IMPACTS ANALYSIS OF CONSERVATION WORKS OF RIVER BHAVANI IN TAMILNADU

A DISSERTATION

Submitted in partial fulfillment of the

Requirements for the award of the degree

of

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CONSERVATION OF RIVERS AND LAKES

By

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CANDIDATE'S DECLARATION

I here by certify that the work which is being presented in this dissertation entitled, **"IMPACTS ANALYSIS OF CONSERVATION WORKS OF RIVER BHAVANI IN TAMILNADU"** in partial fulfillment of the requirement for the award of the degree of **Master of Technology** in **"Conservation of Rivers and Lakes"** submitted in **Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee,** is an authentic record of my own work carried out during the period from July 2005 to June, 2006 under the Supervision of **Dr.M.P.Sharma**, Senior Scientific officer of Alternate Hydro Energy Centre, I.I.T. Roorkee.

The matter embodied in the project has not been submitted by me for award of any other degree or diploma elsewhere.

Date: 30-6-2006
Place: Roorkee

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This is to certify that the above statement made by the candidate is correct to the best of our knowledge.

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(S.BALAJI)

ABSTRACT

Tamilnadu being the Southern most state in India has several rivers but limited water resources for its survival. It has only 4% of India's total fresh water and it caters the needs of 6.3% of the population.

Bhavani, the second largest river in Tamilnadu, begins from Kerala's Silent Valley and flows into western Tamilnadu, covering a distance of 217 km before merging with the Cauvery. The main river courses through, Nilgiris, Coimbatore and Erode districts of Tamilnadu, before reaching the Cauvery at Bhavani town. About 90 per cent of the river's water is used for agriculture, even as industries dot the sub basin at every point.

The main objective of this dissertation is to study the various environmental issues of the basin, water uses for various purposes, point and non-point sources of pollution, analysis of water quality of the river conservation measures need to be taken by various regulatory authorities, impact of the conservation measures on water quality and conclusions made based on the findings and recommendations made to maintain the present water quality, of the river.

The reason for selecting river Bhavani has been its unhealthy environmental conditions because of the discharge of the untreated domestic sewage from the towns in the river basin and also there is no control over the discharge of effluents from the small industries like tanneries and dyeing units, and excess consumption of water for agricultural purposes, use of excess fertilizers and pesticides, monoculture are the other reasons for its pollution. It is under the mandate of NRCD.

In this thesis the river water quality was assessed on the basis of water quality indices computed from the data collected from various sources and water quality maps were prepared for the river. The impact of conservation measures on water quality was assessed and suggestions and recommendations are made to conserve the river.

Bhavani, being the major tributary to river Cauvery in Tamilnadu, the Improvement in the water quality of the river will also improve the water quality of river Cauvery, as its flow is presently depending on the release from Karnataka which affects its water quality to a large extent.

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Abbreviations

MOEF	Ministry of Environment and Forests
NRCD	National River Conservation Directorate
CPCB	Central Pollution Control Board
TWAD	Tamilnadu Water Supply and Drainage Board
TNPCB	Tamilnadu Pollution Control Board
PWD	Public Works Department
NRAP	National River Action Plan
NRCP	National River Action Conservation Plan
NLCP	National Lake Conservation Plan
WQI	Water Quality Index
RPI	River Pollution Index
NSFWQI	National Sanitation Foundation Water Quality Index
STP	Sewage Treatment Plant
ETP	Effluent Treatment Plant
CETP	Common Effluent Treatment Plant
MT	Metric Tonne
Km^3	Cubic Kilometre
KLD	Kilolitres Per Day
Mg/lit	Milligrams Per Litre
MLD	Million Litre Per Day
MLY	Million Litres Per Year
PPM	Parts Per Million
^oC	Degree Centigrade
DO	Dissolved Oxygen
BOD	Bio-Chemical Oxygen Demand
F-Coli	Faecal Coliform
T-N	Total Nitrates
T-P	Total Phosphates

INTRODUCTION

1.1 INDIAN RIVER SYSTEM

India is a land of many rivers and mountains. Its geographical area of about 329 M.ha is criss crossed by a large number of small and big rivers, some of them figuring amongst the mighty rivers of the world. The rivers and mountains have a greater significance in the history of Indian cultural development, religious and spiritual life. It may not be an exaggeration to say that the rivers are the heart and soul of Indian life.

Most ancient civilizations grew along the banks of rivers. Even today, millions of people all over the world live on the banks of rivers and depend on them for their survival all of us have seen a river - large or small, either flowing through our town, or somewhere else. Rivers are nothing more than surface water flowing down from a higher altitude to a lower altitude due to the pull of gravity. One river might have its source in a glacier, another in a spring or a lake. Rivers carry dissolved minerals, organic compounds, small grains of sand, gravel, and other material as they flow downstream. Rivers begin as small streams, which grow wider as smaller streams and rivers join them along their course across the land. Eventually they flow into seas or oceans. The flow in most rivers is not uniform, which means that sometimes there are floods and sometimes no water flows in them. Flood control projects attempt to reduce the variation in flow.

Rivers are the main source of water for drinking, agricultural and industrial purposes as they are available on the surface ready for use that is the reason for their importance. The entire river basin provides water for millions of people depending upon the length and flow of the river. Rivers are also useful for inland navigation, mass bathing purposes, propagation of wild life and fisheries. This reason the towns and cities along the riverbank grows and develops at a faster rate.

India is blessed with many rivers. As many as 12 of them are classified as major rivers whose total catchment area is 252.8 million hectare (m.ha). Of the major rivers, the Ganga - Brahmaputra Meghana system is the biggest with catchment area of about 110 m.ha which is more than 43 percent of the catchment area of all the major rivers in the country. The other major rivers with catchment area more than 10 m.ha are Indus (32.1 m.ha.), Godavari (31.3 m.ha.), Krishna, (25.9 m.ha.) and Mahanadi (14.2 m.ha). The catchment area of medium rivers is about 25 m.ha and Subernarekha with 1.9 m.ha. Catchment area is the largest river among the medium rivers in the country.

These rivers are categorized into four groups:

1) Rivers that flow down from the Himalayas and are supplied by melting snow and glaciers. This is why these are perennial, that is, they never dry up during the year.
2) The Deccan Plateau rivers, which depend on rainfall for their water
3) The coastal rivers, especially those on the west coast, which are short and do not retain water throughout the year
4) The rivers in the inland drainage basin of west Rajasthan, which depend on the rains. These rivers normally drain towards silt lakes or flow into the sand.

Benefits of Rivers

1) Rivers provide water supply for drinking, agricultural, and industrial purposes.
2) They are useful in Outdoors bathing.
3) They are useful in inland navigation.
4) Useful in propagation of wild life and fisheries.
5) For recreational purposes.
6) For industrial cooling and controlled waste disposal

The above benefits of Rivers make it an important resource to a country. Thus rivers are even considered as Gods, and worshipped by the people in India.

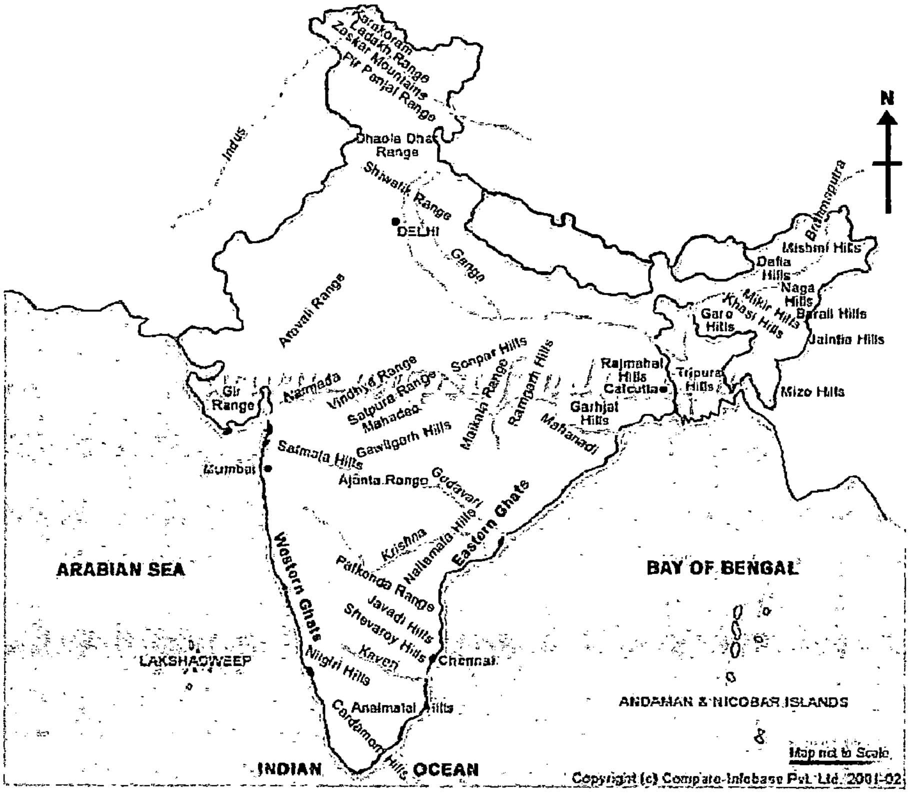


Fig.1.1 Indian River System

The major rivers in India are Gaga, Yamuna, Brahmaputra, Indus, Narmada, Mahanadi, Godavari, and Cauvery.

1.1.1 Status of Pollution of Indian Rivers

Due to population explosion, vast urbanization, the demand of water increases but the resources remains the same. On the other hand human activities pollute the surface and ground water. The total length of river in our country is about 45000 Km of which only 14000 Km remains unpolluted. The total sewage produced by class I cities (population above one lakh) and class II cities (population between 50,000 to one lakh), is about 23000 mld. Class one cities cause 90% of pollution load and class II cities cause 10%pollution load on surface water respectively. Out of the total sewage produced in our country (23000 mld.) only 6000 mld. is treated and disposed off. Hence conservation measures are required to conserve the water resources as they are unevenly distributed and the demand for various purposes increases day by day.

1.1.2 Water Bodies

Inland Water resources of the country are classified as rivers and canals; reservoirs; tanks & ponds; beels, oxbow lakes, derelict water; and brackish water. Other than rivers and canals, total water bodies cover all area of about 7 m.ha. Of the rivers and canals, Uttar Pradesh occupies the First place with the total length of rivers and canals as 31.2 thousand km, which is about 17 % of the total length of rivers and canals in the country. Other states following Uttar Pradesh are Jammu & Kashmir and Madhya Pradesh. Among the remaining forms of the inland water resources, tanks and ponds have maximum area (2.9 m.ha.) followed by reservoirs (2.1 m.ha.).

