This chapter describes the studies conducted to assess the eco-biological characteristics of Western Ramganga River at Almora District. An appreciable number of theoretical explanations given in previous studies made the present investigation more ambitious towards a proper management and evolution of the river for future use. As fresh water bodies play a key role in the upliftment of socio-economic conditions. The present study seems to be of great importance because studies on different physico-chemical parameters of different aquatic media yielded useful data for the understanding of the nature of the river ecology and it throws a flood of light on the changes which have been brought about the intense of human interference. The principal reason behind analysis of present water quality status of Western Ramganga River was to verify:

1. Whether, the river water is polluted or not.
2. Whether, the water quality is suitable for human consumption.
3. Whether, the water is suitable for aquaculture or not.
4. Whether, the river contain any source of pollution load or not if yes, then which type of methods should be applicable for maintaining ecological integrity and to mitigate the water pollution in the river.

Earlier, some limnological aspects of this river were studied by Pathani and Upadhyay, (2006), at that time, there were limited human interference and biotic activities in river catchment. But with the passage of time, human interference and biotic activities in the catchment area have increased considerably. Therefore, one prime objectives of this study was to find out the changes in various limnological parameters, plankton community and fish diversity of the river which have occurred in last few years.

Among all the ecological factors, the temperature can be considered an important factor, temperature affects the speed of various
chemical reactions such as photosynthetic and metabolic rate of aquatic plants and animals. It also regulates decomposition of organic matter. Annual variation in water temperature has a great bearing upon its productivity Wetzel and Likens, (1979). Velocity is an important factor of water quality and has ecological implications which influences the aquatic biota that cannot be ignored.

The ion content of the river water indicates that, conductivity of river has been increased considerably during monsoon (Table 8.1). High concentration of municipal water, anthropogenic activities and less flow increase the ionic content which results in the increased level of conductivity. The Secchi disc transparency of river water also showed considerable improvement after long-term rainfall during monsoon. During rainy season high flood brought more sediment may account for the significant difference in transparency. High water transparency might be a combined effect of reductions in particulate and suspended particles as well as biological productivity. Overall, the water transparency of Western Ramganga River increased considerably from post monsoon to the winter and summer months later it declined steeply till the end of monsoon.

The Total solids concentration presented a significant spatial and seasonal variation with higher values observed in monsoon. High discharge in monsoon bringing soil and other sediments from the adjoining areas and due to turbulent flow which stirred up the non-living matter like silt and sand at the bottom of the river. Beside, that, deforestation, intensive agriculture, manuring, fertilizers, recreation, urbanization, manufacturing of buildings and roads on catchment area further add impurities in it. The river basin is neither industrialized nor too much agricultural thus in these conditions, landslide, soil erosion and use of detergents can be assigned the main sources that affecting water quality of Western Ramganga River. To some extent, fishing and agricultural activities in the catchment also causes nutrient load into the river.

In respect of certain other parameters such as pH, concentration of
**Table 8.1:** Biannual mean values of water quality parameters of Western Ramganga River and desirable and permissible limit of Bureau of Indian Standard (BIS 1994 and 2009), WHO (2011) for drinking water and fish culture.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Tolerance limit for fish culture as per BIS (1994)</th>
<th>Tolerance limit of BIS (2009) for drinking water</th>
<th>Maximum permissible limit of WHO (2011) for drinking water</th>
<th>Mean and Range values of Western Ramganga River</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient temp. (°C)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>22.20 (15.45 to 29.32)</td>
</tr>
<tr>
<td>Water temp. (°C)</td>
<td>2 – 35</td>
<td>-</td>
<td>18.46 (13.45 to 21.48)</td>
<td></td>
</tr>
<tr>
<td>Transparency (cm)</td>
<td>-</td>
<td>-</td>
<td>190.69 (47.5 to 275.67)</td>
<td></td>
</tr>
<tr>
<td>Conductivity (µS/cm)</td>
<td>-</td>
<td>-</td>
<td>221.23 (195.67 to 279.33)</td>
<td></td>
</tr>
<tr>
<td>TDS (mg/l)</td>
<td>-</td>
<td>500</td>
<td>600</td>
<td>106.28 (94 to 134.33)</td>
</tr>
<tr>
<td>Total solids (mg/l)</td>
<td>-</td>
<td>-</td>
<td>128.55 (112.5 to 163.33)</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>6.5 - 8.5</td>
<td>6.5 - 8.5</td>
<td>6.5 - 8.5</td>
<td>8.16 (7.31 to 8.71)</td>
</tr>
<tr>
<td>DO (mg/l)</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>8.96 (7.35 to 10.8)</td>
</tr>
<tr>
<td>Free CO₂ (mg/l)</td>
<td>12</td>
<td>-</td>
<td>-</td>
<td>3.2 (2.18 to 4.53)</td>
</tr>
<tr>
<td>Alkalinity (mg/l)</td>
<td>100-300</td>
<td>200</td>
<td>-</td>
<td>79.2 (56.16 to 103.5)</td>
</tr>
<tr>
<td>Hardness (mg/l)</td>
<td>-</td>
<td>200</td>
<td>-</td>
<td>90.69 (68.5 to 111.16)</td>
</tr>
<tr>
<td>Chloride (mg/l)</td>
<td>-</td>
<td>250</td>
<td>250</td>
<td>4.51 (1.88 to 7.3)</td>
</tr>
<tr>
<td>Water velocity (mt/s)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.54 (0.27 to 0.95)</td>
</tr>
</tbody>
</table>
DO, free CO$_2$ very little or no major changes has been observed in water quality. The pH of river water lowered significantly during monsoon period and high during winter. In general, pH of the water is dependent upon the relative quantity of calcium carbonates and bicarbonates. Slight changes have been observed in pH value from earlier study to present and the pH concentration in the river is little bit higher than the prescribed limit of BIS (1994, 2009) and WHO (2011).

