440 to 0.492% in banana field soils at Sogal and Munevalli have higher percentage (50 to 78.94%) of heterocystous algae. The paddy field soils of M.K. Hubli, Arikoppa, Nuggikari, Kanavihonnnapur with Iron content (0.667 to 1.130%) have abundant growth of heterocystous algae with 2.83 to 4 species per sample. However, the paddy field soils of Holehosur, Nayakanahulakatti, Nayanagar and Ambargatti having Iron content (0.543 to 0.740%) have moderately high percent of heterocystous algae (47.61 to 68.76%) while, sugarcane field soils of Belavadi, Hosur and Anigol with high Iron content (0.447 to 0.802%) have greater number of heterocystous forms which ranges upto 3 species per sample. Some other samples from sugarcane field soils of Kurgund, M.K. Hubli and Holehosur have Iron content (0.330 to 1.688%) and have low number of heterocystous algae with more than 0.75 species per sample.

A distinct relation of Iron exists between all other elements, it alone does not favour or restrict heterocystous algae because it acts as a micronutrient affecting the growth of heterocystous population. In the present investigation, Iron content shows correlation with number of heterocystous blue-green algae.

Cobalt:

Generally it appears that moderately higher concentrations of cobalt favour higher number of heterocystous algae.
The soil, tunnel wall and rock wall of Castle rock have cobalt content varying from 0.0010 to 0.0056% and these samples have 3.19 species per sample of heterocystous algae. Among banana field soils collected at Sogal and Munavalli the cobalt content of Sogal (0.0089%) is more than Munavalli (0.0010%) and these Sogal soils show abundant growth of heterocystous algae (78.94%).

The samples collected from water of Londa and Nuggikeri have cobalt content (0.0004 to 0.0042% respectively) and have high percentage of heterocystous algae (50 to 70.18% respectively). However, the paddy field soils at Nuggikeri, Arikoppa, Nayakannahulakatti and M.K. Hubli have cobalt content varying from 0.0006 to 0.0011% and have greater number of heterocystous algae (2.83 to 4 species per sample). While other paddy field soils at Holehosur, Kanavihonnapur, Ambargatti, Nayanagar and Dharwad have cobalt content (0.0007 to 0.0016%) and have moderate to high number of heterocystous forms with 1 to 2.6 species per soil. In the samples collected from sugarcane field soils the cobalt content is more than 0.0007% and have low number of heterocystous forms (0.75 to 1.8 species) per soil. The bark samples at Kittur show low number (2.2 species per sample) of heterocystous algae with cobalt content of 0.0003%.

Higher percent of cobalt seems to favour the abundance of heterocystous populations.
Copper:

Copper content in different habitats on an average ranges between 0.0007 to 0.0018% and favours higher number of heterocystous algae. The water samples collected at Londa and Nuggikeri shows absence of copper although the number of heterocystous forms is more than 2.4 species per sample. The bark samples collected at Kittur have copper content (0.0018 to 0.0039%) and have a good percentage of heterocystous algae (68.76%).

In the banana field soils collected at Sogal and Munavalli the copper content varies from 0.0013 to 0.0014% which favours the growth of heterocystous forms (1.2 to 3 species) per sample. However, the paddy field soils of Nuggikeri, Arikoppa, Kanavihonnapur and M.K. Hubli shows greater number of heterocystous algae with copper values varying from 0.0007 to 0.0018%. While, other paddy field soils of Holehosur, Nayakanahulakatti, Ambargatti and Nayanagar have copper content (0.001 to 0.0018%) and have moderately high number of heterocystous population (50 to 68.76%).

The sugarcane field soils of Anigol, Hosur and Polehosur have copper content (0.0009 to 0.0014%) and support the growth of heterocystous forms with 1.8 to 3 species per soil. The rest of samples from sugarcane field soils of M.K. Hubli, Belavadi and Kurgund have copper content in the range between
0.0008 to 0.0009% and have moderately greater number of heterocystous algae (69.23 to 75%).

It can be concluded from the above observations that higher concentration of copper in habitat samples favours higher number of heterocystous blue-green algae.

