Chapter - 7

Management Strategies for Sustainable Ecotourism
7.1. Background

The issue of sustainable tourism (ecotourism) was clearly addressed by the World Summit on Sustainable Development held in Johannesburg in 2002, and presented in Chapter IV, paragraph 43 of the Johannesburg Plan of Implementation. The chapter, among other things, emphasizes the promotion of sustainable tourism development and capacity-building in order to contribute to the strengthening of rural and local communities which includes, among many actions, developing programmes that encourage people to participate in eco-tourism, enabling indigenous and local communities to develop and benefit from ecotourism, and enhancing stakeholder cooperation in tourism development and heritage preservation, in order to improve the protection of the environment, natural resources and cultural heritage (WSSD, 2002).

Sustainable tourism development in Chikmagalur has been viewed as one of the areas that could help run the day-to-day protected area management activities through benefit-sharing. Ecotourism, which is regarded as a sub-set of sustainable tourism (Watkin, 2003: 6) is the main form of tourism in the region and focuses on an active conservation of natural and cultural heritages that include local and indigenous communities in its planning, development, operations and benefit sharing (WTO, 1999).

Data from this study were both qualitatively and quantitatively analyzed. Qualitative data were analyzed using content, structural, functional and analytical techniques in which components of verbal discussions from different respondents were broken down into the smallest meaningful units of information, values and attitudes of respondents. Quantitative data were analyzed with the aid of Statistical Package for
Social Sciences (SPSS) version 15 and Excel Spread Sheet in Office 2003. Frequency distribution tables and computation of proportions in percentage were used in analyzing the socio-economic variables for the households, hoteliers and tourists visiting Chikmagalur tourism zone.

7.2. Proposed Management Strategy

The appropriate interaction between environmental protection and tourism planning and development has become a key concern for many institutions at the local, national and international levels. The trans-boundary characteristics and possible negative supra-regional effects of tourism industry require a unified approach and integrated planning and strategy, which have to be implemented for sustainability.

In this respect, total quality management should be based on a platform for developing and promoting optimum efficiency of resource utilization, facility development and environmental management systems to achieve agreed benchmarks by ensuring a coherent sustainable tourism policy.

In this framework the actions should be focused on;

- Continuous monitoring and management of negative impacts of tourism activities
- Assessing of priority issues for sustainable tourism policy.
- Implementing a management strategy applicable district-wide in compliance with tourism standards.
- Evaluating and improving, where necessary the relevant legislative and administrative framework, for sustainable tourism.
- Developing guidance on technical issues.
- Creating public awareness using media tools and information technologies.
- Implementing training and education programs.

The process is designed to provide options for tourism development that respect key sensitivities and involves the following:

### 7.2.1. Identifying the Attributes and Critical Elements

The initial step in this process involves preparing an inventory examining and assessing the attributes and critical elements of the tourism destination. Characteristics of the biophysical and socio-economic environment, current and potential stresses, and demands or expectations of the host community should be investigated. This is in an attempt to identify development opportunity, constraints, and alternatives and is best accomplished by identifying and evaluating key environmental elements and ecological systems. A quantitative as well as qualitative assessment of the local population is also essential and should comprise demographic and economic information such as population size and age, race, ethnicity and occupational information as well as cultural values, overall goals and vision for participation in the tourism development and implementation process.

### 7.2.2. Defining the Tourist Experience

The information obtained from the assessment of the critical environmental, socio-cultural, and economic elements should be combined to determine the full array of experiences that could be offered by a tourism destination. The result of this is a program plan that accurately defines the full range of activities, and the delivery systems required to safely and enjoyably conduct those activities.
7.2.3. Preparing the Development Plan

This phase of the planning process constitutes developing an action plan for managing implementation. It serves as a vehicle for ensuring the development of the program plan into a coherent and unified implementation plan.

The development plan describes the vision for the tourism destination and forms the basis for promotion and marketing, EIA reviews and approvals, and improvement on specific parcels. The plan should clarify the development objectives and outline a realistic path to achieve them. The development plan is intended to define the circulation networks (roads, promenades, corniches, trails, etc.), recreational facilities and open spaces (commercial centers, parks, floodways, and protected areas), the basic infrastructure and services (water treatment plants, wastewater treatment facilities, institutional, educational and health facilities, and employee housing). The information provided by the development plan should not only identify the resources and their estimated cost for delivering guest services, but should also provide valuable input to other planning, design, and management tasks.

In addition, options for tourism development should be generated to investigate the effects of each alternative on the destination and its users. Such an approach will lead to the planning and designing of tourism development that respect key sensitivities and include many different carrying capacities depending on which values are negotiable.

Through the use of tools such as demand management, zoning, appropriate infrastructure design, environmentally sound facility operation and maintenance, monitoring, and site rehabilitation, the range of acceptable options could be enlarged.
The continuing direct involvement of all affected communities in identifying key values and sensitivities, as well as their participation in the choice of development and management options, is critical to the success of this process (Dougherty, 2003).

7.2.4. Applying Sustainability Criteria and Preparing EIAs

The results of the development plan should be monitored to ensure that they meet the established environmental, cultural, and economic goals. This could be achieved by identifying the environmental thresholds and tolerances of wildlife and botanical species, calculating the return on investment and social benefits accrued such as employment, skills development, household income, improved health and education etc., as well as determining the level of preservation of the local culture, indigenous practices, and heritage sites. EIA should outline actions to mitigate undesirable impacts, and the monitoring needed to determine the extent of damage to the environment. The EIA is to be prepared by a professional team of scientists, engineers and planners based on field investigations and research.

7.2.5. Performing Project Planning and Project Monitoring

Based on the above information, the development plan should be modified and subdivisions and land allocation altered to preserve environmentally sensitive areas, provide communal access to significant sites, and be constant with the site constraints and the natural and socio-cultural resources. With EIA approval, detailed planning, appropriate design, and engineering work could proceed for infrastructure and other improvements. Environmental monitoring should include water quality testing, forest life surveys and floral growth measurements and should establish test locations and base line
levels from which to evaluate changes. The estimated costs of construction, operations, and maintenance should also be provided as an integral part of the project-planning phase.

7.2.6. Implementing and Operating

The final phase involves construction of development projects and requires knowledge of the anticipated costs and revenues, the identification of sources of financing, and a plan for finance required to implement the project. The basis of a marketing strategy should also be identified and management plan be produced in order to establish guidelines for the effective performance of guest services, facility operations, community outreach, and environmental stewardship. Furthermore, job training and skills development for the host community should constitute part of the operating activities and should contribute to the realization of human potential and enable the local people to become beneficiaries of the project. Research should also be undertaken regularly to identify changes in the environmental conditions that may effect the operations. The information serves as a feedback mechanism for continually evaluating the quality and integrity of the tourism experience.

This sustainable approach to tourism planning requires the services of a multi-disciplinary team of professionals who are capable of evaluating environmental, economic, and human conditions. The result of this process is an environmentally, economically and culturally viable tourism project that can adapt to change, and thus can be sustained.
7.3. Natural Resources Management and Biodiversity Conservation

In addition to the natural resource endowments provided by national forests, how those endowments are managed will significantly impact the numbers and types of tourists that will be attracted. Traditional multiple-use objectives of national forests may be incompatible with certain types of tourism. For example, it is plausible that certain types of tourists may be unwilling to accept any signs of intensive forest management for commercial timber production. Locations that can enhance or maintain their relative environmental quality will improve their comparative advantage over other destinations. Also, certain recreational activities may be incompatible with others, thereby resulting in conflicts between different tourists seeking different forms of recreation. Hikers may be at odds with off-road vehicle users, hunters may be at odds with birdwatchers, and motorized boaters may be at odds with non-motorized boaters. Accommodating every type of tourist may be infeasible in every location. Tourism planning may require aligning forest management with the preferences of tourists in specific locations. User surveys could assist in identifying specific outdoor amenities and forest management activities that attract or repel different types of tourists and aid in developing appropriate forest management prescriptions in specific locations.