Most of the area under tanks and ponds lies in Southern States of Andhra Pradesh, Karnataka and Tamil Nadu. These states along with West Bengal, Rajasthan and Uttar Pradesh, account for 62 percent of total area under tanks and ponds in the country. As far as reservoirs are concerned, major states like Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Rajasthan and Uttar Pradesh account for larger portion of area under reservoirs. More than 77 percent of area under beels, oxbow, lakes and derelict water lies in the states of Orissa, Uttar Pradesh and Assam. Orissa ranks first as regards the total area of brackish water and is followed by Gujarat, Kerala and West Bengal. The total area of inland water resources is, thus, unevenly distributed over the country with five states namely Orissa, Andhra Pradesh, Gujarat, Karnataka and West Bengal accounting for more than half of the country's inland water bodies.

1.1.3 Surface Water Resources

The annual precipitation including snowfall, which is the main source of the water in the country is estimated to be of the order of 4000 cu.km. For the purpose or rainfall country has been divided into 35 meteorological sub-divisions. The Resources potential of the country, which occurs as natural run off in the rivers is about 1869 cu.km. as per the basin wise latest estimates of Central Water Commission, considering both surface and ground water as one system. Ganga-Brahmaputra-Meghna system is the major contributor to total water resources potential of the country. Its share is about 60 percent in total water resources potential of the various rivers. Based on 1991 census, the per capita availability of water works out to 220 cubic metres (cu.m.).

Due to various constraints of topography, uneven distribution of resource over space and time, it has been estimated that only about 1122 cu.km. of total potential of 1869 cu.km. can be put to beneficial use, 690 cu. km. being due to surface water resources. Again about 40 percent of utilizable surface water resources are presently in Ganga-Brhamputra-Meghna system. In majority of river basins, present utilization is significantly high and is in the range of 50 percent to 95 percent of utilizable surface resources. But in the rivers such as Narmada and Mahanadi percentage utilization is quite low. The corresponding values for these basins are 23 percent and 34 percent respectively. (Ref. Water Resource Dept. Govt. of India)

Table.1.1 Major River Basins

Sl. No.	Name of the River	Origin	Length (Km.)	Catchment Area (Sq. Km.)
1.	Indus	Mansarovar (Tibet)	1114	321289
2.	a) Ganga	Gangotri (Uttar Kashi)	2525	861452
	b) Brahmaputra	Kailash Range (Tibet)	916	194413
	c) Barak & other rivers flowing into Meghna, like Gomti, Muhari, Fenny etc.			41723
3.	Sabarmati	Aravalli Hills (Rajasthan)	371	21674
4.	Mahi	Dhar (Madhya Pradesh)	583	34842
5.	Narmada	Amarkantak (Madhya Pradesh)	1312	98796
6.	Tapi	Betul (Madhya Pradesh)	724	65145
7.	Brahmani	Ranchi (Bihar)	799	39033
8.	Mahanadi	Nazri Town (Madhya Pradesh)	851	141589
9.	Godavari	Nasik (Maharashtra)	1465	312812
10.	Krishna	Mahabaleshwar (Maharashtra)	1401	258948
11.	Pennar	Kolar (Karnataka)	597	55213
12.	Cauvery	Coorg (Karnataka)	800	81155
Total				2528084

Source: Water Resource Dept. Govt. of India-2004

Table.1.2 Basin wise Surface Water Potential of India

Sl. No.	Name of the River Basin	Average annual potential in river(Cubic Km/Year)
1.	Indus (up to Border)	73.31
2.	a) Ganga	525.02
	b) Brahmaputra Barak & Others	585.60
3.	Godavari	110.54
4.	Krishna	78.12
5.	Cauvery	21.36
6.	Pennar	6.32
7.	East Flowing Rivers Between Mahanadi & Pennar	22.52
8.	East Flowing Rivers Between Pennar and Kanyakumari	16.46
9.	Mahanadi	66.88
10.	Brahmani & Baitarni	28.48
11.	Subernarekha	12.37
12.	Sabarmati	3.81
13.	Mahi	11.02
14.	West Flowing Rivers of Kutch, Sabarmati including Luni	15.10
15.	Narmada	45.64
16.	Tapi	14.88
17.	West Flowing Rivers from Tapi to Tadri	87.41
18.	West Flowing Rivers from Tadri to Kanyakumari	113.53
19.	Minor River Basins Drainage into Bangladesh & Burma	31.00
Total		1869.35

Source: Water Resource Dept. Govt. of India-2004

The above tables show the major river basins in our country and the surface water potentials of the river basins. The availability of water in the river basins are uneven as it is very high in Godavari, Ganga, and Brahmaputra and low in Sabarmathi, Krishna, Cauvery and Pennar.

The distribution of water resources potential in the country shows that as against the national per capita annual availability of water as 2208 cu. m. The average availability in Brahmaputra and Barak is as high as 16589 cu m. while it is as low as 360 cu.m. in Sabarmati basin. Brahmaputra and Barak basin with 7.3 percent of geographical area and 4.2 percent of population of the country has 31 percent of the annual water resources. Per capita annual availability for rest of the country excluding Brahmaputra and Barak basin works out to about 1583 cu.m. Any situation of availability of less than 1000 cu. m. per capita is considered by international agencies as scarcity conditions. Cauvery, Pennar, Sabarmati, East flowing rivers and West flowing rivers are some of the basins, which fall into this category.

1.2 IMPORTANCE OF WATER

Water is the elixir of life a precious gift of nature to the mankind and millions of other species living in the earth. It is fast becoming a scarce commodity in most parts of the world.

"Water Water Every where but not a drop to Drink" is the Situation now in most of the developing and developed countries in the world. Even though, two-third of our Globe consists of water 97% of it is sea water (salt water) 2% is in the form of ice in the polar region and only 1% water is available for all living organisms. This 1% water available in the form of surface and ground water is being polluted by various activities by man and now we are in a desperate situation to control these pollution activities and conserve the available water resources, to meet the requirements for drinking, industrial and agricultural purposes.

In spite of astonishing achievements in the field of science and technology, nature remains to be a mystery for human beings. Though, water is also being obtained through desalination, artificial rain by cloud seeding etc. in some of the developed countries, the shortage of water even for drinking purpose is a perpetual phenomenon throughout the world, especially in developing and underdeveloped countries. India is likely to experience 'water stresses' from the year 2007 onwards and therefore it will be pertinent to shift the thrust of the policies from 'water development' to Sustainable water development

1.3 WATER AVAILABILITY

Table.1.3 Rainfall And The Availability Of Water Per Person

Places	Normal Rainfall (in mm)	Availability of water per person per year in litres
World	800	7.5 lakhs
India	1150	2.2 lakhs
Tamilnadu	968	0.8 lakhs

(Source: Tamilnadu water supply and drainage board-2002)

The above table clearly shows that even though the rainfall in India is more than the world average the availability of water per person is less and in Tamilnadu it is still below the National availability. This is because of high population and most of the water runs off into the sea unutilized. Good water management practices will increase the water availability both in India and in Tamilnadu.

Table.1.4 National Water Resources

S. No.	Items		Quantity (km^3)
1.	Annual Precipitation Volume (Including snowfall)		4000
2.	Average Annual Potential flow in Rivers		1869
3.	Per Capita Water Availability (1997)		1967
4	(i) Surface Water Resources	690 Cu.Km.	
	(ii) Ground Water Resources	432 Cu.Km.	
5	To be utilizable water Resources		1122

The above table shows the volume of annual precipitation, average potential flow in the rivers per capita water availability, estimated utilizable water resources, including surface and ground water potentials (Source: Water Resource Dept. Govt. of India-2004)

1.4 GOVERNMENT POLICIES

1.4.1 Need for a National Water Policy

1. Water is a prime natural resource, a basic human need and a precious national asset. Planning, development and management of water resources need to be governed by national perspectives.

2. Water, as a resource is one and indivisible: rainfall, river waters, surface ponds and lakes and ground water are all part of one system.

3. Water is part of a larger ecological system. Realizing the importance and scarcity attached to the fresh water, it has to be treated as an essential environment for sustaining all life forms.

4. Water is a scarce and precious national resource to be planned, developed, conserved and managed as such, and on an integrated and environmentally sound

basis, keeping in view the socio-economic aspects and needs of the States. It is one of the most crucial elements in developmental planning. As the country has entered the 21st century, efforts to develop, conserve, utilize and manage this important resource in a sustainable manner, have to be guided by the national perspective.

5. Another important aspect is water quality. Improvements in existing strategies, innovation of new techniques resting on a strong science and technology base are needed to eliminate the pollution of surface and ground water resources, to improve water quality. Science and technology and training have to play important roles in water resources development and management in general.

In India because of uneven distribution of water resources and high polluting activities, the following water allocation priorities are given, however the priorities could be modified or added if warranted by the area / region specific conditions, based on water availability and pollution levels.

In order to protect the environment and ultimately the water resources the following acts are framed by the Govt. of India.

- Water (Prevention & Control of Pollution) Cess Act, 1977.
- Air (Prevention & Control of Pollution) Act, 1981
- Environment (Protection) Act, 1986 and Rules made thereunder
- Hazardous Waste (Management & Handling) Rules1989.
- Manufacture, storage and Import of Hazardous Chemicals Rules, 1989
- Bio-medical Waste (Management & Handling) Rules, 1998
- Municipal Solid Waste (Management & Handling) Rules, 2000.
- Plastics wastes Rules, 1999 o Coastal Regulation Zone Rules, 1991
- Public Liability Insurance Act, 1991

1.4.2 Water Usages

- In the planning and operation of systems, water allocation priorities should be broadly as follows:
- Drinking water
- Irrigation

- Hydro-power
- Agro-industries and non-agricultural industries
- Navigation and other uses.
- Tourism

Among the above uses drinking water has been given the top priority, as it is the basic need for human and animals. Adequate drinking water facilities should be provided to the entire Population both in urban and in rural areas by 1991. Irrigation and multipurpose projects should invariably include a drinking water Component, wherever there is no alternative source of drinking water. Drinking water needs of human beings and animals should be the first Charge on any available water.

Irrigation has been given the next priority as it involves food production. Irrigation planning either in an individual project or in a basin as a whole should take into account the irritability of land, cost-effective irrigation options possible from all available sources of water and appropriate irrigation techniques. The irrigation intensity should be such as to extend the benefits of irrigation to as large a number of farms Families as possible, keeping in view the need to maximize production. There should be a close integration of water-use and land-use policies.

Water allocation in an irrigation system should be done with due regard to equity and social justice. Disparities in the availability of water between head-reach and tail end farms and between large and small farms should be obviated by adoption of a rotational water distribution system and supply of water on a volumetric basis subject to certain ceilings. Concerted efforts should be made to ensure that the irrigation potential created is fully utilized and the gap between the potential created and its utilization is removed. For this purpose, the command area development approach should be adopted in all irrigation projects.