**Zinc:**

Different samples collected at various places with zinc concentration varying from 0.0003 to 0.0512% favour growth of heterocystous algae. The samples collected from soil, rock wall and tunnel wall of Castle rock have zinc content (0.0123 to 0.0512%) and have maximum number of heterocystous population with 3.19 species per sample. The bark samples of Kittur have zinc content varying from 0.0019 to 0.0081% and show low number of heterocystous algae with 2.2 species per sample. In case of water samples at Nuggikeri and Londa with zinc values (0.0003 to 0.0014%) have high percentage of heterocystous forms with 50 to 70.17%.

The samples collected from sugarcane field soil at Belavadi, Hosur, M.K. Hubli and Anigol have zinc content varying from 0.0026 to 0.0046% and show greater number of heterocystous forms with 1.8 to 3 species per soil. However, sugarcane field soils of Holehosur and Kurgund with zinc concentrations (0.0030 to 0.0084%) have low number (0.75 to
1.8 species) per soil of heterocystous algae. The paddy field soils of Nuggikeri, Kanavihonnapur, M.K. Hubli, Holehosur and Kittur with zinc concentration (0.0027 to 0.0053%) shows optimum growth of heterocystous algae with 1.8 to 4 species per soil.

It may assumed that a distinct relation with micro-nutrients exists and zinc alone does not favour or restrict the heterocystous blue-green algae but acts with other nutrients.
In the present investigation there is not much difference in the occurrence of either in terms of total number of species or percent non-heterocystous blue-green algae. Highest number of non-heterocystous algae are found in the paddy field soils of Kanavihonnapur, Nayakanahulakatti and Arikoppa with 1.8 to 2.67 species per soil. On the other hand there is complete absence of non-heterocystous algae in sugarcane field soils of Kurgund. Different habitats like paddy field soil, sugarcane field soil, banana field soil, rock wall, tunnel wall and water samples show variation in the number of non-heterocystous blue-green algae (0.33 to 2.67 species per sample).

**pH**: Kanavihonnapur, Nayakanahulakatti and Arikoppa have the optimum non-heterocystous algae ranging between 1.8 to 2.67 species per soil. The pH of these soils varies from 6.3 to 8.5. There seems to exist a close relation between the non-heterocystous algae and the pH of these samples, with a gradual increase in pH towards alkalinity, there is a gradual increase in the average number of non-heterocystous populations. Other paddy field soils of Nuggikeri, Dharwad, Ambargatti, Holehosur, Kittur, Nayanagar and M.K. Hubli had pH varying from 5.8 to 8.4 and have high number (0.33 to 1.5 species per sample) of non-heterocystous forms.
The water samples collected at Londa and Nuggikeri with pH in the range of 7.1 to 8.1 favour high number of non-heterocystous algal population with 1.5 to 1.6 species per sample. The banana field soils of Munavalli and Sogal have pH range between 7.7 to 7.8 and have high percentage of non-heterocystous algae (15.79 to 33.33%). The bark samples of Kittur with pH 5.1 to 6.0 have moderately low number (0.5 species per sample) and percentage of non-heterocystous algae (15.62%).

The sugarcane field soils at Hosur, Anigol and Holehosur have pH ranging between 8.1 to 8.8 and have greater percentage (23.07 to 25%) of non-heterocystous algae.

Generally it may be said that slightly acidic to alkaline samples favour more number of non-heterocystous blue-green algae.

**Electrical conductivity:**

It is significant to note that more than 60064.2 micromhos electrical conductivity in different samples favours more number of non-heterocystous algae.

The sugarcane field soils collected at Hosur, Anigol, Holehosur and M.K. Hubli with electrical conductivity (19612.8 to 186457.8 micromhos) have moderately high percentage of non-heterocystous algae (8.33 to 47.37%). The soils of banana field at Munavalli and Sogal with electrical conductivity
varying from 60064.2 to 263683.2 micromhos have low number of non-heterocystous forms (0.6 to 0.8 species) per soil.