7.4. Disaster Management Plan

The District Commissioner along with the assistance of different department’s heads prepares the disaster management action plan for the district. While setting up the district contingency plan it is divided in to 5 major sectors as follows:
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- Law and order
- Civil departments
- Health and safety
- Food and agriculture department
- Social services

These 5 sectors work under the guidance of district commissioner. The flow sheet of the work carried out during disaster is as follows:
7.4.1. Forest Fire Management

The west of the study area is covered with some of the best forest in the country. Throughout the Jagra valley (Bhadra Wildlife Sanctuary), Mudigere, Koppa, Sringeri, N.R. Pura and parts of Chikmagalur taluks was earlier a continuous stretch of highly valuable forests, densely clothing the hillsides. During the years since this tree growth gives valuable shelter to coffee plantations, most of it has been converted into large and extensive coffee estates, so much so that Chikmagalur district has become the foremost among coffee growing districts in the country today. Tea and other plantation crops have also claimed large chunk of pristine forests.

Special causes of fire in Chikmagalur forests:

1) In a number of cases fire has resulted due to burning of agricultural residue by farmers filling the land in valley portions.

2) In Mullayyanagiri and Baba Budan Giri ranges, fire has occurred due to the negligence of the coffee planters while making fire lines around their own coffee estates. Sometimes because of high velocity winds, fire jumps occur over the fire lines engulfing large areas and resulting in destruction of property.

3) In some instance fire has also been intentionally put by the animal grazers, fire wood collectors and encroaches, etc;

4) In Chuchegudda because of hunting fire incidents have increased.

5) Forest offence cases regarding sandal wood and reserve forest wood smuggling and other cases have been registered and aggrieved persons may also be responsible for handling fire in forest areas.
At present some of the measures, which are taken to control fire, are:

1) Frequent removal of dry trees at proper seasons
2) Fire line creation
3) Re-clearing of fire lines
4) Engaging fire watchers

The other important strategies for fire management are:

1. For a sustainable forest fire fighting, local community should be made as a stakeholder through a system of in built incentives such as they may be made beneficial of certain percentage of the forest product so that they feel involved in the preservation of forest.
2. Fire watchtowers to be erected in recurring places.
3. Making people aware is the most important factor in controlling fire.
4. The forest department is to be made nodal department, and the local villagers including women to be associated.
5. Fire lines to be maintained before the summer and periodically monitored.

7.4.2. Flood management

A large portion of the district i.e., about 86% fall under the Krishna Basin while the Cauvery basin over 8.4%. The Thunga, Bhadra and Vedavathi rivers come under Krishna Basin While Hemavathi and Yagachi under the Cauvery Basin and the
Netravathi among west flowing rivers. There are several minor streams also but they are not of much importance. There are two big tanks namely Iyyanakere and Madagadakere in Sakrepatna police station limits.

The average annual rainfall in Chikmagalur district is 1989.8mm. During the period from 1900 to till this date highest rainfall recorded in this district was in 1946 i.e., 135.6% of the normal rainfall. During the remaining period there is no consecutive rise in the average rainfall. The taluks of Chikmagalur, Kadur and Tarikere have never experienced cyclonic fury where as the remaining taluks i.e., Mudigere, N.R.Pura, Koppa and Sringeri are likely to be affected because of the heavy rainfall. Parts of Koppa and Sringeri taluks suffered flood during October 1972 causing heavy damages to the property. The same area was earlier affected in 1924, 1962 and 1963. There were landslides due to flood on all these occasions. Compared to other flood prone districts, this district has not experienced many calamities. However, precautionary measures need to be taken to avoid unexpected situation. The heavy rainfall in Chikmagalur district can also adversely affect other neighboring districts like Shimoga and Dakshina Kannada, as the rivers enter form this district.

The main objects of the scheme are as follows:

1. To prevent unnecessary loss of life.
2. To prevent loss of property.
3. To provide for swift mobilization of a 'Disaster Force' capable of coping with the situation and co-ordinate with the ward of various agencies.
4. To rescue the persons and to protect the properties from the flood-affected areas.
7.4.3. Landslide Management

Landslides can be caused by poor ground conditions, geomorphic phenomenon, and natural physical forces and quite often due to heavy spells of rainfall coupled with impeded drainage. A checklist of causes of landslides is provided below:

1. Ground causes
   - Weak, sensitivity, weathered materials
   - Adverse ground structures (joints, fissures, etc.)
   - Physical properties variation (permeability, plasticity etc.)

2. Morphological causes
   - Ground uplift (volcanic, Tectonic etc.)
   - Erosion (Wind or water)
   - Scour
   - Deposition loading in the slope crust
   - Vegetation removal

3. Physical causes
   - Prolonged precipitation
   - Rapid drawdown
   - Earthquake
   - Volcanic eruption
   - Thawing
   - Shrink and swell
4. Man made causes

- Excavation
- Loading of slope crust
- Draw-down (reservoir)
- Deforestation
- Irrigation
- Mining
- Artificial vibrations

In Chikmagalur district landslides are noticed only in Malnad part of the district. The Ghat sections namely, Charmudi ghat, Agumbe ghat roads are subjected to minor landslides, which will interfere in the smooth traffic flow. The district does not experience the landslides of greater magnitude, which will cause the loss to life and property. The heavy rain and topographical features of the district are the main cause for landslides in the district. The Mullayanagiri peak, Bababudangiri peak are also subjected to minor landslides frequently. The severity of the landslides in the place is not high as the stability of the soil is so strong since it contains Hematite ore.

In general, mitigating measures to be adopted for such areas are

- Drainage correction
- Proper land use measures
- Afforestation of the areas occupied by degraded vegetation
- Creation of awareness among local people
• Re-grading of slope
• Benching of slope
• Provision of fill at the toe
• Relocating is changing the location of the facility to avoid landslide prone areas

7.5. Water Resource Management

Pollution of water resources and resultant degradation are the consequence of a wide range of human activities – such as housing, washing, agriculture, industry, energy extraction and use, and tourism.

• Decreasing water quality (due to urban runoff from resort building, roads and car parks, and the disposal of sewage, which is discharged from treatment plants into streams).

• Impacts on terrestrial vegetation and the spread of weeds (due to resort development).

• Increasing pollution (due to sewage generation and accidental spills).

• Increase and spread of pest (due to road and resort development).

Tourism is more sensitive to environmental degradation than other economic activities, as the environment is its primary resource. Clearly, tourism has a paramount economic role for hilly areas and, if planned and managed correctly, can significantly contribute to sustainable socio-economic development and environmental conservation.
Fluctuations in water demand and wastewater generation in time, low population in off-seasons, water utilities with limited funding are actually the main characteristics differentiating the hilly areas from the urban examples.

Without having an integrated water and wastewater management strategy, the required water quality and the essential tourism standards cannot be achieved. In this respect, applicable discharge limitations, wastewater characterization and appropriate treatment technologies should not be avoided.