1.5 Water Quality Criteria

Water quality criteria is based on the scientific research which gives the safe concentration levels of various parameters beyond that level it is unfit for the specific purpose or use for example Drinking, Bathing, and Irrigation, industrial Etc. These criteria are derived from empirical toxicity data and are stringent enough to protect the most sensitive species potentially exposed to a contaminant in a water body. The Water quality criteria for various purposes as prescribed by Central Pollution Control Board are given in table. (For India) The Water Quality Criteria varies for country to country, because it is decided Based on the pollution levels, type of pollutants, and their concentration and fixed, based on the living standards of the country. The table below shows the water quality criteria for India. Water quality criteria is needed to classify water based on its quality and accordingly use the water for various purposes like drinking, bathing, irrigation, industrial and recreational etc.

Table 1.5 Designated best use Classification of Water Quality

Designated-Best-Use	Class of water	Criteria
Drinking Water Source without conventional treatment but after disinfection	A	Total Coliforms OrganismMPN/100ml shall be 50 or less pH between 6.5 and 8.5 Dissolved Oxygen 6mg/l or more Biochemical Oxygen Demand 5 days 20oC 2mg/l or less
Outdoor bathing (Organized)	B	Total Coliforms Organism MPN/100ml shall be 500 or less pH between 6.5 and 8.5 Dissolved Oxygen 5mg/l or more Biochemical Oxygen Demand 5 days 20oC 3mg/l or less
Drinking water source after conventional treatment and disinfection	C	Total Coliforms Organism MPN/100ml shall be 5000 or less pH between 6 to 9 Dissolved Oxygen 4mg/l or more Biochemical Oxygen Demand 5 days 20oC 3mg/l or less
Propagation of Wild life and Fisheries	D	pH between 6.5 to 8.5 Dissolved Oxygen 4mg/l or more Free Ammonia (as N) 1.2 mg/l or less

Designated-Best-Use	Class of water	Criteria
Irrigation, Industrial Cooling, Controlled Waste disposal	E	pH between 6.0 to 8.5 Electrical Conductivity at 25oC micro mhos/cm Max.2250 Sodium absorption Ratio Max. 26 Boron Max. 2mg/l
	Below-E	Not Meeting A, B, C, D & E Criteria

Source: Central Pollution Control Board, New Delhi-2005

The above table gives the water quality criteria for various uses of water. Based on these criteria the quality of water of a given resource can be estimated. The best-designated use of water is given for the mentioned criteria.

1.6 GOVT AGENCIES INVOLVED IN CONSERVATION WORKS

1.6.1 Ministry of Environment and Forests

The Ministry of Environment & Forests formed in the year 1989 is the nodal agency in the administrative structure of the Central Government, for the planning, promotion, co-ordination and overseeing the implementation of environmental and forestry programmes. MOEF oversees all environmental matters in the country and is a permanent member of the Executive Committee of the National Economic Council.

1.6.2 National River Conservation Directorate

The National River Conservation Directorate (NRCD) functions under the Ministry of Environment and Forests is in-charge of implementing the River Action Plans. The River Action Plans were undertaken based on surveys conducted by the Central Pollution Control Board (CPCB) which identified 27 grossly polluted stretches of major rivers of the country. The objective is to improve the water quality of the major rivers which are the major fresh water sources in the country through the implementation of pollution abatement schemes.

The important works being taken up under the National River Action Plan include:

- Interception and Diversion of works to capture the raw sewage flowing into the river through open drains and divert them for treatment,
- Sewage Treatment Plants (STP) for treating the diverted sewage,
- Low Cost Sanitation works to prevent open defection on river banks,
- Electric Crematoria and Improved Wood crematoria to conserve the use of Wood and help in ensuring proper cremation of bodies brought to the burning ghats,
- River Front Development works such as improvement of bathing ghats etc.

The above programmes are comprehensively monitored at the Centre and State levels.

1.6.3 National Lake Conservation Plan

The National Lake Conservation Plan was approved in 1997 for conservation and management of Dal Lake (J&K), Sukhna (Chandigarh), Sagar (M.P.), Nainital (U.P.), Kodiakanal (Tamil Nadu), Ooty (Tamil Nadu), Udaipur Lakes (Rajasthan), Rabinder Sarovar (West Bengal), Powai Lake (Maharashtra) and Hussain Sagar (Andhra Pradesh). Out of these conservation and management plans, for three lakes, namely, Powai, Ooty and Kodaikanal were approved in May 2001. These plans are under implementation. The Detailed Project Report (DPR) for Dal Lake is under approval. The Project Report for Rabindera Sarovar is under examination. The remaining proposals for other lakes are yet to be received.

a) Handling of Parliament Question on all matters relating to Pollution of River Ganga and other rivers and rivers, which are covered under NRCP.

b) Plantation of Plants/trees other than valuable species along with banks of Ganga, Yamuna, Damodar and other rivers under NRCD.

c) Monitoring of all legal matters (Legal Cell).

1.6.4 National River Conservation Plan

The first river action plan to be taken up under the NRCD was the Ganga Action Plan. The objective of Ganga Action Plan Phase I was to improve the water quality to the following standards:

- Bio-Chemical Oxygen Demand (BOD) -3mg/l maximum
- Dissolved Oxygen (DO) -5mg/l minimum
- Total Coliform Count -10,000 MPN per 100 ml
- Faecal Coliform Count -2500 MPN/per 100 ml

The Ganga Action Plan Model with necessary corrections on the basis of lessons learnt and experience gained from GAP Phase I has been applied to the 27 polluted major rivers of the country under the National River Conservation Plan.

1.6.5 Central Pollution Control Board

The Central Pollution Control Board (CPCB), statutory organization, was constituted in September 1974 under the Water (Prevention and Control of Pollution) Act, 1974. Further, CPCB was entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981.

It serves as a field formation and also provides technical services to the Ministry of Environment and Forests of the provisions of the Environment (Protection) Act, 1986. Principal functions of the CPCB, as spelt out in the Water (Prevention and Control of Pollution) Act, 1974, and the Air (Prevention and Control of Pollution) Act, 1981, (i) to promote cleanliness of streams and wells in different areas of the States by prevention, control and abatement of water pollution, and (ii) to improve the quality of air and to prevent, control or abate air pollution in the country.

Fresh water is a finite resource essential for use in agriculture, industry, propagation of wildlife & fisheries and for human existence. India is a riverine country. It has 14 major rivers, 44 medium rivers and 55 minor rivers besides numerous lakes, ponds and wells which are used as primary source of drinking water even without treatment. Most of the rivers being fed by monsoon rains, which are limited to only three months of the year, run dry throughout the rest of the year often carrying wastewater discharges from industries or cities/towns endangering the quality of our scarce water resources. The parliament of India in its wisdom enacted the Water (Prevention and Control of Pollution) Act, 1974 with a view to maintaining and restoring wholesomeness of our water bodies. One of the mandates of CPCB is to collect, collate and disseminate technical and statistical data relating to water pollution. Hence, water quality monitoring and surveillance are of utmost importance.

1.7 CONSERVATION OF WATER

India even though has good water resources but they are unevenly distributed in the Geography of the country. Due to huge population and fast developmental activities and industrialization the water demand for drinking, agricultural and industrial Purposes increases day by day. Monsoon failures and uneven distribution of rainfall Results in floods in one part and droughts in the other parts of the country. The Disposal of untreated/semi-treated industrial and domestic effluents results in Pollution of surface and ground water sources and thus worsens the conditions.

The rivers passing through different states leads to conflicts in water sharing among the states and it is a very difficult issue to find any solution. The over Exploitation of ground water potential leads to seawater intrusion in coastal areas. Heavy application of chemical fertilizers and pesticides for food production Results in agricultural run-off and pollutes both surface and ground water. Hence it is very essential to conserve our water resources from pollution Activities and use the available water with effective management system.

In developed countries like United States, and European countries where Population is less but resources are more are concerned much about control of pollution but in India where population as well as pollution activities are More we have to pay much attention on conservation works Hence we are in a critical stage to control pollution activities while the Developmental activities are also in a fast rate, which is very important for Economical growth of the country and conserve our water resources.

1.8 SALIENT FEATURES OF TAMIL NADU

Preservation of environmental quality has now been recognized as a prime requirement for the well being of mankind. Of late, developmental programmes have started including in their plan, a component on environmental protection. To take stock of the present situation relating to urbanization, industrialization, deforestation, level of pollution etc., and to reorient the developmental programmes in harmony with nature, it is essential that these aspects need documentation. Status of environment report affords an opportunity to take stock of the present level of environmental quality so as to plan future developmental programmes for sustainable development.

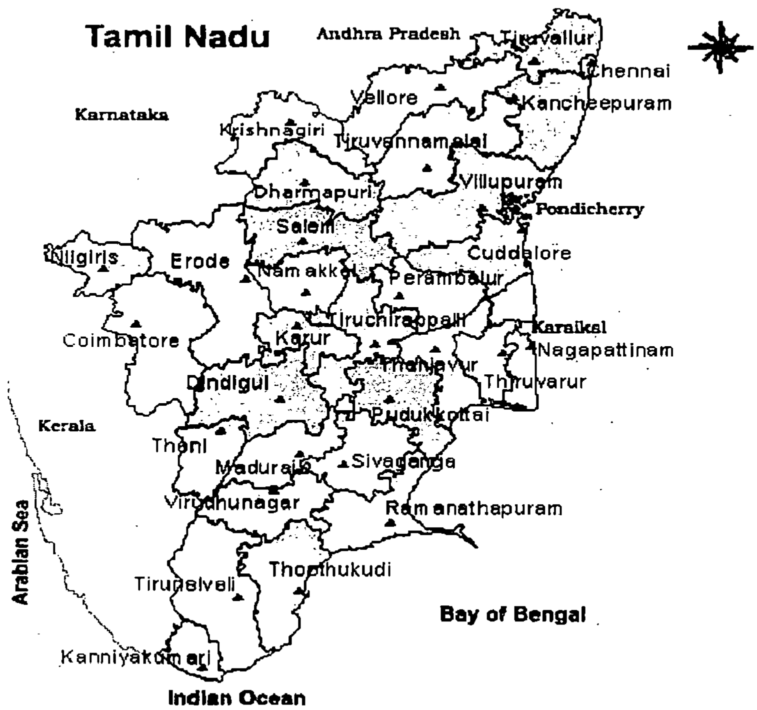


Fig.1.2 Tamil Nadu State Map

(Source: Tamil Nadu Water Supply & Drainage Board)

1.8.1 Demographic Features

The State of Tamil Nadu, occupying an area of 1,30,058 sq.km. Forms the southeastern extremity of the Indian Peninsula. It is geographically positioned between 8^0 5' and 13 ° 35' N Latitudes and between 76 ° 15' and 80 ° 20' E Longitude. The state is bounded by the Bay of Bengal on the east, by the States of Andhra

Pradesh on the north, Kerala on the west, Karnataka on the northwest and by the Indian Ocean on the south. The Eastern Ghats lies between the Palar and the Cauvery, backed up by discontinuous hill ranges with elevations between 1080 M to 1620 M above MSL. The Western Ghats forms the western boundary of the State, comprising the Nilgiris in the north to Anamalaim Palani and Cardamom Hills in the south. The plateau area lies between the Eastern and Western Ghats, with an elevation of 150 to 600 m. the Western Ghats and Eastern Ghats confluence at Nilgiris, the hill ranges of 2000 M above MSL with the Doddabetta with an elevation of 2633 M above MSL is the highest peak in the region. The State has a coastline of 1000 Km in length. The coastal plains lie between Pulicat Lake in the north and Kanyakumari in the south and is further divided into Northern Plains, Cauvery Delta and Southern Plains.

