8. Summary and Conclusion
SUMMARY AND CONCLUSION

Comprising over 70% of the earth’s surface, water is undoubtedly the most precious natural resource that exists on our planet. Without the seemingly invaluable compound, comprised of hydrogen and oxygen, life on Earth would be non-existent. It is essential for everything on our planet to grow and prosper. Although, we as humans recognize this fact, we disregard it by polluting our rivers, lakes, and oceans. Subsequently, we are slowly, but, surely harming our planet to the point, where organisms are dying at a very alarming rate. In addition to innocent organisms dying off, our drinking water has become greatly affected as our ability to use water for recreational purposes. In order to combat water pollution, we must understand the problems and become part of the solution.

Many causes of pollution, including, sewage and fertilizers contain nutrients such as, nitrates and phosphates. In excess levels, nutrients over stimulate the growth of aquatic plants and algae. Excessive growth of these types of organisms consequently clogs our waterways, use up dissolved oxygen as they decompose and block light to deeper waters. This, in turn proves very harmful to aquatic micro organisms in water.

Pollution is also caused when silt and other suspended solids, such as soil, wash of plowed fields, construction and logging sites, urban areas, and eroded river banks when it rains. Under natural conditions, lakes, rivers, and other water
bodies undergo eutrophication, an aging process that slowly fills in the water body with sediment and organic matter. When these sediments enter varied types of waterbodies, plant productivity and water depth become reduced, and aquatic micro organisms and their environments become suffocated. Pollution in the form of organic material enters waterways in many different forms as sewage, as vegetational residues, or as runoff from livestock feedlots and pastures. The microbes like bacteria and fungi in the water, break down these organic materials, they begin to use up the oxygen dissolved in the water. Many types of fish and bottom-dwelling animals cannot survive, when levels of dissolved oxygen drop below two to five parts per million. When this occurs, it kills aquatic organisms in large numbers, which leads to disruptions in the food chain of aquatic ecosystem.

(http://www.umich.edu/~gs265/society/waterpollution.htm).

Based on the topography, nature of riverbed, water flow, sources of pollutants and human interference, six sampling stations were selected for the present investigation which are as follows.

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Sampling Stations</th>
<th>Location</th>
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<tbody>
<tr>
<td>01</td>
<td>Station-I (S1)</td>
<td>Sringeri, near Sharadamba shrine (Chikmagalur district)</td>
</tr>
<tr>
<td>02</td>
<td>Station-II (S2)</td>
<td>Thirthahalli, near Rameshwara Shrine (Shimoga district)</td>
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<tr>
<td>03</td>
<td>Station-III (S3)</td>
<td>Sakarebylu, (Shimoga district)</td>
</tr>
<tr>
<td>04</td>
<td>Station-IV (S4)</td>
<td>Gajanur, near dam site (Shimoga district)</td>
</tr>
<tr>
<td>05</td>
<td>Station-V (S5)</td>
<td>Shimoga, near old Bridge (Shimoga city)</td>
</tr>
<tr>
<td>06</td>
<td>Station-VI (S6)</td>
<td>Koodli, confluencing point (Shimoga district)</td>
</tr>
</tbody>
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Established techniques were employed for the analysis of physicochemical parameters and for isolation and culture of aquatic and extra aquatic fungi. For the degradation studies, the partially decaying organic leaf litter, decaying plant parts debris were collected from sampling stations. Preparation and incubation of samples were made according to the prescribed standard procedures. Fungal composition, diversity, distribution and decomposition of organic waste were conducted and the results have been discussed.

The inter relationship between physico-chemical parameters, with the percent occurrence, distribution and periodicity of aquatic fungi and extra aquatic fungi has also been made. Further, the nature of biodegradation process, mediated by fungi has been studied in the laboratory by conducting experiments to elucidate the biodegradation process by using two cultured active fungal species which, helps in biodegradation of cellulosic substances. The following observations have been recorded.