Watershed management is a mechanism for safeguarding natural resources (water, soil and forests) while at the same time, improving incomes for generally poor locals. Sustainable management of water resources in the regime of ecotourism and with due respect to ecological, economic and ethical sustainability, requires a holistic and integrated approach involving engineering, socio-economic and environmental aspects. All the problems should be looked at in their totality.

Chikmagalur, like other districts, faces the challenges in efficiently developing and managing its water resources while working to maintain water quality and protect the environment and the hilly areas of Chikmagalur is no exception. Further, there is a need to continue to develop the water resources in order for the economic and social development and to keep pace with the rapidly growing and modernizing populations fixed as well as floating. Towards this goal, new management approaches and organizational arrangements need to be designed to address the critical issues of water resource management. The following measures should be considered as guidelines to provide for effective management of water resources.
7.5.1. Water resources planning

Comprehensive strategies for managing ponds and reservoirs need to be designed for the unique physical and biological characteristics of the watershed, including the type of ecosystem, climate and topography and the socio-economic conditions, such as population density and the pressure on the resources, the economic and environmental objectives and the legal policy and institutional setting in which the water body is a part. The basic idea is:

• To put forward an integrated water resources policy in order to prevent natural hazards

• To rationally satisfy the various uses

• To meet the requirements of sustainable development

• To protect the aquatic environment

Integrated view of water resources would require multi-disciplinary policy making, planning and executing teams, in place of largely undisciplined civil engineering-oriented teams which exist at the moment. It is particularly necessary that there is effective interface between hydrological and socio-economic planning units. Academic and scientific communities, environmental groups, representatives of project-affected people should also be involved in management of water resources.

7.5.2. Effective management

Managing ponds and reservoirs so that they can provide their varied benefits for the future requires a comprehensive approach, involving all stakeholders and covering all activities affecting the water resources throughout the watershed. To work effectively,
management plans must be developed at the community level, involve the participation of all the groups who benefit directly and indirectly from the water bodies and have clear and transparent rules for resolving conflicts.

7.5.3. Co-operative partnership and strong community participation

To even consider the management of a complex ecosystem like a watershed or lake, it is necessary to foster a cooperative partnership approach. This is one of the lessons coming out of decades of failures of centrally-planned watershed development projects through which local people have been either coerced or paid to undertake terracing, bunding, destocking and other technical measures that external experts believed would cure watershed degradation. Thus, participation is expected to achieve what coercion and subsidies would not, namely to make watershed development more successful and sustainable.

Effective partnerships are based on good information and educational efforts. Cooperation requires that the parties have a knowledge of why, how, when and where to cooperate, which can only be gained from shared information and communication. Mutual trust is necessary to make partnerships work and trust can only be earned.

Participation of all stakeholders to developmental activities both in the planning and operation stages, especially to those of water resources, is of high importance. Environmental Impact Assessment (EIA) studies are an effective way of encouraging public participation in projects at the planning stage.
7.5.4. Pollution prevention and abatement

Reducing pollution effectively requires controlling both point and non-point source pollution. Many ecotourism locations have successfully reduced point and non-point source pollution using policies combining regulations, economic instruments, public education and enforcement measures. Choosing the right combination of regulations and market-based instruments for controlling pollution to lakes and reservoirs will require careful assessments of the nature and sources of pollution and the practical issues of implementation.

Action need to be taken to increase the share of the population having sustainable sanitation treatment system. Further, the price structure of water should be revised to better reflect the investment and maintenance costs and to ensure its rational use.

7.5.5. Monitoring

In order to define environmental and social guard rails for water quality, it is necessary to carry out monitoring operations as comprehensively as possible. Efforts to build a database on freshwater ecosystems are need of support. Geographical and ecological parameters should be included, as should adverse anthropogenic impacts. The database should also provide the results of a coordinated water body monitoring program, support the production of specialized maps and be available to a wide range of users. Special research exists with respect to:

- Determine the status of aquatic habitats by expanding water body monitoring in regions and categories on which little data has been collected hitherto, in order to provide a foundation for the national database.
• Collection of reference data from relatively unpolluted water bodies and investigation of the natural variability of factors relevant to quality in order to assess national and regional changes.

The monitoring of environmental parameters must be rigorously undertaken. NGOs and the affected public should be associated with this process. Fixing realistic norms and standards, providing training and allocating sufficient funds, can strengthen monitoring.

The development and implementation of a monitoring program follow a logical progression and contain ten essential elements:

1. Clear management goals and monitoring objectives
2. Assessment questions formulated directly from goals
3. Monitoring program design
4. Indicator selection
5. Quality assurance
6. Data management
7. Data analysis and assessment
8. Program reporting
9. Programmatic evaluation
10. General support and infrastructure planning
7.5.5.1. Water quality analysis in the study area

Water is the most essential and valuable nature's gift to the mankind as well as the producer and consumer of this planet. Without water there would have been no life, hence it is a matrix of life. It is vital for many aspects of economic and social development for agriculture, energy production, domestic, industrial supply and it is a critical component of environment. Presently, there is growing awareness that the development of water resources must be sustainable, which implies that the natural resources must be managed and conserved in such a way that it meets the needs for present and future generation.

Water resources have been the most exploited natural system since the beginning of the human civilization, with rapid growth of human population, increasing levels of living standards, in industrialization and generation of power.

Unfortunately, during these days, water resources are getting polluted by human activities and becoming unfit for use sooner than expected. Use of polluted water itself takes toll of 25,000 people all over the world every day (Anil Kumar et al., 2001). The United Nations Food and agricultural Department estimates that, if the present day practices of wasting and polluting water are not stopped, then within less than a century the world's biosphere including man will disappear (Anil Kumar et al., 2001).

7.5.5.2. Distribution of water in earth

Water was created three billion years ago (Beck, 1985). Earth is said to be a water planet and 70.8% of earth's surface is covered by water. Its reserve is definite and the same water is being used in time and recycled. The self purification capacity during
recycling is a prominent phenomenon. Only one percent of earth's water passes the cyclic path and is referred as hydrological cycle (Gupta et al., 2000). The water in the hydrosphere is distributed to an extent of about 97.5% in the oceans as salt water and remaining 2.5% is distributed over the continents as fresh water and as polar ice caps.

Out of estimated 1,011 million km$^3$ of the total water present on earth, only 33,400 km$^3$ of water is available for drinking purpose, agriculture, domestic and industrial consumption. The rest of the water is locked up in oceans as salt water, polar ice caps, and glaciers and under groundwater (Dara, 1993).

7.5.5.3. Water quality tests

The characteristics, which specify the quality of water, have been classified as under

1. Physical

Physical characteristics relate to the quality of water for domestic use and usually cover parameters such as color, taste, odor, turbidity, pH, electrical conductivity, TDS and temperature.

2. Chemical

Chemical characteristics are due to the presence of dissolved gases, salts and other chemical constituents in water. Water quality varies depending on the nature and content of these constituents.

3. Biological

Biological matter is very important in relation to public health and may also be significant in modifying the characteristics of water.
7.5.5.4. Sources of water pollution

Major sources of water contamination are municipal, industrial, agricultural, domestic and environmental and each is divided into continuous and accidental types (Alexander, 2000).

During these days, water is being polluted due to various anthropogenic or natural phenomena, which include,

1. Environmental

This type of pollution is due to the environment through which the flow of water takes place.