1.8.2 Climatological features

The climate in Tamil Nadu is tropical in plains with temperature variations from 11.9°C during winter and 45.2°C during summer. In the hilly ranges, the temperature varies from 1°C to 27.1°C. April, May and June are the hottest months, with January being the coolest. Frost is common during November to February. However, the climatic conditions do not register any sharp variation in the maximum and minimum temperatures.

1.8.3 Rainfall

The average rainfall of the State is 946.9 mm. the State normally gets the rainfall during the South-West Monsoon commencing from June, July and August and the North-East Monsoon commencing from September / October with maximum rainfall.

1.8.4 Population

Tamil Nadu is the tenth largest State in the country and occupies the seventh position in population. As per 1991 Census, the population of Tamil Nadu is 55 million (55,858,946). The state ranks as the second highest urbanized State in the County. The urban population of Tamil Nadu is about 16 million (15,927,952), constituting about 33 percent of the total population in the State. The State has 434 urban centers. Of these 21 centers have population over 1,00,000 (Class I), containing about 8 million people. While Chennai Metropolitan are has a population of 4.3 million, each urban agglomeration of Madurai, Coimbatore, Thiruchirapalli and Salem covers a population of 2.9 millions. There are 41 urban centres with a population of 50,000 to 1,00,000 (Class II), accommodating 3 million people and 90 towns with population between 20,000 to 50,000 (Class III) have 3 million people. The urban population is distributed in 6 Municipal Corporations, 102 Municipalities, 9 Municipal Townships and 635 Town Panchayats. The rural population is distributed in 12,584 Village Panchayats.

1.8.5 Soils

The soils of Tamil Nadu can be divided into Black, Red, Laterite and Lateritic, Alluvial, Forest or Hills Soils, Saline and Alkaline and Peaty and Marshy depending upon their nature and properties. The black soil area is grater in Ramanathapuram, Cuddalore, and Villupuram Districts. Black soil in Tamil Nadu may further be divided into heavier black soil represented by the Kovilpatti Black Soil and lighter type found in Coimbatore. Red soil occupies 7.69 million hectares (63% of the cultivable area) as compared to less than 2.43 million hectares of black soil.

The largest are of occurrence is in Madurai and Vellore Districts. It also occupies more than 60 percent of the cultivable are in Tiruvallur, Cuddalore, Salem, Erode, Coimbatore, Tiruchirapalli, Perambalur and Tirunelveli District. Lateritic and laterite soil are developed in regions of heavy rain fall. Alluvial soils are found mainly in the valley of the Cauvery. The river deltas in the coast constitute the deltaic alluvial. Saline soils are found along the coast and in the interior, where due to scarcity rainfall, the natural washing out of salts from the soil does not take place. Marshy soils are found in the South East Coastal tract of the State and in the Valley bottoms of the Nilgiris District.

1.8.6 Geology

The State forms part of the peninsular shield and about three fourths of the total are of the State is underlain by unclassified crystalline rocks of archean age. The sedimentary belt forms about one fourth of the total are all along the coast, flanking the main crystalline mass on the West. The sedimentary formations mainly consist of the upper gondwana, cretaceous, tertiary and quaternary deposits. The upper gondwana beds occur periodically between the archean and cretaceous formations. The coastal tract is covered by younger alluvial and coastal and formations of quaternary age.

The Fig.1.3 below shows the different geological formations in Tamilnadu.

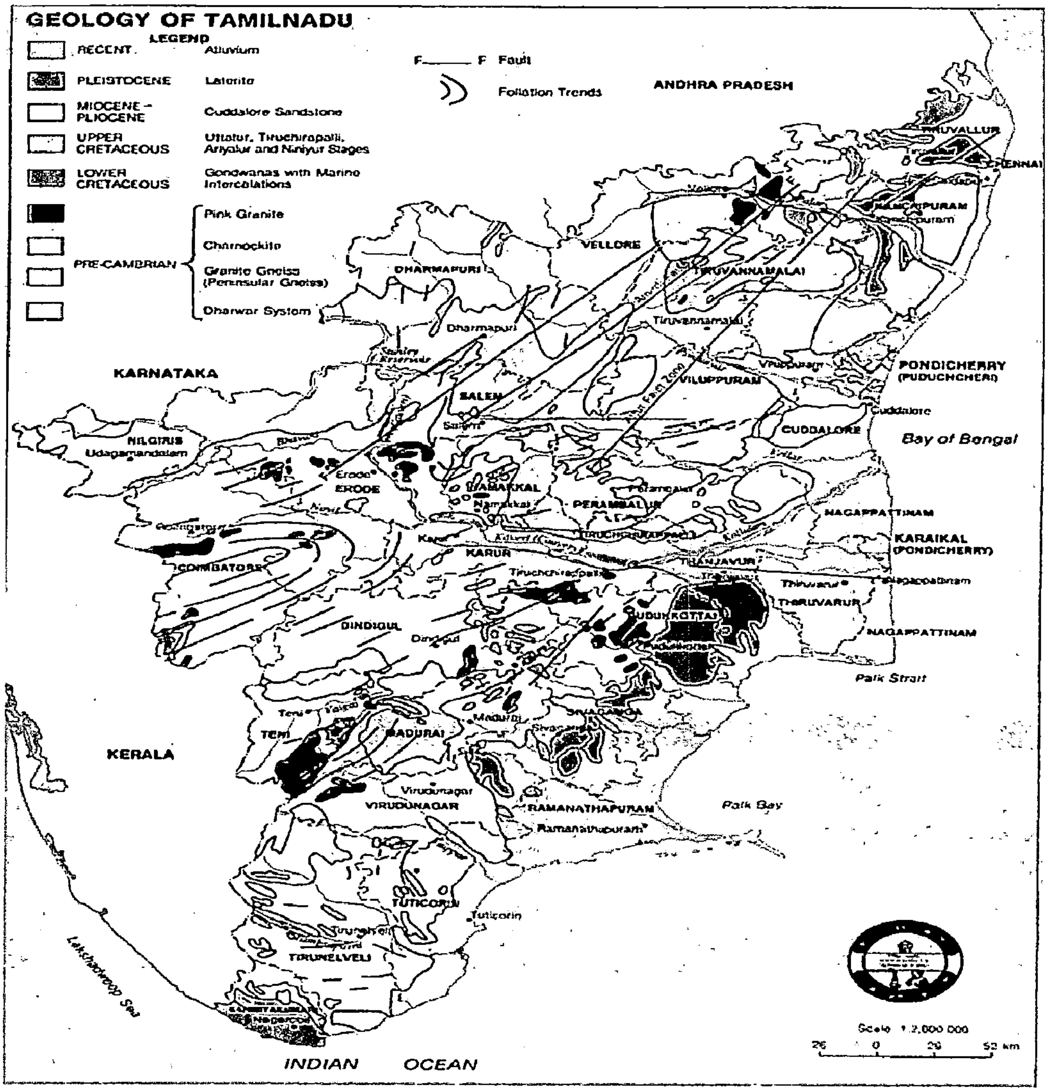


Fig.1.3 Geology of Tamil Nadu

(Source: Tamil Nadu Water Supply & Drainage Board-2002)

1.8.7 Forests

The forest ecosystem is nature's gift to mankind. Besides being the habitat of wide range of flora and fauna, it influences climatological conditions as well as quality of the flowing water bodies. Uncontrolled exploitation of these natural resources has resulted in many environmental repercussions like soil erosion, landslides, siltation of reservoirs, vanishing of rare species of wild life etc. Tamil Nadu has forest area of 22747.75 square kilometers, which is 17.49 percent of the total land area. The variations in the climate and rain-fall have been the cause for the diverse categories of natural vegetation in the forests of this State. The important forest types in the State are:-

- Southern Tropical West Ever Green Forests.
- South Indian Moist Deciduous Forests.
- Southern Tropical Dry Deciduous Forests.
- Southern Tropical Thorn Forests.
- Tropical Dry Evergreen Forests.
- Tidal Swamp Forests and
- Southern Mountain Wet Temperate Forests.

1.8.8 Wildlife

Preservation of wild life is attracting global concern in the recent past, though belatedly, Wild life comprising of natural fauna is an asset to any Country, as a tourist attraction. Besides, ensuring nature's balance, it also affords an opportunity to study the biological activity of various species of animals, birds, flora, fauna, water and soil. Any change brought out in one of them results in an equal change in other systems. Tamil Nadu with its rich forest wealth has been the habitat of many species of wild life tiger, panther, sloth bear, gaur (bison), spotted dear, sambur, black buck, elephant, lion-tailed macaque, tahr etc. Due to continued exploitation through poaching, many species have become rare and endangered. Tiger, abundant, just 20 years ago has become rare due to indiscriminate shooting.

Panther (leopard) now restricted to Salem, Namakkal, Dharmapuri, The Nilgiris, Madurai, Tirunelveli and Tuticorin Districts. The sloth bear and the sambar and the four horned antelope have become rare. The black buck is now found only in Point Calimere Sanctuary and Guindy National Park area. The Gaur (bison) has been reduced in number due to the epidemic of rinderpest. The dwindling rate of wild animals has necessitated the creation of sanctuaries to afford protection to the species and to prevent their extinction. Sanctuaries also provide an opportunity to enjoy the life of many rare species. They serve as a tool for promotion of tourism. Mudumalai, Guindy Deer Park, Mundanthurai, Anamalai, Calimere, Vedanthangal, Kalakkad and Vettangudi are the important wild life sanctuaries in Tamil Nadu.

1.8.9 Agriculture

Agriculture has been the main stay of economy of the State. The State has been adopting maximum utilization of land for cultivation. Nearly fifty percent of the total geographic area has been brought under cultivation and nearly one fourth of the total sown area is sown more than once. To ensure ecological balance and to increase agricultural productivity, intensive cultivation practices using fertilizers and crop protecton chemicals have been adopted. Area under principal food crops increased form 5,621 thousand hectares to 5,832 thousand hectares during the period from 1970-71 to 1978-79. Production of cereals increased from 65.73 lakh tonnes to 71.88 lakh tonnes during 1981-82 and pulses from 135 to 188 lakh tonnes. Intensive cultivation practices have registered considerable increase in usage of fertilizer and pesticides. Consumption of nitrogenous fertilizers increased from 0.96 lakh tones in 1967-67 to 3.07 lakh tones in 1981-82. consumption of phosphatic and potash fertilizer increased from 0.29 lakh tonnes to 0.91 lakh tonnes and 0.30 lakh tonnes to 1.07 lakh tonnes during the period from 1967-68 to 1981-82. As far as pesticides are concerned, the consumption of 5.43 lakh litres under liquid formulation and 0.25 lakh tonnes under dust formulation during 1970-71 increased to 19.04 lakh litres and 0.65 lakh tonnes during 1981-82.