Oxygen is very important chemical parameter released by phytoplankton and other aquatic plants in the aquatic system during the process of photosynthesis. DO content reflects the physical and biological processes prevailing in water and is influenced by aquatic vegetation and plankton population apart from the temperature and organic matters present. Low oxygen content in water is usually related with organic pollution. Similar to the pH, very little fluctuation in DO content have been noticed. Earlier studies indicates that due to little or modest human interference river water contain plenty of DO (8 to 15mg/l) but at present pollution load by human activities causes little bit decrement in DO concentration. Overall, during entire study period oxygen deficiency was never noticed in the water of Western Ramganga River.

Another important change has occurred in concentration of CO$_2$. High free CO$_2$ content approximately 20mg/l indicates aquatic pollution. Previous study indicates that, earlier the free carbon dioxide is not only low in quantity but also absent in some months of the year. But at present, increment in free CO$_2$ concentration have been noticed. Beside that CO$_2$ present in all seasons. This is most detrimental change in the present investigation which may show its long term effect in near future.

The data on the concentration of several other parameters of water quality were examined and compared with safe water quality standard such as Bureau of Indian Standard (BIS, 1994, 2009) and (WHO, 2011) for human consumption and for survival of aquatic biota (Table 8.1). It was found that the all physico-chemical parameters except pH were within
permissible limit. As per norms of BIS and WHO for drinking water, the river water was also suitable for drinking after proper treatment and disinfection.

To assess river health phytoplankton are representative of primary producers in the spectrum of organisms. Any alteration in physico-chemical properties of the water primarily influences on its biological components. During the monsoon and post monsoon period considerable changes in phytoplankton community structure and organization have been observed in present study. The species composition of phytoplankton community was altered considerably according to season. Phytoplankton community of the river destabilized with the start of monsoon due to sudden water turbulence, however, it reappeared within a few weeks and thereafter it flourished more comprehensively. The total community abundance of phytoplankton decreased during monsoon season and relative group abundance also responded differentially. The density of Chlorophyceae and Bacillariophyceae decreased during monsoon period and Cyanophyceae that of increased significantly. High water transparency and dissolved oxygen levels contributed greatly to the phytoplankton growth. Impact of external as well as internal nutrients loading during monsoon and post monsoon period have also contributed greatly to the variations in phytoplankton community structure. Observations on percent contribution of dominant phytoplankton species to the total phytoplankton standing crop have also indicated that the Chlorophyceae was the first dominant species during entire study period. The importance value index (IVI) of almost all phytoplankton species varied significantly during entire study period.

Same as the phytoplankton community, the zooplankton community also showed marked seasonal variations. High nutrition load and fair amount of dissolved oxygen in river influenced the zooplankton community up-to a great extent. High transparency and low velocity of Western Ramganga River water in combination to the maximum dissolved oxygen and immense rate of metabolism and reproduction of large bodied
zooplankton stimulated the Rotifers and Protozoans to flourish distinctly. Also, due to the rare/absence of zooplanktivorous fishes the rate of predation by zooplanktivorous fish species increased the zooplankton community abundance in Western Ramganga River. Fish and fisheries in the aquatic media are structurally and functionally influenced by biotic and abiotic components. The growth of fishes depends on natural food present in water. If in an aquatic media sufficient natural food is present, fishes grow well and remain healthy. Seasonal variation affects the growth of plankton and by this growth and development of fishes. During the monsoon and post monsoon period considerable changes in the number of fish have been observed in present study. The species composition of fishes was altered considerably according to season.

Grave concerns

- Present study revealed that the water temperature of Western Ramganga River is suitable for the growth of aquatic biota and also for fish production perspective.
- Study also indicates that TDS concentration in Western Ramganga River is under the standard limit therefore the river water is suitable for fish production perspectives and also fit for drinking but after proper treatment.
- pH of river in the present investigation is little bit higher than the prescribed limits of aforementioned standards. It could be the major fact for limited ichthyofauna and plankton diversity in the river.
- In present research, the concentration of free CO₂ in the river is lower than the prescribed limit.
- Present research indicates that DO content in the River Western Ramganga is also suitable for fish production.
Total alkalinity and hardness of the river water is also below the standard limit for human consumption and fish production perspective.

Chloride concentration in the river water is much lower than the prescribed limit of safe water quality standard.

**Suggestions**

Water pollution is overwhelming subject to tackle, to prevent water pollution from getting worse in Western Ramganga River few suggestions are given here:

- Deforestation, landslides, constructional work in the catchment should be regulated to prevent the entry of silt and pollution load in the river.
- The fine way to combat soil erosion is to keep river bank well covered with soil retaining plants. It have significantly positive impact on mitigation of soil erosion.
- Awareness programs should be organized to aware localities.
- Fishing should be strictly banned because this is the best way to conserve biodiversity and to protect fishery resources.

**Conclusion**

Briefly, extensive survey, observation and fair examination of the biotic and abiotic components in the Western Ramganga River and their comparison with standards references, it can be concluded that the water quality of the Western Ramganga River River at Gairsen, Chaukhutiya and Masi region is fair good. Moreover, the river water is habitable for fishes as the quality of water is suitable for fishes and they can find shelter and protection under stones and rocks. Studies also indicates that in river plenty of DO, food in the form of algae and insects are available for fishes, there were practically no competition among species.