2. Domestic

Domestic pollution is caused due to the accidental breakage of sewers, percolation from septic tanks and artificial recharge of aquifers by sewage.

3. Industrial

This is due to the indiscriminate disposal of industrial wastes on land and in to water bodies.

4. Agricultural

This type of pollution occurs due to the infiltrating of irrigation water and rain water containing fertilizers, salts and pesticides.
In view of above aspects, the problem of water pollution studies has been important and timely in the hilly areas of Chikmagalur district. In addition to the anthropogenic activities, the availability of potable water resources is being deteriorated by industrial, agricultural and over exploitation. Hence, it needs an immediate focus on the status of water in the hilly areas of Chikmagalur district.

Quantitative measurements of these parameters in natural water serve as a keystone to address the basic environmental problems. Most of the problems in environmental studies must be approached initially in a manner that will define the problem. For effective maintenance, continuous monitoring of water quality is needed. The monitoring can be made by adopting suitable analytical methods to test various water quality parameters.

To understand the quality of water, the sampling of the water was done in order to pursue the quality of the water and to determine the extent of damage due to pollution (Allen and Harrel, 1978; Kotaiah, 1994).

In the present study, water samples were collected from 50 locations and analyzed during the years 2006-07 and 2007-08 (Table 7.4 and 7.5).

7.5.5.5. Analysis of samples

Physico-chemical parameters

Water samples from the eco-tourism places were collected. In case of bore wells, initially the water was allowed to run for 15 minutes in order to flush out stationary water. Further, the sample bottles were also flushed with water before the samples were
collected. As water is dynamic in nature and during sampling it enter the new environment from its natural environment, its chemical composition may not remain same but may tend to adjust itself according to its new environment (Sawyer, 1978) and its content alters at very different rates particularly with organic materials. Therefore, as soon as the collection of water, temperature and pH were measured immediately. The other parameters of water such as dissolved oxygen and total dissolved solids were analysed on the spot. The remaining parameter were analysed in the laboratory. Hence, the water was carried to the laboratory in suitable inherit bottles. The samples were analysed using various analytical methods (APHA, 1995; BIS, 1998; NEERI, 1998). The recommended and adopted method for water sample preservation and analysis are represented in Tables 7.1 and 7.2.

For bacteriological examination, sampling was carried out using a sterile glass Stoppard bottle, covered with aluminum foils to prevent contamination. The tips of the hand pump was cleaned and then flamed for a sufficiently long time to ensure sterilization and to avoid the external contamination during the sampling. Further, the water was allowed to run free in a narrow stream for approximate 5 minutes before filling the bottle. The sample bottle was closed under sterile conditions and labelled properly. To prevent the increase in the bacterial count due to high temperature, the samples were preserved, cooled and protected from breakage during transportation to the laboratory. Immediately after arrival, samples were refrigerated approximately at 4°C.

Analysis of nutrients

The water samples collected were investigated for micro nutrient concentration pertaining to nitrate and phosphate using spectrophotometer following standard procedures (APHA, 1995; BIS, 1998).
### Table 7.1. Recommended methods for water sample preservation

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Recommended sample volume in cm³</th>
<th>Recommended container</th>
<th>Preservation method</th>
<th>Maximum storage time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>1000</td>
<td>P.C., G</td>
<td>Analyse immediately</td>
<td></td>
</tr>
<tr>
<td>Colour</td>
<td>500</td>
<td>P.C.</td>
<td>Refrigeration at 4°C</td>
<td>24 hours</td>
</tr>
<tr>
<td>TDS</td>
<td>500</td>
<td>P.C.</td>
<td>Refrigeration at 4°C</td>
<td>23 days</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>200</td>
<td>P.C.</td>
<td>Refrigeration at 4°C</td>
<td>24 hours</td>
</tr>
<tr>
<td>Sulphate</td>
<td>100</td>
<td>P.C.</td>
<td>Refrigeration at 4°C</td>
<td>28 days</td>
</tr>
<tr>
<td>Fluoride</td>
<td>500</td>
<td>P.C.</td>
<td>Refrigeration at 4°C and H₂SO₄ to pH &lt; 2</td>
<td>28 days</td>
</tr>
<tr>
<td>Total hardness</td>
<td>100</td>
<td>P.C.</td>
<td>Add HNO₃ to pH &lt; 2</td>
<td>6 months</td>
</tr>
<tr>
<td>Nitrate</td>
<td>100</td>
<td>P.C.</td>
<td>Refrigeration at 4°C add H₂SO₄ to pH &lt; 2</td>
<td>48 hours</td>
</tr>
<tr>
<td>pH</td>
<td>100</td>
<td>P.C.</td>
<td>Analyse immediately</td>
<td>2 hours</td>
</tr>
<tr>
<td>DO</td>
<td>300</td>
<td>G.</td>
<td>Analyse immediately or fix on site</td>
<td>6 hours</td>
</tr>
<tr>
<td>BOD</td>
<td>1000</td>
<td>P.C., G</td>
<td>Refrigeration at 4°C</td>
<td>48 Hrs.</td>
</tr>
<tr>
<td>COD</td>
<td>50</td>
<td>P.C., G</td>
<td>Refrigeration at 4°C add H₂SO₄ to pH &lt; 2</td>
<td>28 Days</td>
</tr>
<tr>
<td>Phosphate</td>
<td>100</td>
<td>G.</td>
<td>Refrigeration at -10°C</td>
<td>48 hours</td>
</tr>
<tr>
<td>Turbidity</td>
<td>100</td>
<td>P.C.</td>
<td>Analyse same day store in dark</td>
<td>24 hours</td>
</tr>
<tr>
<td>Iron</td>
<td>200</td>
<td>P.C.</td>
<td>Add HNO₃ to lower pH &lt; 5</td>
<td>6 months</td>
</tr>
<tr>
<td>Chloride</td>
<td>100</td>
<td>P.C.</td>
<td>Analyse immediately</td>
<td>24 hours</td>
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</tbody>
</table>

P.C. = Polythene Container and G. = Glass (Borosilicate) Container
Table 7.2. Methods adopted for water analysis

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Physical</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Temperature</td>
<td>-</td>
<td>Thermometer</td>
</tr>
<tr>
<td>2</td>
<td>Colour</td>
<td>Standard platinum cobalt colour comparison</td>
<td>Colorimeter</td>
</tr>
<tr>
<td>3</td>
<td>Turbidity</td>
<td>photometric</td>
<td>Digital-nephelo-turbidity meter model 132 (Systrons)</td>
</tr>
<tr>
<td>4</td>
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<td>Electrometric method</td>
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169
Table 7.3. Drinking water quality standards (BIS and WHO)

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P = Permissible limit; E = Excessive limit