1.8.10 Land use

The total Geographical area of the State is 1.30 crore ha It has been classified according to different types of land use during 03-04 and presented in the table below.

Table 1.6. LAND UTILIZATION DURING 03-04 AS COMPARED TO 02-03. (in ha)

Category		03-04 Area	%	02-03 Area	%
1.	Forests	21,22,041	16.3	21,31,604	16.4
2.	Barren and uncultivable land	5,09,378	3.9	4,78,237	3.7
3.	Land put to non-agricultural uses	21,13,353	16.2	20,12,025	15.5
4.	Culturable waste	3,79,439	2.9	3,89,289	3.0
5.	Permanent pastures and other grazing lands	1,13,474	0.9	1,18,313	0.9
6.	Misc. tree crops and groves not included in the net area sown	2,82,980	2.2	2,77,596	2.1
7.	Current fallow	9,53,963	7.3	15,02,616	11.6
8.	Other fallow lands	18,62,861	14.3	14,91,311	11.5
9.	Net area sown	46,89,156	36.0	45,90,331	35.3
Total Geographical area		**1,30,26,645**	**100.0**	**1,29,91,322**	**100.0**
Area sown more than once		**6,26,871**	**4.8**	**6,00,777**	**4.6**
Gross area sown		**53,16,027**	**40.8**	**51,91,108**	**40.0**

(Source Statistical Dept. Govt. of Tamilnadu-2004)

The variation of 35,323 ha in the total Geographical area of the state during 03-04 was due to the latest land survey as reported by the D.R.Os of Theni and Kanyakumari districts. While cultivated land (cultivated at least once in its entire span) consisting of net area sown, current fallow and other fallow lands is 75,05,980 ha (which is 57% of the total geographical area), land not cultivated but available for cultivation (cultivable waste) accounted for 379439 ha forming 2.9% of the total geographical area during 03-04.

1.8.11 Industries

Industrial Sector of a Country contributes to the economical uplift of the society at large through generation of employment potential, production of material goods for comforts, setting standards for better living etc. Technological advancement ahs resulted in the tremendous growth in this sector. Over the years, Tamil Nadu ahs made good strides in the industrial sphere. There are 19,895 registered industries and in total there are 3,24,627 industries in Tamil Nadu, including the units in the small-scale, tiny, village and khadi sectors. The cotton textile industry in Tamil Nadu accounts for 21.6% of the spindle capacity of the country and accounts also 21.6% of India's Cotton Yarn production. Tamil Nadu produces nearly 17.8% of the country's cement and 10% of the sugar produced in the country.

In Tamilnadu there are 25 class-1 cities having population 1,00,000 and above, 42 Class-2 towns having population 50,000-99,000 and 71 class-3 towns having Population 20,000 –49,900. The wastewater generated by the above towns are 1065 mld., 702 mld., 162 mld. respectively.

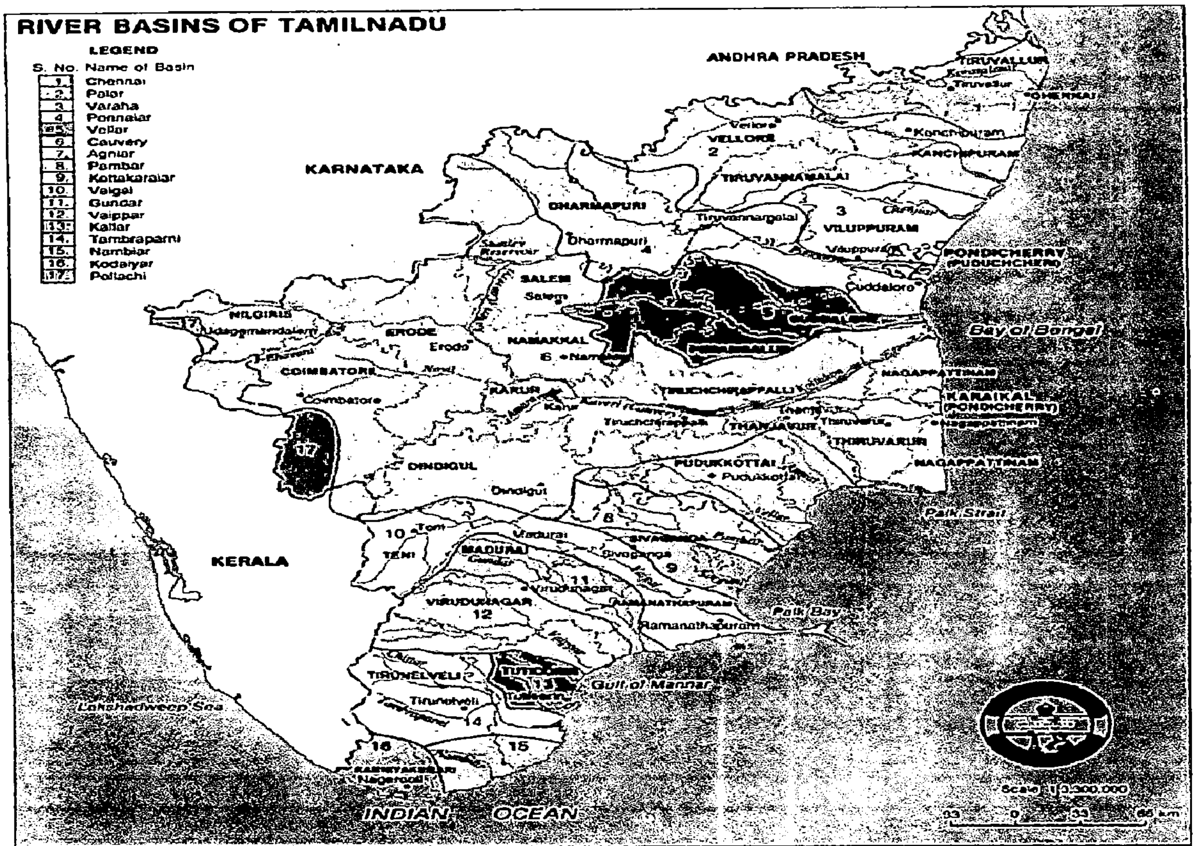
1.9 TAMILNADU-RIVERS AND WATER RESOURCES

1.9.1 Surface Water

The water requirement of the State is met from surface and ground water resources. There are 21 river basins in Tamil Nadu. As the terrain gently slopes from the foot of the hill ranges on the west to the sea on the east, it creates defined river basins, which divide the land into strips lying east west. River Cauvery is the biggest river that flows through Tamil Nadu draining the largest basin.

1.9.2 River Cauvery basin

River Cauvery is one of the most important rivers of Tamil Nadu, irrigating two thirds of the irrigated area in the State. The basin extends over an area of about 81,115 sq.km., out of which 44,016 sq.km. lies in Tamil Nadu. The river originates from Tala Cauvery in Brahmagiri ranges of the Western Ghats. The river enters the state near Hogainakal, with a fall, continues its course and flows mostly eastwards. In the delta, the river splits into the Cauvery and the Coleroon and number of distributaries. The main tributaries to the river are the Bhavani, Noyyal and the Amarvathy. Average annual rainfall of the basin as a whole is 1,155 mm. irrigation development in the basin is supported by the Grand Anaicut and the Stanley Reservoir at Mettur. The system irrigates about 4,68,144 hectare of land, of which 1,86,291 hectare of land is under double crop.



RIVER BASINS

Sl. No.	Name of Basins	Drainage area in Tamil Nadu	Normal annual rainfall (in mm)	Normal rain volume in Km³	Ground water potential (in MCM)
1.	Chennai	5542	1130	6.26	1120
2.	Palar	10674	940	10.03	2610
3.	Varaha	3637	1250	4.65	1482
4.	Ponnaiyar	12141	920	11.17	1560
5.	Vellar	8558	980	8.39	1344
6.	Cauvery	48730	930	45.32	–
7.	Agniar	4463	910	4.06	920
8.	Pambar	3488	880	3.07	976
9.	Kottakaralar	1813	880	1.60	
10.	Vaigai	7741	900	6.97	993
11.	Gundar	4838	770	3.73	766
12.	Vaippar	6255	800	5.00	1167
13.	Kallar	1739	800	1.04	69
14.	Tambraparni	5482	1110	6.09	744
15.	Namblar	1561	950	1.48	275
16.	Kodaiyar	1533	1720	2.64	342
17.	Pollachi	2174	810	1.33	751
	Total	130369	–	122.73	–

Figure 1.4 River Basins of Tamilnadu

(Source: Tamil Nadu Water Supply & Drainage Board-2002)

1.9.3 River Basins around Chennai City

Rivers Araniar, Kortaliar, the Coovam and the Adyar fall in this zone. These are short rivers with small catchment areas and shallow basins, particularly close to the sea, leading to floods during heavy rains. The Araniar is an Inter-State river with a catchment area of 1,290 sq.km., of which 590 sq.km. lies in Tamil Nadu. The river serves an area of 2,388 hectare of land. The Kortaliar originates from Kesaaram Anaicut, fed by the Palar and is joined by Bagari stream. The total catchment area is

3,521 sq.km. The river meets the water supply needs of Chennai City and irrigation needs of 2,052 hectare of land at the outskirt. Poondi Reservoir and the Tamaraipakkam Anaicut across the river, diverts the flow to Cholavaram and Red Hills Lakes for a total yield of 5.7 TMC. The Coovum and the Adyar are mostly used as local drains and practically there is no irrigation with the two river waters. However, a channel from the Korattur Anaicut across the Coovum feeds the Chembarambakkam Tank.

1.9.4 River Palar Basin

River Palar is an Inter-State river originating from Kolar District in Karnataka, flowing through Andhra Pradesh before entering Tamil Nadu. The river is joined by Ponniyaru from Andhra Pradesh and the Cheyyar from Tamil Nadu. The total area drained by the river is 17,871, sq.km. The average rainfall in the basin is 1,000 mm. However, there is flow in the river only during the rainy season. The total ayacut of the system is 51,800 hectare of land.

1.9.5 River Vaigai Basin

The Vaigai originates from the eastern slopes of the Varshanad Hills and flows down north-north easterly direction, upto its confluence with Varahanadhi and then flows, towards south and southeast. The river enters Palk – Bay near Mandapam. Suruliar, Theniar, Varahanadhi and Manjalar are important tributaries of the river. The river has a catchment are of 7,740 sq.km. with nearly 12 TMC of water flows into the river and it irrigates an area of 51,993 hectare.