The samples collected from paddy field soils of Ari-koppa, Nayakanahulakatti, Nuggikeri, Dharwad and Kanavihonnapur with electrical conductivity ranging between 130888.2 to 961027.2 micromhos favour abundant growth of non-heterocystous algae with 1 to 2.67 species per soil. However, at Holehosur, Ambargatti, Kittur, M.K. Hubli and Nayangar where electrical conductivity varying between 60064.2 to 327016.2 micromhos have low percentage (8.33 to 26.31%) of non-heterocystous forms. The bark samples at Kittur have electrical conductivity varying from 106780.8 to 240273.6 micromhos have decreased number of non-heterocystous algae (0.5 species per sample).

The tunnel wall, rock wall and soil samples collected at Castle rock had electrical conductivity within the range of 16480.2 to 871680.0 micromhos have high number (1.25 species per sample) of non-heterocystous algal populations.

Phosphate:

Lower values of phosphate support a higher average of non-heterocystous algae; while higher values have a relatively retarding effect on the growth of non-heterocystous forms.

Maximum number of samples examined have phosphate 0.002% where the average non-heterocystous algae range between 44.44%, while other paddy field soils at Nayakanahulakatti,
Arikoppa, Nuggikeri and Dharwad have values of phosphate (0.001 to 0.002%), where average non-heterocystous forms are 37.50 to 42.86%. The banana field soils of Munavalli and Sogal with high percent of phosphate (0.014 to 0.034%) support lesser percentage (15.79 to 33.33%) of non-heterocystous algae.

The bark samples of Kittur have phosphate content varying from 0.008 to 0.011% and have decreased number of non-heterocystous algae with 0.5 species per sample. The sugarcane field soils at Holehosur, Anigol and Hosur have phosphate content in the range of 0.001 to 0.012% and favours the growth of non-heterocystous algae (0.67 to 1.8 species) per soil. However, sugarcane field soils of Belavadi, M.K. Hubli and Kurgund with phosphate (0.007 to 0.014%) have reduced number of non-heterocystous algal forms with nil to 0.4 species per soil. While, tunnel wall, rock wall samples collected from Castle rock with phosphate content more than 0.002% favour abundant growth of non-heterocystous algae (1.25 species per sample).

Organic carbon:

Average values (1.54 to 1.89%) of organic carbon seems to favour the abundance growth of non-heterocystous algae.

The banana field soils of Munavalli and Sogal with 1.99 to 2.17% of organic carbon have reduced number of non-heterocystous forms with 0.6 to 0.8 species per soil. The bark sample
at Kittur with higher values (7.44 to 8.04%) of organic carbon support a lesser percentage (15.62%) of non-heterocystous algae. The sugarcane field soils at Belawadi, Anigol and Hosur have organic carbon content in the range between 1.35 to 1.71% and have greater percentage of non-heterocystous forms (15.39 to 47.37%) while sugarcane field soils of Kurgund, M.K. Hubli and Holehosur having organic carbon (1.54 to 2.14%) have low percentage (0 to 25%) of non-heterocystous algae.

The samples collected from paddy field soils at Kanavihonnapur, Nayakanahulekatti, Arikoppa, Holehosur and Kittur with organic carbon content varying from 1.35 to 2.41% have high number (0.5 to 2.67 species per soil) of heterocystous forms. However, paddy field soils of Nuggikeri, M.K. Hubli, Ambargatti and Nayanagar with organic carbon content (0.97 to 1.51%) have decreased number of non-heterocystous algae (0.5 to 1.5 species per soil).

**Sodium:**

Sodium content more than 0.029% appears to be a greater number of non-heterocystous algae. The paddy field soils collected from Kanavihonnapur, Arikoppa, Nuggikeri, Nayakanahulekatti and Ambargatti with sodium content (0.025 to 0.059%) have total number (1 to 2.67 species per soil) and percentage of non-heterocystous algae (26.31 to 44.44%). Hosur and Anigol sugarcane field soils with sodium content varying from 0.030 to 0.073% show comparatively higher number (1.2 to 1.8 species per soil)
of non-heterocystous populations. On the other hand banana field soils from Sogal and Munavalli have sodium content (0.023 to 0.060%) and have slightly low (0.6 to 0.8 species) per soil respectively number of non-heterocystous forms.