All parameters are in mg/l except temperature (°C), pH, colour (Hazen units) and turbidity (NTU).
Table 7.4. Average values of physico-chemical and bacteriological parameters of study sites during Pre-monsoon season (2006-07)

| Sample No. | Temp | pH  | Col | Tur  | TDS | TH  | Alk | Cl⁻ | NO₃⁻ | PO₄³⁻ | SO₄²⁻ | F⁻  | Fe  | BOD | COD | E. coli |
|------------|------|-----|-----|------|-----|-----|-----|-----|------|------|-------|------|-----|-----|-----|-----|---------|
| S1         | 23   | 6.68| 48  | 30   | 250 | 152 | 110 | 11  | 4.7  | 0.2  | 3     | 0.16 | 1.71| 2.5 | 3.6 | 0      |
| S2         | 23   | 7.72| 19  | 20   | 22  | 20  | 18  | 15  | 2    | 0.1  | 4     | 0.17 | 0.04| 1   | 1.4 | 0      |
| S3         | 23   | 6.99| 34  | 16   | 210 | 148 | 84  | 65  | 4.7  | 0.1  | 13    | 0.12 | 0.74| 1.2 | 4.3 | 0      |
| S4         | 20   | 8.10| 26  | 20   | 45  | 20  | 18  | 5   | 2    | 0    | 1     | 0.71 | 0.18| 1.5 | 3.6 | 0      |
| S5         | 22   | 7.2  | 0.4 | 20   | 46  | 18  | 12  | 8   | 4    | 0.1  | 2     | 0.1  | 0.20| 1.4 | 2.3 | 0      |
| S6         | 22   | 8.46 | 43  | 14.2 | 691 | 405 | 256 | 108 | 16   | 0.3  | 88    | 0.7  | 0.62| 1.4 | 9.3 | 1      |
| S7         | 23   | 7.92 | 12  | 4.2  | 983 | 345 | 160 | 124 | 19   | 0.3  | 19    | 1.3  | 0.71| 2.5 | 8.6 | 0      |
| S8         | 23   | 7.43 | 1   | 12   | 108 | 100 | 62  | 20  | 1.2  | 0.2  | 2     | 0.31 | 0.63| 0   | 1   | 0      |
| S9         | 23   | 7.13 | 10  | 40   | 74  | 40  | 16  | 50  | 0.20 | 0.1  | 1     | 0.1  | 0.51| 0   | 2.8 | 0      |
| S10        | 23   | 7.68 | 18.2| 2    | 62  | 39  | 36  | 17.5| 6.0  | 0.2  | 2     | 0.2  | 0.06| 1.5 | 3.6 | 0      |
| S11        | 22   | 6.57 | 34  | 17   | 254 | 250 | 72  | 56  | 4.2  | 0.3  | 14    | 0.21 | 0.47| 1.3 | 3.4 | 0      |
| S12        | 23   | 7.92 | 1   | 3    | 704 | 290 | 128 | 104 | 18   | 0    | 106   | 0.7  | 0.72| 2.7 | 5.2 | 0      |
| S13        | 23   | 7.94 | 10.1| 2.6  | 603 | 325 | 156 | 118 | 12.9 | 0.1  | 86    | 0.7  | 0.58| 0   | 1.2 | 0      |
| S14        | 23   | 8.64 | 1.9 | 1.3  | 825 | 332 | 135 | 75  | 10.9 | 0.1  | 22    | 0.8  | 0.52| 1.3 | 1.8 | 1      |
| S15        | 22   | 7.25 | 6.3 | 1.25 | 275 | 143 | 85  | 65  | 3.5  | 0.53 | 18    | 0.34 | 0.10| 0   | 1.5 | 0      |
| S16        | 23   | 6.86 | 18.1| 14.1 | 519 | 305 | 162 | 154 | 14   | 0.2  | 83    | 1.2  | 1.63| 1.9 | 7.8 | 0      |
| S17        | 23   | 8.10 | 21.8| 20   | 45  | 20  | 38  | 5   | 0.1  | 0.3  | 1     | 0.71 | 0.18| 1   | 3.1 | 0      |
| S18        | 24   | 7.26 | 19.8| 8    | 80   | 28  | 26  | 20  | 1.7  | 0.1  | 5     | 0.11 | 0.69| 0   | 1.2 | 0      |
| S19        | 23   | 7.17 | 5   | 19   | 90  | 70  | 38  | 8   | 0    | 0.2  | 1     | 0.2  | 0.17| 0   | 0   | 0      |
| S20        | 23   | 6.73 | 5   | 2    | 30   | 20 | 11  | 2.5 | 1.3  | 0    | 1     | 0.1  | 0.07| 0   | 1.3 | 0      |
| S21        | 24   | 7.65 | 4   | 11   | 70   | 40 | 35  | 9   | 3.9  | 0.1  | 4.5   | 0.2  | 0.23| 2.76| 4.6 | 0      |
| S22        | 22   | 7.24 | 2   | 11   | 60   | 50 | 44  | 15  | 2    | 0.2  | 2     | 0.23 | 0.24| 1   | 2.6 | 0      |
| S23        | 25   | 7.6  | 7   | 18   | 140  | 80 | 58  | 38  | 3    | 0.2  | 3.1   | 0.05 | 0.21| 2.16| 5.4 | 0      |
| S24        | 23   | 6.5  | 6   | 24   | 20   | 12 | 7   | 4.5 | 0.5  | 0    | 1     | 0.2  | 0.48| 1.1 | 3.7 | 0      |

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All parameters are in mg/l except temperature (°C), pH, colour (Hazen units) and turbidity (NTU)
Table 7.5. Average values of physico-chemical and bacteriological parameters of study sites during post-monsoon season (2007-08)

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<th>pH</th>
<th>Colour (Hazen units)</th>
<th>Turbidity (NTU)</th>
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<td>1.1</td>
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<td>1.1</td>
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<td>2.3</td>
</tr>
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<td>1.4</td>
<td>2.4</td>
</tr>
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<td>7.9</td>
<td>1.5</td>
<td>2.5</td>
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<td>1.5</td>
<td>2.6</td>
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<td>6.1</td>
<td>1.4</td>
<td>2.8</td>
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<td>7.9</td>
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<td>2.4</td>
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<td>21</td>
<td>7.0</td>
<td>1.5</td>
<td>2.5</td>
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</table>

All parameters are in mg/l except temperature (°C), pH, colour (Hazen units), and turbidity (NTU).
7.5.5.6. Results and Discussion

**Physico-chemical parameters**

Water analysis was carried out, by taking 16 parameters, which are very essential to know the water qualities for drinking purpose. The parameters are differentiated as physical, chemical and bacteriological. The physical parameters includes temperature, colour, turbidity, pH, total dissolved solids, while chemical parameters includes total hardness, alkalinity, chloride, nitrate, sulphate, fluoride, phosphate, trace metal like iron. The count of *E. coli* was considered as bacteriological parameter. The standard values of various physico-chemical and bacteriological parameters for drinking water as per BIS and WHO are presented in Table 7.3.

**Physical parameters**

**Temperature**

In the present investigation, temperature values varied from a minimum of 20°C to a maximum of 25°C in the pre-monsoon season and 20°C to 25°C in the post-monsoon season. The BIS acceptable limit for temperature is 25°C. In the present study, all the water samples in the study area in both the seasons are within the acceptable limit (BIS standards).

**pH**

It is one of the indicators of water quality. The pH of a solution at any given temperature represents the hydrogen ion concentration at that temperature. In pH scale,
the values of the water are less than seven, it indicated acidic condition of that water and
greater than seven indicate the alkaline condition of water. It is one of the important
parameters of water whose determination facilitates a quick evaluation of acidic or
alkaline nature of water. Higher values of pH hasten the scale formation in water heaters
and reduce the germicidal potential of chlorine (Mohapathra and Purohit, 2000).

In the present investigation, pH values varied from a minimum of 6.15 – 8.64 in
pre-monsoon season (Tables 7.4). In post-monsoon season pH value varied from a
minimum of 6.5 to a maximum of 8.48 (Tables 7.5). The recommended value of pH for
drinking purposes is between 6.5 to 9.2 (BIS, 1998). In the present study all the water
samples analyzed are well within the permissible limits except sample No. 14.