1.9.6 River Tamiraparani Basin

River Tamiraparani rises on the eastern slopes of the Western Ghats and flows in Tirunelveli District before joining the Gulf of Mannar. The Chittar and the Manimuthar are the important tributaries. The total are drained by the river is 5,482 sq.km.

1.9.7 River Chalakudi Basin

Sholayar, Parambikulam, Thunakadvu and Peruvaripallam are tributaries in the Chalakudi basin and the Aliyar and the Palar are tributaries of the Ponni, all-flowing west. The rich potential of this basin has been tapped through the Parambikulam Aliyar Project and five other dams across the tributaries.

1.10 CURRENT STATUS OF RIVERS OF TAMILNADU

About 70% of rivers in Tamilnadu are polluted. The main causes for pollution are disposal of untreated or semi treated municipal waste industrial waste, mining waste and agricultural runoff. These wastes contain organic matter, dissolved solids, nutrients, and pathogenic microorganisms. These pollutants cause increase in B.O.D level decrease in D.O. level eutrophication and makes the water unfit for any use.

1.11 REASONS FOR CHOOSING RIVER BHAVANI

In Tamil Nadu most of the rivers including River Cauvery are polluted by the discharge of domestic and industrial wastes. A number of conservation programmes have already been started for river Cauvery but not much attention is paid on River Bhavani which is the major tributary to river Cauvery in Tamilnadu.

The condition of River Bhavani is satisfactory at present but it is under severe polluting environment, which will lead to detereoration of water quality in future.

In order prevent such conditions and to maintain its water quality to satisfactory level efforts are made in this dissertation by analyzing various pollution activities of the basin and necessary suggestions are made to improve the present conditions.

1.12 OBJECTIVES OF THE THESIS

The present thesis involves assessment of current status of the water quality in Bhavani River and assessment of the water requirement for various uses in the basin, identify point and non-point sources of pollution and collection of water quality data from various state agencies, processing and computing water quality indices(Horton, NSF and McDuffie's water quality indices prioritization of NSF-water quality indices, preparation of water maps based on water quality indices, impact assessment, suggestions and conservation measures to improve the present conditions of the river basin.

This thesis consists of five chapters the first chapter deals with Indian River system, status of pollution of rivers, Govt. policies, water quality criteria, need for conservation works, salient features of Tamilnadu, Rivers and water resources of Tamilnadu, current status of rivers, objectives of the dissertation, planned work done, and summary of the work done in this thesis. The second chapter deals with general details of river Bhavani, location, and catchment area, point and non-point sources of pollution. The third chapter deals with water quality indices, different types of indices, softwares used and methods of calculation. The fourth chapter deals with sampling locations in river Bhavani, calculation of water quality indices for river Bhavani using Horton's, NSF, and McDuffie's, water quality indices.

The fifth chapter deals with results and discussions, findings, conservation measures needed, suggestions and recommendations to improve the present conditions, conclusions, references, Maps and Photos.

It is concluded that water quality indices were calculated and water quality maps were developed. The pollution activities of the river basin are discussed and it is found that the disposal of untreated industrial effluents from minor industries and the disposal of untreated domestic sewage are the main problems, and accordingly conservation measures are suggested.

CHAPTER-2

STATUS OF POLLUTION OF RIVER BHAVANI

2.1 RIVER BHAVANI

Bhavani, the second largest river in Tamilnadu, begins from Kerala's Silent Valley and flows into western Tamilnadu, covering a distance of 217 km before merging with the Cauvery. The basin drains an area of 0.62 million ha, spread over Kerala (9 per cent), Karnataka (4 per cent) and Tamilnadu (87 per cent). The main river courses through Coimbatore and Erode districts of Tamilnadu, before reaching the Cauvery at Bhavani town. About 90 per cent of the river's water is used for agriculture, even as industries dot the sub basin at every point.

The Bhavani river basin with a catchment area of 6154sq.km is the fourth largest tributary of river Cauvery and it is second longest in terms of length. About 87% of the Bhavani river basin area is located within the Geographical boundary of the state of Tamilnadu, while the rest is spread over Kerala and Karnataka state.

This river basin forms an independent Hydrological unit. Overall water consumption of the Bhavani river basin is 196,458 Million liters per year, the consumption for agricultural purpose is 101,833 Million liters per year for industrial purpose is 53,640 million liters per year and for drinking water purpose is 40,985 million liters of water per year. Water transfer from the Bhavani river basin to non-basin area is 34,310 Million liters of water per year. This water transfer is primarily for industrial and drinking water purpose.

2.2 LOCATION AND CATCHMENT AREA

2.2.1 Location

The River originates from the western part of Tamilnadu in the Western Ghats the Upper streams are from Kerala and portion of streams from Karnataka and Tamilnadu And then flows into Tamilnadu. Its Geographical location falls between $76^0 30'$ and $77^0 30'$ E Longitudes and $11^0 00'$ and $11^0 45'$ N Latitudes. The basin covers Coimbatore, Erode, and Nilgiris districts in the western part of Tamilnadu.

2.2.2 Catchment Area

The Bhavani river basin with a catchment area of 6154sq.km is the fourth largest tributary of river Cauvery and it is second longest in terms of length. The major portion of the catchment area is located in the Western Ghats consists of Forests extends in the states Tamilnadu, Kerala &Karnataka. Biogeographically, the hill chain of the Western Ghats constitutes the Malabar province of the Oriental realm, running parallel to the west coast of India from 8 ° N to 21 ° N latitudes for around 1600 km. Rising up from a relatively narrow strip of coast at its western border, the hills reach up to a height of 2800 m before they merge to the east with the Deccan plateau at an altitude of 500-600 m.

The average width of this mountain range is about 100 km. This bioregion is highly species rich and under constant threat due to human pressure, and is considered one of the 18-biodiversity hotspots of the world. It has complex, heterogeneous landscapes and high levels of biodiversity. In the plains its catchment area lies in the districts of Coimbatore, Nilgiris, and Erode.

Table.2.1 Land Use in Districts Coimbatore, Erode & Nilgiris Dt.

Sl. No.	Type of Land	Coimbatore Dt. (Area in ha.)	Erode Dt. (Area in ha.)	Nilgiris Dt. (Area in ha.)
1	Forest Land	166104.00	6957.00	143350.93
2	Agricultural Land	243642.00	189734.00	53834.63
3	Fallow Land	156756.00	130266.00	18294.00
4	Uncultivated Land	48557.00	36115.00	9916.00

(Source: Statistical Dept. Govt. of Tamilnadu-2001)

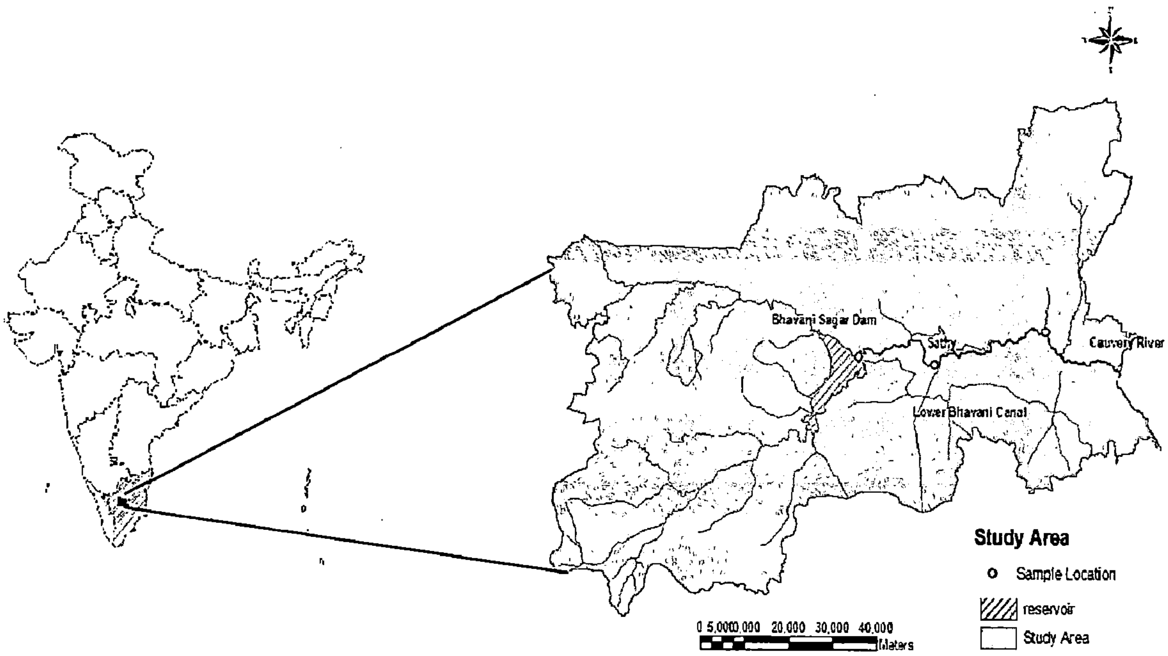


Figure 2.1: Location Map of River Bhavani

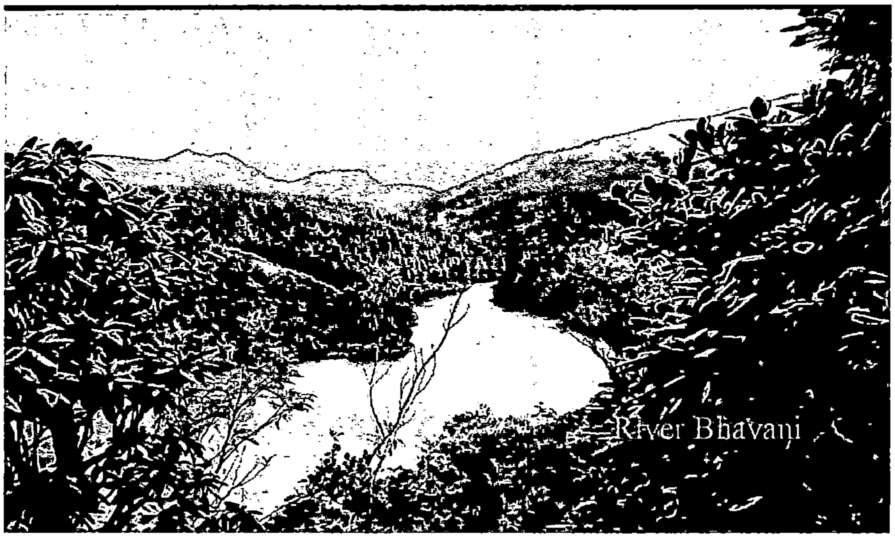


Fig.2.2 Photo showing a view of river Bhavani

2.3 STATUS OF POLLUTION OF THE RIVER

Excessive water consumption, contamination of surface and ground water, growing water demand, rapid change in land use pattern, unsustainable agricultural practices, extensive use of chemical fertilizers and pesticides, degradation of forests, and natural resources in the catchment area, drying aquifers, disappearing streams, encroachment of freshwater tanks, falling ground water table, drinking water scarcity, unemployment due to decline in agricultural activities, environment issues related to disposal of sewages and effluents, and tourism and its impact on environment are the major micro level environment issues of the Bhavani river basin.