**Physico-chemical parameters**

**Temperature**

Air and water temperatures appear to show marked differences. The distribution and annual rainfall in the study area has profound effect on the seasonal variations of the temperature. The recorded average values of air and water temperature, ranged from 30.71°C to 31.8°C and 24.8°C to 25.7°C, respectively.
pH

The pH of water is found to be neutral to alkaline with a range between 7.72 to 8.18. Station-V has encountered alkaline pH, when compared to all other stations and the pH value was found to be more during pre-monsoon compared to all other seasons.

Electrical conductivity (EC)

The values of electrical conductivity were found to be high during pre-monsoon period at all the stations and its value varied between 123.27 μmhos/cm to 126.70 μmhos/cm.

Total hardness (TH)

Total hardness average values ranged from 33.12 mg/l to 39.45 mg/l. The seasonal average values indicate that, the total hardness was high during pre-monsoon and low during monsoon season in all the stations.

Carbonates and Bicarbonates

Average value of carbonates, by and large, was found to be less than 0.17 mg/l, whereas, bicarbonates ranged between 1.65mg/l to 2.36 mg/l. Seasonally, carbonates and bicarbonates values reached its maximum during pre-monsoon season and low during monsoon season.
Dissolved oxygen (DO)

Average value of dissolved oxygen content fluctuated from 6.78 mg/l to 8.14 mg/l and low values are recorded at Station-IV and V in the down stream point. Seasonally, it was found to be high during monsoon and low during pre monsoon at all the stations.

Biological oxygen demand (BOD)

The maximum BOD values were recorded moderately high at Station-V and its values ranged between 2.72 mg/l to 4.14 mg/l. Interestingly its highest concentration was recorded during pre monsoon and lowest during monsoon season.

Chemical oxygen demand (COD)

The values of COD were found to be high during pre monsoon season and low during monsoon at all the stations. The values of COD ranged from 8.91 mg/l to 13.18 mg/l.

Sulphate and chloride

These two anions are important and found to be dominant in the river water. Average values of sulphate ranged from 19 mg/l to 26.12 mg/l. whereas, chloride values varied 20.41 mg/l to 27 mg/l. The values of sulphate and chloride were found to be high during pre-monsoon season and drastically reduced in monsoon season.
Phosphate

Phosphate was recorded at all the stations and its value varied from 0.13 mg/l to 0.19 mg/l. Seasonally, it was found to be high during pre monsoon season and drastically reduced in monsoon season.

Sodium and potassium

These two cations which are needed as the micronutrients for the growth of the aquatic microbes. It has been observed that, the values of sodium were higher than that of potassium. The concentration of sodium varied between 2.22 mg/l to 3.41 mg/l, whereas the concentration of potassium ranged between 0.11 mg/l to 0.19 mg/l. Seasonally, sodium and potassium values are found to be moderately high during pre monsoon and low during monsoon season at all the stations.

Calcium and Magnesium

Concentration of calcium was always higher than that of the magnesium. The concentration varied between 14.20 mg/l to 14.96 mg/l, where as the concentration of magnesium ranged between 3.2 mg/l to 5.6 mg/l. Seasonally, the values of calcium and magnesium were found to be high during pre-monsoon and low during monsoon at all the stations.

Total dissolved solids (TDS)

The total dissolved solids ranged from 113 mg/l to 122.8 mg/l. seasonally, its values were found to be high during pre-monsoon and low during monsoon at all the stations.
2. Periodicity and distribution of aquatic fungi

Periodicity, distribution and percentage of fungal occurrence directly depend on the various physico-chemical parameters of the water. Some of the important factors directly affect the distribution, percent occurrence and periodicity of aquatic mycoflora are temperature, dissolved oxygen (DO), biological oxygen demand (BOD) and pH.

During the present investigation, the physico-chemical characteristics of water at all the six identified sampling stations, showed variations in their concentration. The data obtained from the analysis of physico-chemical parameters of all the stations reveals that, the average value of physico-chemical parameters of water, recorded at Station-I, favors the abundant occurrence of both aquatic fungi and extra aquatic fungi, as the river at this station is comparatively free from pollution. But, this scenario at Station-IV and Station-V seems to be unfavorable for the fungal occurrence, compared to Station-I, due to the interference of industrial effluents, domestic sewage and urban solid wastes.