Colour

In natural water, colour may occur due to the presence of humic acids, fluvic
acids, metallic ions, phytoplankton, weeds and industrial effluents. In some highly
coloured industrial wastewater principally colloidal or suspended matter contributes the
colour. The intensity of sewage colour is due to strength and condition of the sewage.
Colour developed by dissolved solids, dissolved gases, decomposition of vegetarian
organic matter, microorganisms, excess of iron and manganese etc. Colour less and above
the tolerance limits causes repellant in the consumers (Abbasi, 1998).

In the present investigation, colour values varied from a minimum of 0.4-91 HSU
in pre-monsoon season, 1.3-60 HSU in post-monsoon season. The BIS acceptable limit
for colour is 25 Hazen units. In the present study, 30% of water samples in pre-monsoon
season and 30% of water samples in post-monsoon cross the BIS (1998) acceptable limits
for drinking water (5.0 to 25.0 Hazen units). In the pre-monsoon season, the sample Nos. S1, S3, S4, S6, S11, S16, S26, S28, S32, S35, S36, S37, S41, S43 and S44 have crossed the acceptable limits (BIS standards). In the post-monsoon season, the sample Nos. S1, S3, S4, S6, S11, S16, S26, S28, S32, S35, S36, S37, S42 and S43 have crossed the acceptable limits (BIS standards).

From the results it revealed that the colour values had shown an increasing trend in the post-monsoon through pre monsoon season. This indicates that the percolation of the natural water in the post-monsoon season taken place in fast pace. In pre monsoon season, the colour may be due to surface run-off, municipal sewage, anthropogenic activities or dissolving of various ingredients. Further, precipitation and agricultural run-off through seepage or percolation or infiltration may also be responsible (Knight, 1981; Black et al., 1977).

**Turbidity**

It is the resistance of water to the passage of light. In natural water, it is caused by suspended matter like clay, silt organic matter, phytoplankton and other microscopic organisms and is the expression of tyndall effect. It restricts the light penetration in water, resulting in reduced primary production. Under flood conditions and soil erosion, great amounts of topsoil are washed into receiving streams. Groundwater is less turbid since, sand is a good filtering media.

In the present study, the turbidity values ranged between 0.4 to 74 NTU in pre-monsoon season (Table 7.4) and 1.2 to 56 NTU in post-monsoon season (Table 7.5). The BIS (1998) acceptable limit for turbidity is 25 NTU. In the present study, 6% in
pre-monsoon and 6% in post-monsoon season cross their permissible limit with reference to the BIS standards. In the pre-monsoon season, the sample Nos. S1, S9 and S41 have crossed the acceptable limits (BIS standards). In the post-monsoon season, the sample Nos. S1, S9 and S41 have crossed the acceptable limits (BIS standards).

**Total dissolved solids (TDS)**

It includes all soluble materials in solution whether ionized or non-ionized. It does not include suspended sediments, colloids or dissolved gasses. TDS values are estimated by pursuing the empirical relationship (USSLS, 1954; Hem, 1985; Kotaiah and Kumaraswamy, 1994; Rambabu et al., 1996). TDS is commonly found in carbonates, bicarbonates, chlorides, sulphates and nitrates of calcium, magnesium sodium, potassium, iron and manganese mineral containing rocks. A high content of dissolved solids elevates the density of water, influencing osmoregulation of fresh water organisms, reduces solubility of gases (oxygen) and utility of water for drinking, irrigation and industrial purposes.

Many dissolved substances are undesirable in water. Dissolved minerals, gases and organic constituents may produce aesthetically displeasing colour, taste and odour. Some dissolved chemicals may be toxic. The dissolved solids increases with depth and with the time and water has traveled in the ground. Carrol, (1962) had classified fresh water based on TDS values and are as follows;

<table>
<thead>
<tr>
<th>Type</th>
<th>TDS Values</th>
</tr>
</thead>
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<td>Fresh</td>
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</tr>
<tr>
<td>Brackish</td>
<td>1,000-10,000 mg/l</td>
</tr>
<tr>
<td>Saline</td>
<td>10,000-1,00,000 mg/l</td>
</tr>
<tr>
<td>Brine</td>
<td>Above 1,00,000 mg/l</td>
</tr>
</tbody>
</table>

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In the present study TDS values ranged from a minimum of 20 mg/l to a maximum of 983 mg/l in pre-monsoon season (Table 7.4), and in post-monsoon, a minimum of 28 mg/l to a maximum of 990 mg/l (Table 7.5) were recorded. The BIS (1998) acceptable limit for TDS is 1000 mg/l. In the present investigation, all samples are within the acceptable limits of BIS drinking water standards.

The TDS values have exhibited an increasing trend in post-monsoon compared to pre-monsoon season. Owing to the fact that during post-monsoon season dissolution of more quantity of constituents of soil particles as groundwater table increases during post-monsoon season.

Chemical Parameters

Total hardness (TH)

Total hardness of water is the sum of the concentration of alkaline earth metal cations present in it. Calcium and magnesium are the principle cations imparting hardness. It is defined as the concentration of multivalent metallic cations in solution. At saturated conditions, the cations react with anions in water to form solid precipitate.

The hardness of water is generally of two types

1. Temporary hardness (carbonate hardness)-is due to carbonate and bicarbonates of calcium and magnesium.

2. Permanent hardness (non-carbonate hardness)-is due to sulphate, chlorides of calcium and magnesium.
In the present investigation, total hardness values varied from a minimum of 12 to a maximum of 405 mg/l in pre-monsoon season (Table 7.4) and a minimum of 13.6 to a maximum of 510 mg/l in post-monsoon season (Table 7.5).

The BIS (1998) acceptable limit for total hardness is 600 mg/l. All samples are within the permissible limits of BIS drinking water standards.

The degree of hardness (ppm) has been classified in terms of equivalents of calcium carbonate concentration (APHA, 1995; Kotaiah and Kumaraswmy, 1994) as,

- Soft : 0-50 mg/l
- Medium : 50-150 mg/l
- Hard : 150-300 mg/l
- Very hard : > 300 mg/l

**Alkalinity**

Alkalinity is the quantitative capacity of a water sample to neutralize an acid to a set pH. This measurement is very important in determining the corrosive characteristics of water due primarily to hydroxide, carbonate and bicarbonate ions. Bicarbonates are the most common sources of alkalinity. Almost all natural supplies have a measurable amount of this ion, ranging from 0 to about 850 mg/l.

In the present study, alkalinity values ranged from a minimum of 7 mg/l to a maximum of 256 mg/l in pre-monsoon season (Table 4) and a minimum of 8 mg/l to a maximum of 276 mg/l in post monsoon season (Table 7.5).
The BIS (1998) acceptable limit for alkalinity is 600 mg/l. All samples are within the acceptable limits of BIS drinking water standards.

**Chloride (Cl)**

Chlorides occur in natural water in varying concentrations. The chloride content increases as the mineral contents increases. It is commonly found in soils and rocks. The primary source of chloride is sedimentary rocks and saline water intrusion and the minor sources are igneous rocks. High concentration of chloride makes water unpalatable and unfit for drinking and other purposes.

