Introduction:

Water is one of the most fascinating gifts of nature. About 70 percent of Earth’s is water covered. But water also exists in the air as water vapour and in the ground as soil moisture and in aquifers. Water is susceptible to get contaminated by any foreign matter and this may be either natural or artificial. Any alteration in the physical, chemical and biological properties of water as well as contamination of any foreign substances leads to health hazards. The domestic waste water entering into the water bodies is the main cause for the pollution. The heavy inflow of the pollutants into the water bodies directly affects the aquatic life, human health, loss of soil fertility and reduction in the yield. Due to rapid urbanization and industrialization, encroachment of land and change in land use pattern is affecting the sources for replenishment of water bodies.

Byramangala reservoir was built by the British in 1942 as a result of impoundment of Vrishabhavathi stream south of Bangalore City. Its exact location on the map is on latitude
12°47″N and longitude 77°20″E. The total area of the lake is 412 hectares. The lake water is being utilized for agriculture, fisheries and for other various vegetation purposes. Until in the late 60’s, the Byramangala water quality was of the highest purity. Since then the water quality has been receding to a point where the reservoir is highly polluted as it receives both industrial effluents and untreated sewage from the Bangalore Urban Area. Heavy metals such as iron, zinc, chromium, magnesium etc. and nutrients such as nitrogen and phosphorous are rendering the water unfit for the human consumption.

**Objective of the Project:**

The objectives of the present study are:

a) To evaluate the degree of Heavy metal concentration in the selected polluted Lake.

b) To evaluate the Trophic Status Index of the Lake and hence determine its Eutrophication status.

c) To suggest Bioremediation techniques and methodologies for the revival of the Byramangala Lake.

**Methodology:**

The current study includes -

- Collection and analysis of water samples
- Identifying the source of pollution
- For deep sources water samples are drawn from borewells at various stations in the study area. The physical, chemical and biological parameters of the water samples are determined by conducting various tests.
- For surface source water samples are drawn from Byramangala reservoir. For subsurface source, water samples are drawn from open wells at various locations in the study area.

**Methods to determine TSI -**

**Carlson’s Trophic Status Index and water quality:**

Carlson developed TSI and water quality index for lakes and rivers. The following equations can be used to compute the Carlson’s TSI.

\[
\text{TSI - P} = 14.42 \times \ln [\text{TP}] + 4.15 \text{ (in ug/L)} \quad \text{(i)}
\]
TSI - C = 30.6 + 9.81* Ln [Chlor-a] (in ug/L) ------- (ii)

TSI – S = 60 – 14.41* Ln [SD] (in meters) ----------- (iii)

Using Kratzer and Brezonik’s equation:

TSI –N = 54.45+14.43*Ln [TN] --------------- (iv)

Average TSI = [TSI (P) + TSI (CHL ‘a’) + TSI (N) + TSI (SD)]/2 --------- (v)

Where,

TP is total phosphorus, TN is total nitrogen, SD is secchi depth, chlor A is chlorophyll.

Table showing Carlson’s Trophic State Index

<table>
<thead>
<tr>
<th>TSI</th>
<th>State</th>
<th>Status of Lake</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 30</td>
<td>Oligotrophy</td>
<td>Classical Oligotrophy: Clear water, oxygen throughout the year in the hypolimnion, salmonid fisheries in deep lakes.</td>
</tr>
<tr>
<td>30-40</td>
<td>Mesotrophy</td>
<td>Deeper lakes still exhibit classical oligotrophy, but some shallower lakes become anoxic in the hypolimnion.</td>
</tr>
<tr>
<td>40-50</td>
<td>Mesotrophy</td>
<td>Water moderately clear, but increasing probability of anoxia in hypolimnion during summer.</td>
</tr>
<tr>
<td>50-60</td>
<td>Eutrophy</td>
<td>Lower boundary of classical eutrophy, Decreased transparency, anoxic hypolimnia during the summer, macrophyte problems evident, warm-water fisheries only.</td>
</tr>
<tr>
<td>60-70</td>
<td>Eutrophy</td>
<td>Dominance of blue-green algae, algal scums probable, extensive macrophyte problems.</td>
</tr>
<tr>
<td>70-80</td>
<td>Hyper-eutrophy</td>
<td>Heavy algal blooms possible throughout the summer, dense macrophyte beds, but limited light penetration. (Often would be classified as hypereutrophic)</td>
</tr>
<tr>
<td>-------</td>
<td>----------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>&gt;80</td>
<td>Hyper-eutrophy</td>
<td>Algal scums, summer fish kills, few macrophytes, dominance of rough fish etc.</td>
</tr>
</tbody>
</table>

**Results and Conclusions:**

The samples were collected for the analysis of physical, chemical and bacteriological parameters. The analysis of physical, chemical and bacteriological parameters were performed as per IS methods. The results obtained for various parameters of physical, chemical and bacteriological tests reveals that the surface water is contaminated at various locations. High concentration of sodium, calcium, magnesium, chlorides, sulphates, nitrates, biocarbonates, hardness, BOD, and turbidity are observed in the Lake water beyond the permissible limits. The heavy metals such as Copper, Iron, Zinc, Manganese, Chromium, and Cadmium are also well above the permissible limits during both the samplings. The lake is getting polluted over time. The lake was initially mesotrophic which has gradually changed to hyper-eutrophic perhaps due to the increased Total Nitrogen and Total phosphorous content and various anthropogenic activities in the catchment.

The main objective of carrying out the studies on heavy metal concentration and eutrophication in polluted lakes is to assess the eutrophication status of the lake and to discuss bioremediation that can be adopted for the restoration of lake. Our study of physical, chemical and bacteriological characterization of the water was taken up to highlight the existing trophic state index and to propose remedial measures that are required for lake. The factors that affect the pollution of the water are the type of industries, the nature of waste disposal etc. Considering the above reason it is important to note that intensive farming in the village should be reduced. Many industries are situated in and around reservoir and hence most of these industries dispose their effluent without any primary treatment. Every industry releasing its effluent into the reservoir must be equipped with a treatment unit at the source of
disposal complete with a screening chamber and other units to undergo primary treatment of waste before it is finally released into the tank.

Depending upon the eutrophication status and source of pollution, one or more Bioremediation techniques alone or in combination can be employed for lake revival. The results of sampling at six locations of Byramangala Lake during the month of March and April, 2014 indicated that the lake has approached to Hyper-eutrophic state and conservation measures like control of point sources and Bioremediation techniques like Anoxic Bioremediation Technology (ABR), Green Bridge Technology, Soil Scape Filter and many others can be implemented to revive the lake.

**Scope for future work:**

As mentioned above, several Bioremediation techniques and methodologies can be adopted to restore and revive the lake. An attempt can be made to apply natural flora and fauna in well-designed manner in Byramangala Reservoir catchment areas which contributes polluted sewage inlet into the reservoir. This cost effective and less energy intensive treatment methodology may be adopted to control the pollution emanating from point and non-point sources. The techniques such as Green Bridge Technology, Stream eco system, Hydrarch succession Pond and Phytofiltration can be adopted to reduce further pollution in the Lake in in-situ condition itself. Several ex-situ bioremediation techniques which can be used to reduce the reservoir pollution are Soil Scape Filter and Anoxic Bioremediation Technology (ABR).