2.4 POINT SOURCES OF POLLUTION

The various point sources of pollution, such as domestic sewage, industrial effluents, water consumption for different purposes, and list of major polluting industries are discussed below

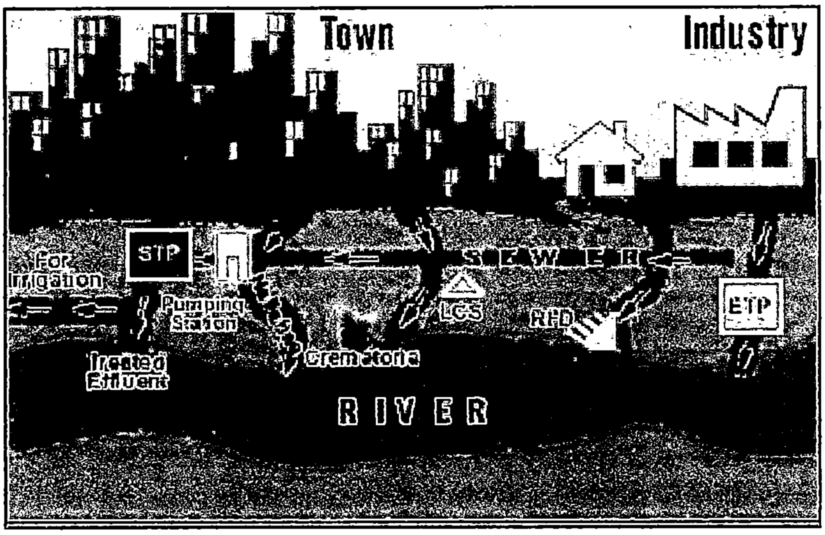


Fig: 2.3 Schematic Diagram of Point Sources of Pollution

2.4.1 Domestic Sewage

Total effluents discharged by seven municipalities located in the Bhavani river basin are 30.37 million liters per day MLD (March 2004). In the year 2011, the discharge of effluents will reach 43.87 MLD if the trend of growth remains unaltered. The drinking water consumption of the river basin is 25,538 million liters per year with a population of 2,580,361 in 16 development blocks with 216 village and 48 town panchayats and 7 Municipalities (March2004).

Mettupalayam is the first municipality situated in the plains on the bank of the river Bhavani. This is major town having population around 65,000. A huge quantity of sewage is generated which is sewage abruptly mixed into the river Bhavani. The municipality is letting out more or less 4,550 kiloliters of sewage per day in the river Bhavani.

Next major town located in this riverbank is Sathyamangalam. Population of this town is about is 40,000.This Municipality lets out about 4000 KL of Sewage. Next to Sathyamangalam town is Gobichettipalayam, which is having population around 50,000. This municipality is also taking river water for its water supply and also generating about 3,800-KL of sewage per day and directly mixing with River Bhavani.

Bhavani municipality is also generating around 4,000 KL of sewage per day by its 35000 population, discharges it into River Bhavani untreated. Some other small towns like Athani and Bhavanisagar also let out their municipal sewage in to the river. Untreated sewage from Ooty, Coonoor, is also dumped into the river. At Mettupalayam, numerous slaughterhouses add their waste to the domestic sewage of the town.

2.4.2 Industrial Effluents / Wastes

Overall water consumption of the Bhavani river basin is 196,458 Million liters per year, the consumption for agricultural purpose is 101,833 Million liters per year for industrial purpose is 53,640 million liters per year and for drinking water purpose is 40,985 million liters of water per year. Water transfer from the Bhavani river basin to non-basin area is 34,310 Million liters of water per year. This water transfer is primarily for industrial and drinking water purpose.

There are 505 dyeing and bleaching units, 248 tea factories, textile industries, 4 sugar mills and distilleries, 6 paper and board manufacturing industries, 56 tanneries and 210 other industries are located in the Bhavani river basin. Distillery, paper, tannery, textile, dyeing and bleaching units are the major water polluting industries located in the basin. The processing nature of all above mentioned industries are water intensive.

The dyeing and bleaching companies in the Bhavani river basin consume 10166 million liters per year (MLY), textile mills -672 MLY, paper board manufacturing companies -7788 MLY, sugar mills and alcohol distilleries – 2250 MLY, tanneries-776 MLY, tea factories – 222 MLY, and other industries -12903 MLY. Needle industry, photo film manufacturing, pharmaceutical industry, and other small industries located in the Bhavani river basin are clubbed together with other industries. Total water consumption for industries within the basin is 34,777 million liters per year.

This is 50.5% of the total water consumption of the industries and this value includes the non-effluent discharging industrial water consumption. The contamination of surface and ground water by the industrial effluents in the Bhavani River takes place even at its prime catchment area in the Nilgiris till its confluence point. The tested samples of various effluents of all the industries indicate that the total dissolved solids, total suspended solids, and alkalinity, hardness and other chemicals are more than the permissible limits prescribed by the State and National standards.

The treated effluents should adhere to the International standards fixed by World Health Organization for drinking water. The classification of standards for inland surface by water and irrigation etc., should be abolished in State standards. Alternatively the permissible limits fixed by the Bureau of Indian standards and Tamilnadu Pollution Control Board must be revised to the standards fixed by World Health Organization. The state of Tamilnadu is a state reeling under hydrological poverty and with its current population growth and water demand, has no other alternative for protecting each and every drop of water. The total water consumption for industries is 53,640 million liters per year this is inclusive of basin and non-basin area consumption).

The Details of some of the major Polluting Industries in the River Basin are given below:

Table 2.2: List of major Polluting Industries

Sl. No.	Name of Industry	Product	Quantity Produced	Quantity of effluent	Treatment Facility
1	M/s K.G.Denim LTD	Processed Denim fabrics	21000 MT/month	818 KLD	Available (recycled)
2	M/s Sharadha Terry Products Ltd	Terry Towel	100 MT/month	630 KLD	Available (Recycled)
3	M/s United Bleachers Ltd	Processed Fabrics, Knitted fabrics &yarn	500 MT/month	1668 KLD	Available (partly recycled)
4	M/s Vaishnoo Devi Mills(P) Ltd	Dyed Knitted Fabrics	75.50 MT/month	124 KLD	Available
5	M/s Siruvani Textiles (P) Ltd	Dyed cotton yarn	21.75 MT/ month	41.20 KLD	Available (Recycled)
6	M/s ITC Ltd	Duplex Board	7424 MT/month	2610 KLD	Available
7	M/s Synthite Industrial Chemicals Ltd	MariGold extract,Jasmine,mimosa concrete	28 MT/month	36.50 KLD	Available
8	M/s Sudarsan paper Mills Ltd	Printing & writing paper	840MT/ month	986 KLD	Available
9	M/s Pioneer Boards (P) Ltd	Mill & Craft Board	150 MT/month	150.75 KLD	Available (Recycled)
10	M/s Tan India Ltd	Wattle extract (solid liquid)	750 MT/month	52.25 KLD	Available
11	M/s Sriram Chemical Industries	Aluminium Sulphate	4.50 MT/month	3.30 KLD	Available

(Source: Tamilnadu Pollution Control Board-2005)

2.4.3 Wastes from other Industries:

Besides the Industries listed above there are several other Industries are in the River basin which discharge un-treated / partly treated effluents into the River. Different types of industries located in Bhavani river basin are all highly polluting and depleting the natural ecology of this area. Among these the most important industries are textile processing, pulp, paper and board, distilleries and sugar industries. These industries are scattered through out the entire stretch of the river. Some other industries located in the Nilgiris are Rallies India Ltd, Ponds India Ltd, Hindustan Photo Films, Chordate factory, Needle industries, and Proteins products Ltd etc., These industries discharge its effluents in the river without proper treatment. This industrial discharges into the river cause increase in sulphide amines, chloride, sulphates, phosphates, nitrate and ammonia. Effluents from Hindustan Photo Films mixed in to the river Bhavani through sandhya odai (channel) near Kamaragsagar Anaicut before Pykara. This effluent is highly alkaline having high COD & BOD.

Down stream side of Bhavanisagar is a cluster of paperboard Industries. These units are used to produce Paper and Board Products using waste papers as raw material. Some of the Board Industries located in this area are Balkart Brothers India Ltd., formerly known as TTk Paper Division, Sam Turbo Industries Paper Division, Vaigunth Paper & Boards, Andal Paper Boards, Akshara Paper Boards and Karthikeya Paper & Boards.

2.5 NON-POINT SOURCES OF POLLUTION

The following may be the non-point sources of pollution.

2.5.1 Agriculture

The total agricultural crop area of the basin is 1, 76,789 hectares. Quantity of chemical fertilizers applied in cultivation is estimated as 342275 tons per year in the Bhavani river basin. The water consumption for agricultural purpose of the basin is

101,833 million liters per year but it comprises of surfaces and ground water resources. The environmental impacts of agriculture are enormous.

The fertilizers and pesticides used in the following three districts will give an Idea about the pollution caused in the River basin.

Table.2.3 Consumption of Fertilizers and Chemicals

Sl. No.	Description.	Coimbatore Dt Tonnes/year	Erode Dt Tonnes/year	Nilgiris Dt Tonnes/year	Total Tonnes/year
1	Chemical Fertilizers	112200	156706	17987	286893
2	Urea	Not available	50882	4500	55382
3	Bio-Fertilizers	416500	88.38	100.00	416688.38
4	Pesticides	Not available	276077	Not available	276077

(Source: Agricultural Dept. Govt. of Tamilnadu-2001)

The above tables clearly show the application of chemical fertilizers and pesticides in the three districts of the river basin. Which leads to run-off from the fields and ultimately reaches the river. This pollution increases year by year as the application rate increases. Though fertilizers are readymade artificial manures supplying essential nutrients for boosting crop production, their continuous and indiscriminate use makes the soils sterile and results in degradation of soil potential. Hence use of different types of organic manures bio-fertilizers, etc. Plays an important role as a part of Integrated Nutrient Management Package.

The effects of intensive agricultural practices, increasing pressures of the growing population, climate changes particularly low precipitation rate in the hills due to degradation of forests, changing hydrological cycle, changing rainfall values, shift in monsoon season and ozone layer depletion emission, water pollution due to industrial effluents, water pollution due to application of chemical fertilizers and pesticides, loss of biodiversity as a result expansion of agricultural lands, soil erosion due to unsustainable agricultural practices, salinity of soil and water resources, depletion of water resources , depletion of water resources due to environmental changes and adoption of water intensive agricultural methods, decline in soil fertility, the increasing use of nitrogen, phosphorous, potassium, fertilizers, weedicides, pesticides, led to increase in run-offs, which are finally discharged to the river causing it more polluted.

2.5.2 Tourism

Now, there are 141 boarding and lodging hotels available in Nilgiris. The Nilgiris municipality draws more water than any other municipality located within the Bhavani river basin during summer season.