Water samples collected at Nuggikeri and Londa with sodium content ranging from 0.360 to 896% show optimum number (1.5 to 1.6 species per sample respectively) and percentage of non-heterocystous algae (26.31 to 33.33%). Samples collected from tunnel wall and rock wall have sodium value (0.232 to 1.440%) have also show optimum number (1.25 species per sample) of non-heterocystous forms. However, some sugarcane and paddy field soils of Dharwad, M.K. Hubli, Belavadi, Nayanagar, Kurgund and Kittur with sodium value varying between 0.011 to 0.022% have low number of non-heterocystous algae (0.2 to 0.5 species per soil).

**Nitrogen:**

Nitrogen content in the range between 0.0606 to 0.1295% in the paddy field soils of Arikoppa, Nayakanahulakatti, Kanavihonnapur and Nuggikeri favour high number (1.5 to 2.67 species per sample) and percentage of non-heterocystous algae (26.31 to 44.44%). While, other paddy field soils of Dharwad, Ambargatti, Holehosur and Kittur having nitrogen content (0.0470 to 0.1053%) have moderately high total number of non-heterocystous population (0.5 to 1 species per soil). Sugarcane field soils from Hosur and Anigol with nitrogen content (0.0582 to 0.1165%) have 1.2 to
1.8 species per soil of non-heterocystous forms. The banana field soils of Sogal and Munavalli with nitrogen value varying from 0.0672 to 0.0695% show low number (0.6 to 0.8 species per soil) of non-heterocystous population.

Bark samples collected from Kittur having nitrogen content (0.0450 to 0.0932%) show low percentage (15.62%) of non-heterocystous algae. Tunnel wall, rock wall and soils of Castle rock have nitrogen value ranging between 0.0002 to 0.1255% and have more number of non-heterocystous forms (1.25 species per sample). The water samples collected from Londa and Nuggikeri having nitrogen content (0.2700 to 0.3400%) show good number (1.5 species per sample) of non-heterocystous algae.

**Calcium:**

All most all samples examined have calcium in the range between 0.0100 to 1.8100%. Some water samples of Nuggikeri and Londa have optimum number of non-heterocystous algae (1.5 to 1.6 species per sample) with 0.1603 to 0.6412% of calcium content. However, samples collected from tunnel wall, rock wall and soils at Castle rock with calcium content from 0.2405 to 0.8817% have a number of non-heterocystous algae (1.25 species per sample).

Sugarcane field soils collected from Anigol and Hosur with calcium content (0.0101 to 0.0158%) have more number (1.2 to 1.8 species per soil) of non-heterocystous algae. Whereas sugarcane field soils of Belavadi, Holehosur and M.K. Hubli
have calcium content (0.0200 to 0.0606%) and show low number of non-heterocystous population ranging from 0.33 to 0.67 species per soil. Kanavihonnapur, Nuggikeri, Nayakanahulakatti and Arikoppa paddy field soils with calcium content varying from 0.0225 to 0.0928% have high number (1.5 to 2.67 species per soil) and percentage of non-heterocystous algae (26.31 to 44.44%). Banana field soils of Sogal and Munavalli with calcium content (0.0130 to 0.180%) show 0.6 to 0.8 species per soil of non-heterocystous forms.

Magnesium:

The paddy field soils collected from Nuggikeri, Arikoppa, Nayakanahulakatti and Kanavihonnapur with magnesium content (0.0024 to 0.0100%) have maximum number of non-heterocystous algae with 1.5 to 2.67 species per soil. Hosur, Anigol and Holehosur sugarcane field soils with magnesium content varying from 0.0036 to 0.0200% have optimum number of non-heterocystous forms (0.67 to 1.8 species per soil). However, banana field soils at Munavalli and Sogal show low number (0.6 to 0.8 species per soil) of non-heterocystous algae with magnesium content varying from 0.0030 to 0.0290%.

The tunnel wall, rock wall and soil samples of Castle rock with magnesium content varying from 0.0004 to 0.2200% have considerable number (1.25 species per sample) of non-heterocystous forms. Whereas water samples of Londa and Nuggikeri with magnesium content (0.0120 to 0.0800%) have considerable
percentage (26.31 to 33.33%) of non-heterocystous algae.