Chloride ion is generally present in natural water and its presence can be attributed to the dissolution of salt discharge from chemical industries, oil wells, sewage discharges, contamination from leachates. The salty taste produced by chloride ion depends on chemical composition of the water (Kumar, 2002). Chloride in shallow groundwater is a useful indicator of contaminants from human sources compared to background concentration (e.g. Urban land use, septic tanks, agricultural fields, solid waste dumping site).

Chlorides in excess, imparts the salty taste to water and people are not accustomed to high chloride are subjected to laxative effect (Ramprakash and Rao, 1989). Chlorides in reasonable concentration are not harmful to humans. Concentration greatly in excess of 100 mg/l may cause physiological damage. At concentration above 250 mg/l the water becomes salty taste. Hence, the chlorides are generally limited to 250 mg/l in supplies intended for public use.
In the present study, chloride values ranged from a minimum of 2.5 mg/l to a maximum of 154 mg/l in pre-monsoon season (Table 4) and a minimum of 1.3 mg/l to a maximum of 160 mg/l in post monsoon season (Table 7.5).

It is also found that chloride ion concentration bear a conjugational relationship with mineral content of the respective water samples as chloride content increases with increasing mineral content (Mohapathra and Purohit, 2000). The BIS (1998) acceptable limit for chloride is 1000 mg/l. In the present investigation, the values of chloride for all the seasons are within the acceptable range as prescribed by BIS drinking water standards.

**Sulphate**

The sulphate content of natural waters is an important parameter in determining the suitability of water for residential use or public use. Higher concentration of sulphate (>250 ppm) cause cathartic action and gastrointestinal irritation in human beings (BIS, 1998). Hence, determination of sulphate in fresh water becomes an essential tool to suggest the proper management.

Waters with above 500 mg/l of sulphate have a bitter taste and with 1000 mg/l or more sulphate may cause intestinal disorders.

In the present study, sulphate values ranged from a minimum of 1 mg/l to a maximum of 106 mg/l in pre-monsoon season (Table 4) and 1 to a maximum of 110 mg/l in post-monsoon season (Table 7.5). The BIS (1998) permissible range for sulphate is 400 mg/l. In the present investigation, the sulphate values for both the seasons are within the prescribed limit of BIS drinking water standards.
Fluoride

Fluoride is widely dispersed in nature and is common constituent of most soils, rocks, plants and animals. Due to its high electronegativity, it forms only fluorides and no other oxidation state are found (Hem, 1992).

Fluorine is a common element representing about 0.38 gm/kg of the earth crust, which exists in the form of fluorides in a number of minerals. Fluorides are used in the production of aluminium, brick, tiles, ceramics, phosphate fertilizers and toothpaste (GCDWK, 1979). The high concentration of fluoride causes mottling of teeth, skeletal fluorosis, bending of vertebral column, deformation of knee joints and other bone disorders of the body and even causes paralysis.

Phosphatic fertilizers like super phosphate and rock phosphate being extensively used in India and are the major culprits for fluoride concentration in the environment. These contain fluoride as impurity, leads to high fluoride accumulation in soil. Various sources of fluoride entering in human beings are drinking water, food, air, industrial exposure, drug, cosmetics, tooth paste and mouth rinses.

Fluoride enters the environment through natural as well as anthropogenic sources. The chief source of fluoride are minerals viz., (fluorite, fluorapatite, micas and hornblend) rocks and sediments. Fluoride bearing minerals occur in all geological factors such as sedimentary, metamorphic and igneous deposits (Korting, 1979 and Hem, 1985).

Fluoride ions have dual significance in water supplies. High concentration of fluoride causes dental fluorosis (disfigurement of the teeth). At the same time, concentration less than 0.6 ppm results in dental caries and dental mottling. Hence, it is
essential to maintain fluoride concentration between 0.6- 1.2 ppm in drinking water (WHO, 1994).

In the present investigation, fluoride values varied from a minimum of 0 mg/l to a maximum of 1.3 mg/l in pre-monsoon season (Table 7.4) and a minimum of 0.06 to a maximum of 1.26 mg/l in post-monsoon season (Table 7.5).

The BIS (1998) acceptable limit for fluoride is 1.5 mg/l. In present study fluoride values for both the seasons are within the prescribed limit of BIS drinking water standards.

Nutrients

Nitrate (NO₃⁻)

Nitrate is found naturally in air and soil and is an essential nutrient for plant and animal growth. Nitrate sources in the environment include the decomposition of plants and animal wastes, sewage and the application of fertilizer. Nitrate is a common constituent of groundwater. It is made up of nitrogen with three oxygen atoms. The recommended level for drinking water in India is 45 mg/l.

In the present findings, the values of nitrate ranged from a minimum of 0 mg/l to maximum of 19 mg/l in pre-monsoon season (Tables 7.4) and in post-monsoon season it varies from a minimum of 0.4 mg/l to a maximum of 21 mg/l (Table 7.5).

The BIS acceptable limit for nitrate is 45 mg/l. In present study nitrate values for both the seasons are within the prescribed limit of BIS drinking water standards.
Phosphate (PO₄³⁻)

Phosphorous is widely distributed over the surface of the earth in biologically available forms, cycling within the plants, animals, soil and water. Phosphorous is nontoxic and does not cause any direct health effects to human beings and other organisms. They do represent a serious indirect threat to water quality in excess amounts. Small quantity of phosphorous in drinking water is necessary for living beings. Phosphate can also interfere with chemical coagulation of turbid water in water supplies and reduces the scale formation and so that carrying capacity of water increases by preventing corrosion in water mains. However, the presence of phosphorous in large quantities in fresh water indicates pollution through sewage and industrial waste (NEERI, 1998; Kotaiah, 1999).

Generally, Phosphate levels in natural water are low and occur between 0.001 mg/l and 0.024 mg/l with an average concentration of 0.012 mg/l in the tropical rivers (Meybeck, 1979). Phosphorous is one of the important nutrients, limiting the growth of the autotrophs and biological productivity of the system. High phosphorous content causes increased algal growth often as blooms.

In the present study the phosphate values ranged from a minimum of 0 mg/l to maximum of 0.6 mg/l in pre-monsoon season (Tables 7.4) and a minimum of 0.01 mg/l to a maximum of 0.54 mg/l in post monsoon season (Tables 7.5).

Trace metal

In natural water, several heavy metals present in small quantities are required for better growth of plants and animals. The dissolved iron content in the water of the study
area varied from a minimum of 0 mg/l to a maximum of 3.98 mg/l in pre-monsoon season (Table 7.4) and a minimum of 0.025 to a maximum of 4.0 mg/l in post-monsoon (Table 7.5). In the present study 8% of water samples in pre-monsoon season and 8% in post-monsoon season crossed their acceptable limit of 1 mg/l (BIS standards).

**Biochemical Oxygen Demand (BOD)**

BOD is typically reported as 5 day BOD and ultimate BOD at 20° C and reported as milligrams of oxygen consumed per liter (mg/l). BOD₅ is used by regulatory agencies for monitoring wastewater treatment facilities and monitoring surface water quality. BOD is the biochemical oxygen demand of the water and it is related to the concentration of the bacterial facilitated decomposable organic material in the water. A sample with a 5 day BOD between 1 and 2 mg/l indicates a very clean water, 3.0 to 5.0 mg/l indicates a moderately clean water and > 5 mg/l indicates a nearby pollution source. BOD is a laboratory test that requires an oxygen sensing meter, incubator, nitrifying inhibitors, and a source of bacteria.