A total of 13 genera and 24 species of aquatic and extra aquatic fungi were recorded during the entire period of study. All the 24 species of both aquatic and extra aquatic fungi, commonly observed in all the four stations, but their percentage of occurrence is varied from one station to another station.
Out of 24 identified fungal species, 11 species and one genera belongs to aquatic fungi (aquatic phycomycetes) they are *Achlya debaryana*, *A. oryzae*, *A. ambisexualis*, *A. racemosa*, *A. androgyna*, *A. stellata*, *Brevilegnia linearis*, *Blastocladiella variabilis*, *Dictyuchus sterilis*, *Saprolegnia ferax*, *Saprolegnia parasitica*, and *Rozella sp*. Out of which, *Achlya debaryana*, *A. oryzae*, *A. diffusa*, *Brevilegnia linearis*, *Blastocladiella variabilis*, *Dictyuchus sterilis* *Saprolegnia ferax*, *S. parasitica*, and *Rozella Sp* are found to be dominant in all the six stations. The other fungi occurred in less percentage are *Achlya stellata*, *A. ambisexualis*, and *A. racemosa*. Similarly, there are about 13 extra aquatic fungi recorded in all the six stations that include, *Alternaria alternata*, *Aspergillus flavus*, *A. fumigatus*, *A. niger*, *Cladosporium herbarum*, *Fusarium eqiuseti*, *F. oxysporum*, *F. semitectum*, *F. solani*, *Penicillium commune*, *Rhizopus nigricans*, *Trichoderma viride* and *T. harzianum*. Among them, the dominant extra aquatic fungi recorded in all the six stations are, *Aspergillus flavus*, *A. fumigatus*, *A. niger*, *Fusarium oxysporum*, *F. eqiusiti*, *F. solani*, *Penicillium commune* and *Trichoderma harzianum*.

Other species of extra aquatic fungi, which were encountered in this station at low percentage, include *Alternaria alternata*, *Cladosporium herbarum*, *Rhizopus nigricans* and *Trichoderma viride*.

The periodicity and seasonal variation of both aquatic and extra aquatic fungi are found to be in good number at upstream sampling points (Station-I, II
and III) due to the favorable environmental conditions viz., low average temperature (30.71°C) and a high amount of dissolved oxygen (8.14 mg/l) and neutral pH (7.72) and all the other parameters are within the permissible limits. But, their percentage occurrence and seasonal variation are moderately detoroited in the downstream points (Station-V and VI) due to the pollution interference and unfavorable environmental conditions. Interestingly, slow recovery in the distribution and occurrence of both aquatic and extra aquatic fungi was noticed in the last station of the down stream of the river (Station-VI). Probably, this is due to the increase in DO level, decreased temperature and neutral pH that were encountered at this station due to the dilution factor.

**Biodegradation study**

Destruction and spoilage of any organic substances, with the help of living organisms is called as bio-degradation. It's the topic of prime importance and proved to be very economical to encounter the organic pollution. Few noted national and international research organizations are concentrating very hard for this purpose. A new dimension has to be employed with useful microbes and to utilize them to combat organic pollution. Aquatic mycoflora are the nature's own gift to the aquatic ecosystem, which helps in self purification and to control pollution. Fungi are active bio-degraders of organic materials. To experiment this phenomena in the laboratory condition, we employed the following fungi to destruct the partially degraded organic materials, such as, leaves and aquatic plant
materials obtained from the natural riverine eco-system. The identified fungi is employed for this study was Achlya oryzae and Fusarium solani, the results obtained from this study proved that, these fungi are active bio-degrading agents. They actively degraded the cellulosic substance obtained from the above mentioned substrates. The data was collected through the application of standard dry weight loss method. Fusarium solani, an extra aquatic fungi degraded the organic substances more effectively, when compared to Achlya oryzae (true aquatic fungi). These fungi degraded aquatic plant parts more effectively, than the partially degraded leaf materials. The overall study and the analysis of the obtained data revealed that, the process of degradation increases from 10th day of incubation onwards, the process of degradation increases with increased incubation period by Fusarium solani and Achlya oryzae. However, Fusarium solani appears to be more active in degrading cellulosic substances, when compared to Achlya oryzae.