Potassium:

Banana field soils of Sogal and Munavalli with potassium value varying from 0.0195 to 0.033% have slightly low number (0.6 to 0.8 species per soil) of non-heterocystous population. Paddy field soils of Kittur, M.K. Hubli, Dharwad, Nayanagar and Ambargatti have potassium content ranging between 0.0180 to 0.0320% and have low number (0.33 to 1 species per soil) of non-heterocystous algae while, paddy field soils at Kanavihonnapur, Nayanakanahulakatti, Arikoppa and Nuggikeri with potassium value (0.0165 to 0.0430%) have high number of non-heterocystous algae with ranges between 1.5 to 2.67 species per soil.

The sugarcane field soils of Hosur and Anigol with potassium content (0.0215 to 0.0380%) have moderately high percentage (23.07 to 47.37%) of non-heterocystous algae. While, sugarcane field soils of Belavadi, Holehosur and Kurgund with potassium values varying from 0.0145 to 0.0400% have lowest number (0 to 0.67 species per soil) of non-heterocystous forms. Tunnel wall, rock wall and soils of Castle rock with potassium content (0.1600 to 0.4800%) have also 1.5 to 1.6 species per sample of non-heterocystous population.

Iron:

The paddy field soils of Kanavihonnapur, Nayanakanahulakatti, Nuggikeri and Arikoppa, where iron content in the range
of 0.667 to 0.983%, favours the high percentage (26.31 to 44.44%) of non-heterocystous algae. Sugarcane field soils at Hosur, Anigol and Holehosur with iron content (0.405 to 0.803%) show moderately high number of non-heterocystous forms with 0.67 to 1.8 species per soil. Whereas sugarcane field soils at Belavadi and M.K. Hubli with iron content varying from 0.447 to 1.688% have low number (0.33 to 0.4 species per soil) of non-heterocystous algae.

Bark samples at Kittur with iron value (0.071 to 0.078%) also show low number (0.5 species per soil) of non-heterocystous forms. However, rock wall, tunnel wall and soils at Castle rock with iron content (1.012 to 4.313%) have 1.25 species per soil of non-heterocystous form. While water samples of Nuggikeri and Londa with iron content (0.012 to 0.062%) have low percentage (15.62%) of non-heterocyst population.

Cobalt:

There is no clear relation between the non-heterocystous algae and cobalt in the present study. The cobalt content which is highest at Sogal, Nuggikeri and Castle rock (0.0032 to 0.0089%) have moderately high number (0.6 to 1.5 species per sample) of non-heterocystous forms. While, at Kanavihonnnapur, Hosur and Arikoppa with cobalt content (0.0006 to 0.0013%) have maximum number of non-heterocystous algae with 1.8 to 2.67 species per sample.
There exists no relation of cobalt value with non-heterocystous population in other places.

Copper:

Copper content of all the samples vary from nil at Londa to 0.0039% at Kittur. Sugarcane field soils of Anigol and Hosur with copper content (0.0012 to 0.0014%) have optimum number (1.2 to 1.8 species per soil) of non-heterocystous form. While, paddy field soils of Arikoppa, Kanavihonnapur, Nayakashulakatti and Nuggikeri with copper content varying from 0.0007 to 0.0019 % have highest number of non-heterocystous algae (1.5 to 2.67 species per soil).

Bark samples at Kittur with copper content (0.0018 to 0.0039%) show low number (0.5 species per sample) of non-heterocystous population. Whereas tunnel wall, rock wall and soils of Castle rock with copper content (0.0003 to 0.0021%) have 18.70% of non-heterocystous forms.