In the present investigation, BOD values varied from a minimum of 0 mg/l to a maximum of 2.8 mg/l in pre-monsoon season (Table 7.4) and a minimum of 0 mg/l to a maximum of 2.5 mg/l in post-monsoon season (Table 7.5).

The BIS acceptable limit for BOD is 5 mg/l. In present study BOD values for both the seasons are within the prescribed limit of BIS drinking water standards.
Chemical Oxygen Demand (COD)

COD is used as a measure of the oxygen equivalent of the organic matter content of the sample. Only the organic matter that is susceptible to oxidation by strong chemical oxidant. COD is typically used when there are industrial wastewater sources, comparing biological to chemical oxidation in the selection of treatment process and performances, or depending on the waste stream it can provide insight into the concentration of reduced inorganic metal inorganic, such as ferrous iron, sulfide, and manganese.

In the present investigation, COD values varied from a minimum of 0 mg/l to a maximum of 9.3 mg/l in pre-monsoon season (Table 7.4) and a minimum of 0 mg/l to a maximum of 9.8 mg/l in post-monsoon season (Table 7.5).

The BIS acceptable limit for COD is 10 mg/l. In present study COD values for both the seasons are within the prescribed limit of BIS drinking water standards.

Bacteriological parameters

Escherichia coli (E. coli)

One of the most commonly tested indicators of water quality is coliform bacteria. Coliform bacteria are a large group of bacteria found in the digestive tracts of warm blooded animals. Some coliform bacteria are harmless and some are disease causing. Public water supplies use chlorine as a disinfectant to kill the bacteria before the water leaves the treatment plant. The presence of E. coli in the water indicates the infiltration of the sewage from the drainage. They are likely to occur in small numbers even in water supplies from the possibility of human contamination. Water grossly polluted with human
excreta. Sewage contains them in larger numbers. The test for *E. coli* presence is an index of the degree of pollution.

The examination of water samples for *E. coli* contamination has revealed that the bacteria count was not found in many of the samples except sample No.6, 7 and 14. This is attributed to the percolation of untreated domestic sewage and solid waste leachate into the water source.

**7.6. Government initiatives**

**7.6.1. Economic instruments - regulations and incentives**

Ecotourism, in particular, should be carefully monitored, regulated and sometimes even prohibited in ecologically fragile areas. In protected areas, such as national parks and natural world heritage sites, tourism activities should be strictly subject to the preservation of biological diversity and ecosystems, not stressing their limited capacity to absorb human presence without becoming damaged or degraded.

In addition to regulation, governments should also consider the use of economic instruments to promote sustainable tourism, including in remote regions where institutional capacity for environmental regulation may be limited. In fact, it can be argued that market-based mechanisms, which apply monetary values to environmental assets, are more efficient for environmental management than government regulation, even at the global level. Since the tourism industry consumes significant amounts of natural resources, economic pricing of scarce local resources – together with the phasing-out of existing subsidies that encourage wasteful consumption – will help to ensure that the true costs of these resources are adequately incorporated into tourist activities.
Prices that reflect the economic value of water and energy, for example, will promote their efficient use and conservation, and provide additional revenue that can be used to improve the management of those resources. Pollution taxes can also be applied on the amounts of liquid and solid waste generated, as a means to reduce discharges and to generate funds for proper treatment and disposal. Similarly, market-based instruments can also be used effectively for the sustainable use of forest natural resources.

Economic instruments, such as user fees and tourist taxes, can actually be used to better internalize environmental costs and thus to promote broader environmental protection objectives. As it is well known, one of the main reasons why markets fail is that important environmental costs, such as pollution, are not reflected in the prices of goods and services. In a free-market economy, individual economic agents will only attempt to maximize their own utility or profit; external costs will thus not be reflected in prices. If total production costs do not incorporate full environmental costs, resources will be allocated inefficiently, both within countries and globally. One way to deal with externalities is thus to internalize them through taxes so that the full costs of production are reflected in prices.

7.6.2. Leadership

Government must take the lead, but in doing so it must work in partnership with other levels of government, host communities and the tourism industry.

Leadership involves

- Establishing national tourism objectives that reflect the unique character, opportunities and constraints in the hilly areas of Chikmagalur
• Developing a shared vision of what type of tourism is wanted and how to achieve that goal

• Establishing a policy framework to achieve those objectives

• Developing, in collaboration with others, guidelines, policies and practices for both new tourism projects and the management of ongoing tourism activities

• Working with the Academy, educational institutions and other organizations in education, training and development programs

• Providing a longer-term commitment to move from the current situation to a more attractive future position.

Overall, ecotourism is one of the fastest growing segments of the tourism sector and further rapid growth is expected in the future. There is, however, little agreement about its exact meaning because of the wide variety of so-called ecotourism activities provided by many different tour operators and enjoyed by an equally broad range of diverse tourists. Its main features include

1. All forms of nature tourism aimed at the appreciation of both the natural world and the traditional cultures existent in natural areas,

2. Deliberate efforts to minimize the harmful human impacts on the natural and socio-cultural environment and

3. Support for the protection of natural and cultural assets and the well being of host communities.
In other words, if carried out responsibly, ecotourism can be a valuable means for promoting the socio-economic development of host communities while generating resources for the preservation of natural and cultural assets. In this way, ecologically fragile areas can be protected with the financial returns of ecotourism activities made by both the public and private sectors. In many developing countries, ecotourism has been particularly successful in attracting private investments for the establishment of privately owned natural parks and nature reserves. Many of such reserves are well managed, self-financed and environmentally responsible, even when profit remains the main motivation behind the operation of a private reserve. In this way, the tourism industry can help to protect and even rehabilitate natural assets, and thus contribute to the preservation of biological diversity and ecological balance.

However, if not properly planned, managed and monitored, the concept of ecotourism can be distorted for purely commercial purposes and even for promoting ecologically damaging activities by large numbers of tourists in natural areas given their inadequate physical infrastructure and limited capacity to absorb mass tourism, the fragile land and aqua ecosystems.

There is, in fact, a crucial distinction between ecotourism and sustainable tourism: while the former can be broadly defined as an alternative, nature-based type of tourism, the sustainability principles must be applied to all types of tourism activities and all segments of the tourism industry.
Fig. 7.1. Seasonal variation of pH recorded in different study sites.

Fig. 7.2. Seasonal variation of colour recorded in different study sites.
Fig. 7.3. Seasonal variation of turbidity recorded in different study sites.

Fig. 7.4. Seasonal variation of TDS recorded in different study sites.
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Fig. 7.5. Seasonal variation of total hardness recorded in different study sites.

Fig. 7.6. Seasonal variation of alkalinity recorded in different study sites.
Fig. 7.7. Seasonal variation of chloride recorded in different study sites.

Fig. 7.8. Seasonal variation of nitrate recorded in different study sites.
Fig. 7.9. Seasonal variation of phosphate recorded in different study sites.

Fig. 7.10. Seasonal variation of sulphate recorded in different study sites.
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Fluoride: Premonsoon & postmonsoon seasons

Fig. 7.11. Seasonal variation of fluoride recorded in different study sites.

Iron: Premonsoon & postmonsoon seasons

Fig. 7.12. Seasonal variation of iron recorded in different study sites.
Fig. 7.13. Seasonal variation of BOD recorded in different study sites.

Fig. 7.14. Seasonal variation of COD recorded in different study sites.
PLATE-IX

Collection of Water Samples