Zinc:

Zinc content ranges between 0.0019 to 0.0040%, it favours non-heterocystous algae. The highest zinc content (0.0512 %) at Castle rock has 1.25 species per sample of non-heterocystous forms. Whereas paddy field soils of Kanavihonnapur, Arikoppa, Nayakashulakatti and Nuggikeri with zinc content (0.0028 to 0.0053%) have highest number of non-heterocystous population (1.5 to 2.67 species per soil).
Sugarcane field soils at Anigol, Hosur and Holehosur with zinc content varying from 0.0026 to 0.0048% have moderately high percentage (25 to 23.07%) of non-heterocystous forms. While, at other places at Belavadi and M.K. Hubli zinc content (0.0008 to 0.0009%) show low number of non-heterocystous algae with 0.33 to 0.4 species per sample.
Unicellular

The average number of unicellular blue-green algae in samples collected from different habitats of the present investigation do not show much variation. Their greatest number recorded is 2.25 species per sample at Castle rock. In all other samples they are less than 2.25 species per sample reaching to a minimum of number 0.17 species per sample at Holehosur. Their optimum percent occurrence is 26.67% in Nayanagar samples with the lowest percent (3.50%) in samples of Nuggikeri.

pH:

The highest number of unicellular blue-green algae observed in all the different samples is above 0.67 species per sample in habitats of Castle rock, Anigol, Londa and Nayanagar. The pH in all the samples are above neutral and those samples that have the hydrogen ion concentration more than 7.1 seem to favour higher number of unicellular algae. Hosur, Belavadi and Munavalli samples have pH in the range between 7.8 to 8.8 but favour an average of only 0.4 species per sample unicellular blue-green algae.

A similar correlation exists when the percent occurrence of unicellular forms are considered. Those samples that have a nearly neutral pH support higher percentage of unicellular algae. Samples collected from Kanavihonnapur
and Ambargatti have acidic pH 5.8 to 6.6 have reduced number
of unicellular algae (0.2 to 0.33 species per sample).

**Electrical conductivity:**

The existing range of Electrical conductivity does not
show clear relation either with total number of percentage of
unicellular blue-green algae. However, Dharwad, Nayanagar
(paddy field soils), M.K. Hubli and Anigol (Sugarcane field
soils), Londa (water samples) and Castle rock (rock wall,
tunnel wall and soils) with electrical conductivity range
between 19612.8 to 871680.0 micromhos favour high number (0.6
to 2.25 species per sample) and percentage (16.67 to 33.64%) of
unicellular blue-green algae. While, at Arikoppa, Nayaka-
nahulakatti, Kittur, Kanavihonnapur, Ambargatti, Holehosur and
Nuggikeri (paddy field soils), Munavalli and Sogal (banana
field soils) and Hosur and Kurgund (sugarcane field soils)
with electrical conductivity (23017.8 to 327016.2 micromhos)
have reduced unicellular algal percentage (3.50 to 16.67%).

**Phosphate:**

Higher values of phosphate seem to favour higher
average of unicellular forms, although many different samples
have phosphate range between 0.004 to 0.011% they also
support good number of unicellular forms. However, phosphate
values between 0.0007 to 0.0009% are optimum values for the
growth of unicellular populations. A similar relation also
exists between percent phosphate and percent unicellular blue-green algae.

**Organic carbon:**

Organic carbon average values of all the different samples range between 0.038 to 0.768% and perhaps this percent of organic carbon is suitable for the growth of unicellular algae. However, Londa (water) samples completely lack in organic carbon content, but yet show the moderately high percent (16.67%) of unicellular populations. Therefore, a distinct relation between these cannot be traced since different samples in which unicellular forms are less also show organic carbon values between 0.012 to 0.97 percent.

**Sodium:**

Different samples collected at Castle rock (tunnel wall), Londa (water), Anigol and M.K. Hubli (sugarcane field) and Nayanagar and Dharwad (paddy field) with sodium content varying from 0.011 to 1.280% favour the greater number of unicellular algae (0.6 to 2.85 species per sample). Bark samples at Kittur with sodium content (0.221 to 0.480%) have considerable number (0.5 species per sample) of unicellular forms.

A similar behaviour of the occurrence of percent unicellular algae towards percent sodium exists. Kanavihonnapur paddy field soils although having 0.059% sodium have low number (0.33 species per soil) of unicellular populations.
Nitrogen:

The existing range of nitrogen percent in the samples collected from different habitats does not show a clear correlation between total number of unicellular algae and percent nitrogen. However, paddy field soils of Nayanagar, Dharwad, Arikoppa, Nayakanahulakatti and Kittur with nitrogen content (0.0470 to 0.1053%) have high number of unicellular forms (0.5 to 0.67 species per soil). Some of the tunnel wall, rock wall and soil samples collected at Castle rock with nitrogen value ranging between 0.0004 to 0.1255% also favour high number (2.25 species per sample) of unicellular blue-green algae.

Calcium:

Different habitat samples that have calcium value of 0.0101 to 0.0606% possess unicellular populations in higher number. But there are some samples that do possess calcium in the same range but do not show the growth of unicellular populations. The same results hold good when the percent unicellular algae are considered.

Magnesium:

Magnesium content in the range of 0.0018 to 0.0220% favour high number of unicellular algae. However, Castle rock samples have the highest percentage of unicellular (33.67%) in
which magnesium content ranging between 0.0004 to 0.2200%. The paddy field soils collected at Arikoppa, Nayakanahulakatti, Kittur, Kanavihonnapur and Nuggikeri with magnesium content (0.0024 to 0.0072%) have moderately low percentage (3.50 to 15.62%) of unicellular algae. The average number remains in close relation to the other different samples.

**Potassium:**

Potassium content (0.0140 to 0.0380%) favours greater number of unicellular algae (0.4 to 1 species per sample) while, tunnel wall, rock wall and soils of Castle rock with potassium content (0.6124 to 2.0800%) also favour greater number (2.25 species per sample) of unicellular algae. However, bark samples of Kittur with potassium value varying from 1.2500 to 1.4800% have less percentage (15.62%) of unicellular algae.

Generally low percentage of potassium favours the unicellular populations.

**Iron:**

Iron content varying from 1.078 to 4.313% favour higher number of unicellular algae. The different samples at Castle rock (tunnel wall, rock wall and soils), Dharwad, Kanavihonnapur and M.K. Hubli (paddy field soils) with iron content ranging between 1.688 to 3.787% have moderately high number of unicellular forms with 0.33 to 2.25 species per sample. The average number remains in close relation to the other samples.
Cobalt:

Lower content of cobalt (0.0009 to 0.0015%) in sugar-cane field soils at Anigol, Hosur and Belavadi have 0.4 to 1 species per sample of unicellular algae. Whereas paddy field soils at M.K. Hubli, Nayanagar and Dharwad with cobalt content (0.0007 to 0.0015%) favour higher number (0.6 to 0.83 species per soil) of unicellular algae. There is no clear correlation between cobalt content and the total number of unicellular forms in other samples.

Copper:

There exists no direct relation between the percent copper of different samples and the occurrence of unicellular blue-green algae. However, Londa (water) sample showed complete absence of copper but show higher percentage of unicellular forms (16.67%).

Zinc:

There is no clear relation between zinc and unicellular populations but at Castle rock samples with highest zinc value (0.0512%) have highest number (2.25 species per sample) of unicellular forms while, lowest zinc value (0.0003%) at Londa (water) have moderately high number (0.8 species per sample) of unicellular blue-green algae.
Algae in relation to soil types

Soil types collected for the present study can be classified into Alluvial soils; Black soils; Red soils and Leteritic soils (Table 2). Algal productivity in these different soil types is given in Table 12.

Leteritic soils have maximum number of Blue-green algae (5.27 species per soil) and Red soils have minimum number of algae (3.73 species per soil) while all the other types of soils have a considerably high algal productivity (3.86 to 4.20 species per soil).

Maximum number of heterocystous forms occur in Alluvial soils (3.20 species per soil) and minimum number of heterocystous forms occur in Black soils (2.16 species per soil). All the other soil types have also considerably high number of heterocystous forms with 2.42 to 2.46 species per soil. None of the soil types have greater number of non-heterocystous blue-green algae, the maximum being 2.57 species per soil in leterites. The maximum number of unicellular blue-green algae (of 0.81 species per soil) occur in Black soils and all other soil types have less than 0.34 species.
### Table 12

Average number of blue-green algae in different soil types

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Heterocystous</th>
<th>Non-heterocystous</th>
<th>Unicellular</th>
<th>Total species</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Alluvial soils</td>
<td>3.20</td>
<td>0.80</td>
<td>0.20</td>
<td>4.20</td>
</tr>
<tr>
<td>2. Black soils</td>
<td>2.16</td>
<td>0.89</td>
<td>0.81</td>
<td>3.86</td>
</tr>
<tr>
<td>3. Red soils</td>
<td>2.46</td>
<td>0.93</td>
<td>0.34</td>
<td>3.73</td>
</tr>
<tr>
<td>4. Leteritic soils</td>
<td>2.42</td>
<td>2.57</td>
<td>0.28</td>
<td>5.27</td>
</tr>
</tbody>
</table>
Algae in relation to major crops

The soils under study are classified on the basis of the blue-green algae occurring in relation to the major crops (Table 3). The observations made on the algal productivity of these different groups have been presented in Table 13.

On a general consideration of Heterocystous blue-green algae occurring in different soils it is found that they are represented more in the fields where paddy is grown with an average of 2.63 species. They are least where sugarcane is cultivated. In the soils where banana is grown the average number of heterocystous forms observed is 2.40 species.

The average number of Non-heterocystous blue-green algae observed in these soils is less as compared to the number of heterocystous blue-green algae. This highest number is seen in soils, where paddy is cultivated and in other crop soils they range between an average of 0.70 to 0.72 species.

The average number of Unicellular blue-green algae observed is 0.63 species in soils where paddy are grown, and range from an average of 0.30 in banana soils to 0.48 species in sugarcane soils.

On consideration of the total number of blue-green algal species in relation to the major crops under study, it is evident that they are highest in paddy soils and least in sugarcane soils. In general, it is found that the average number of blue-green algae are more in soils where paddy is cultivated.
Table 13
Average number of blue-green algal species in soils with different major crops

<table>
<thead>
<tr>
<th>Major crops</th>
<th>Heterocystous</th>
<th>Non-heterocystous</th>
<th>Unicellular</th>
<th>Total species</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Paddy</td>
<td>2.63</td>
<td>1.41</td>
<td>0.63</td>
<td>4.67</td>
</tr>
<tr>
<td>2. Sugarcane</td>
<td>1.92</td>
<td>0.72</td>
<td>0.48</td>
<td>3.12</td>
</tr>
<tr>
<td>3. Banana</td>
<td>2.40</td>
<td>0.70</td>
<td>0.30</td>
<td>3.40</td>
</tr>
</tbody>
</table>
Algae in relation to fertilizers

A wide variety of fertilizers, both chemical and natural are used locally to add to the various crops. The fertilizers used in the collected samples are given in Table 4 and observation on total productivity is given in Table 14. All algae occurring in these soil types have been accounted and the averages represented. Wherever chemical fertilizers have been added the average heterocystous algae are found to be very high as compared to fields where only cow-dung or a mixture of cow-dung and chemical fertilizers have been used. Non-heterocystous forms are also high where chemical fertilizers are used (2.25) and are least where only cow-dung is used (0.25). Unicellular blue-greens do not seem to vary with the type of fertilizer used and range at an average between 0.62 and 0.96. When the distribution of total blue-greens is considered, they are high where chemical fertilizers are used (8.38), while their variation in the other two is not well marked.

It may be concluded, from the above observations that blue-green algae are abundant at places where chemical fertilizers are used and are least where natural fertilizers are used. Similar observations have been made by Gistl (1933), Peterson (1935) and Lund (1947).
<table>
<thead>
<tr>
<th>Fertilizers</th>
<th>Heterocystous</th>
<th>Non-heterocystous</th>
<th>Unicellular</th>
<th>Total species</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Manured with chemical fertilizers such as urea, potash, ammonium phosphate, diammonium phosphate, superphosphate and complex.</td>
<td>5.17</td>
<td>2.25</td>
<td>0.96</td>
<td>8.38</td>
</tr>
<tr>
<td>2. Manured with cow-dung and chemical fertilizers like diammonium phosphate, ammonium phosphate, potash, urea and complex.</td>
<td>1.86</td>
<td>0.81</td>
<td>0.40</td>
<td>3.07</td>
</tr>
<tr>
<td>3. Manured with only cow-dung</td>
<td>1.87</td>
<td>0.25</td>
<td>0.62</td>
<td>2.74</td>
</tr>
</tbody>
</table>

Table 14

Average number of blue-green algal species in soils with different fertilizers