The water demand of hotel industry grows up to 442 million liters for 4months of peak tourist season and 439 million liters for 8 months of non-season. During summer alone Uthagamandalam municipality generates 90 tons of solid waste everyday particularly during flower show exhibition in the month of May. Solid waste generated by Coonoor during summer season reaches 47 tons per day. Uthagamandalam and Coonoor municipalities discharge 5.94 and 3.08 MLD of sewage (annual average per day) respectively.

Fun city water theme park located in Ooty town and Black Thunder water theme park located near Mettupalayam attracts summer tourists. They consume huge quantity of water. The area of Black Thunder water theme park is 65 acres and it is located in the elephant corridor. Black Thunder consumes 4500 million liters per annum. The development of new mini town covering on area of 1000 acres of establishment in the prime migratory route of elephants is a threat to wild life.

2.5.3 Pollution by Agricultural Run-off

The another most important source of pollution is agricultural run off. From Mettupalayam to Kalingarayan Anaicut farmers cultivate only wetland crops like paddy, turmeric and sugarcane. They are using chemical fertilizers such as urea.

Diammouium phosphate, potash, and other micronutrients. These major and micronutrients are persisting in soil, leached from the land and reaches the river through agricultural run off. It causes the nutrient enrichment of river and other water bodies. .

The farmers are also using huge amount of organic and inorganic pesticides, such as endrin, aldrin, parathion, malathian and 2-4D. Which are all highly toxic to the Pests and human life. These are leached from the field through agricultural run off and mixed directly with the river water. These toxic substances enter in to the food chain and causing the loss of Biodiversity along the River basin.

2.5.4 Pollution by monoculture

Majority of the farmers in the River basin are found to practice monoculture. There is about 2,36,484 acres of land in the plains under the ayacut of Bhavani River basin. The farmers cultivate only single type of crop especially Paddy. They cultivate Paddy twice per year. Very few farmers are practicing alternative crop pattern, they like banana, turmeric and sugarcane.

This single type of cropping requires more nutrients and is easily affected by Pests. Soil cultivated under monoculture losses its fertility and change in its texture. By the addition of more and more inorganic fertilizers and Pesticides, the soil is tightened as a result earthworm and other organism are eradicated from the land. The excess nutrients and pesticides are leached from the field and are mixed with the River water leading to severe pollution. This monoculture practices are include in the biodiversity and species diversity along the River Basin.

2.6 SILTATION AND SEDIMENTATION

Siltation and Sedimentation are the common problems in all Reservoirs of any River basin. It is due to poor watershed management. It is generally high in the catchment areas where soil erodibility is high and the slopes are steep. Deforestation in the catchment areas increases siltation in the reservoirs and pollution activities in the river basin increases Sedimentation. Good watershed management practices reduce the above two problems. Following are the Soil conservation works and Catchment area treatment works executed in the Bhavani River Basin.

2.7 STATUS

The above point and non-point sources of pollution will degrade the water quality to a large extent in future and especially during lean flows. The domestic sewage has to be treated and only the treated effluent satisfying the standards to be discharged into the river. Industries must be watched for operating their effluent treatment plants, and common effluent treatment plants has to be installed for small industries. Agriculturists must be given proper guidance in using the chemical fertilizers and pesticides, which will reduce the non-point sources of pollution.

CHAPTER-3

WATER QUALITY INDICES

3.1 WATER QUALITY PARAMETERS

Water quality parameters provide important information about the health of a water body. These parameters are used to find out if the quality of water is good enough for drinking water, recreation, irrigation, and aquatic life. Water quality parameters gives the concentration levels of various elements, pollutants dissolved, suspended particles present in water by which one can understand the quality of water.

In River water quality has as many as 32 parameters to assess the quality. The following are some of the important parameters Temperature, Specific Conductance, pH, Dissolved Oxygen, Total Organic Carbon, Hardness, Alkalinity, Nitrate and Nitrite, Ammonia, Phosphate, Fecal Coliform Bacteria, Turbidity, Total Suspended Solids, Total Dissolved Solids, etc.

3.2 WATER QUALITY INDICES

Water quality index is a means devised to reduce large quantity of data (water quality Parameters) down to its simplest form i.e. into a single number retaining essential Meaning so that even a layman can understand the water quality.

A water quality index provides a single number (like a grade) that expresses overall water quality at a certain location and time based on several water quality parameters. The objective of an index is to turn complex water quality data into information that is understandable and useable by the public. A single number cannot tell the whole story of water quality; there are many other water quality parameters that are not included in the index. The WQI presented is not specifically aimed at human health or aquatic life regulations.

For calculation of WQI, section of parameters has great importance. Since selection of too many parameters might widen the quality index and importance of various parameters depends on the intended use of water, twelve physico-chemical parameters namely pH, Conductivity, Turbidity, Total hardness, Mg hardness, Ca hardness, TDS, Chlorides, Alkalinity, Sulphate, Nitrates, Iron, were used to calculate WQI. In practice a number of parameters are analyzed in water quality analysis (River Water-32 parameters) and only Experts can understand the water quality, and Hence it is necessary to transform these data into a form (single number) that Is readily understood by anyone.

3.3 ROLE OF WATER QUALITY INDICES

The role of water quality indices are in water quality monitoring Programmes, Assist in formulating Policy, Provide means for judging the effectiveness of environmental Protection programme and Assist in designing these programmes, Facilitate communication with Public covering conditions of Environment and progress towards its enhancement. The six Basic uses of Water Quality Indices are, identified as Resource allocation, Ranking of allocation, Enforcing standards, Trend analysis, Public information, Scientific Research.

The limitations of the water quality indices are it is very difficult to incorporate all parameters, in the process of transformation to a single index. In the process of transformation some information is lost and some distortion may occur due to loss of information.

3.4 SCALES

There are two scales for the Water quality Indices, increasing scale where the pollution level increases with the increase of water quality index. If the index value is zero it indicates good water quality (No pollution) and if the index value is 100 then it indicates poor water quality (severe pollution), in decreasing scale where the pollution level decreases with the increase in water quality index. Here zero represents poor water quality (Severe pollution) and 100 represents good water quality (No pollution).

3.5 DIFFERENT TYPES OF INDICES

A number of water quality indices have been developed based on different parameters and for different water bodies, the following WQI are discussed in this work, which is suitable for analysis of Surface waters.

Following are the list of WQI available for analysis of water quality:

1. Horton's Index
2. Brown's or the National Sanitation Foundation's water quality index (NSFWQI)
3. Prati's implicit index of pollution
4. McDuffie's river pollution index (RPI)
5. Dinius' water quality index (1972)
6. Dininus' second index
7. O'Connor's indices
8. Deininger and Landwehr's PWS index
9. Walski and Parker's index
10. Stoner's Index
11. Nemerow and Sumitomo's pollution index
12. Smith's index (1987)
13. Viet and Bhargava's Index (1989)
14. Chesapeake Bay water quality indices (Haire et al 1991)
15. Li's regional water resource quality assessment index (1993)
16. Coastal water quality index for Taiwan (Shyue et al 1996)

Table 3.1 Comparison of the water quality indices

Index	Sub indices	Aggregation function	Flaws
Horton's	Segmented linear (step functions)	Weighted sum multiplied by 2 Dischotomous Term	Eclipsing region
Brown et al. (NSF WQI_a)	Implicit nonlinear	Weighted sum	Eclipsing region
Landwehr (NSF WQI_m)	Implicit nonlinear	Weighted product	Non linear
Parti et al.	Segmented non linear	Weighted sum (arithmetic mean)	Eclipsing region
McDuffie & Haney	Linear	Weighted Sum	Eclipsing region
Dinius	Non linear	Weighted sum	-----do-----
Dee et al.	Implicit nonlinear	-----do-----	-----do-----
O'Connor's (FAWL, PWS)	Implicit nonlinear	Weighted sum	Eclipsing region
Deininger &	-----do-----	Weighted sum	-----do-----
Landwehr (PWS)		Weighted product	Non linear
Walski & Parker	Non linear	Weighted product	-----do-----
		Geometric mean	
Stoner	-----do-----	Weighted sum	
Nemerow & Sumitomo	Segmented linear	Root mean square of max. & arithmetic mean	– ve value
		Minimum operator	
Smith	Multiple types		–
		Weighted product	
Viet & Bhargava	-----do-----		–

Among the above the following three indices are selected for analysis in this work based on the availability of data and they are suitable for analysis of surface water (river water) Horton's index is simple to calculate whereas Brown's and McDuffie's indices are suitable for surface waters.

- The Horton's Index
- Brown's or the National Sanitation Foundation's water quality Index (NSFWQI)
- McDuffie's river pollution index (RPI)

3.5.1 The first modern WQI: Horton's Index

Horton (1965) set for himself the following criteria when developing the first-ever modern WQI:

1. The number of variables should be limited to avoid making the index unwidely.
2. The variables should be of significant in most parts of the country.
3. Only such variables, of which reliable data is available, or obtainable, should be included.

It is based on the following eight parameters with weights.

Table 3.2 Parameters and Weights

Sl. No.	Parameter	Weight	Remarks
1	Dissolved Oxygen	4	---
2	Sewage Treatment	4	% Population served with abatement activities
3	PH	4	---
4	Coliforms	2	---
5	Specific Conductance	1	Approx. measure of TDS
6	Carbon chloroform extract	1	Reflect influence of organic matter
7	Alkalinity	1	---
8	Chlorides	1	---
	Total	18	---

The index score is obtained with a linear sum aggregation function. The function consists of the weighted sum of the sub indices divided by the sum of the weights and multiplied by two coefficients M_1 and M_2, which reflect temperature and obvious pollution, respectively:

$$QI = \frac{\sum_{i=1}^{n} W_i I_i}{\sum_{i=1}^{n} W_i} M_1 M_2$$

Horton's index is easy to compute, even though the coefficients M_1 and M_2 require some tailoring to fit individual situations. The index structure, its weights, and rating scale are highly subjective as they are based on the judgement of the author and a few of his associates.

The Sub-Indices are calculated based on the following ranges of parameters given in the Tables.

Table 3.3 Parameters and Weights

Sub-Index	**Parameters**		
	% DO	Coliforms mpn/100ml	Carbon chloroform extract
100	>70	<1000	0-100
80	50-70	1000-5000	100-200
60	30-50	5000-10000	200-300
30	10 to 30	10000-20000	300-400

Table 3.4 Parameters and Weights

Sub-Index	Parameters			
	pH	Specific Conductance	Alkalinity	Chlorides
100	6 to 8	0-750	20-100	0-100
80	5-6 & 8-9	750-1500	5-20,100-200	100-175
40	4-5& 9-10	1500-2500	0-5,>200	175-250
0	<4 >10	>2500	Acid	>250

Table 3.5 Parameter and Weight

Sub-Index	Sewage Treatment (%Population Served)
100	95-100
80	80-95
60	70-80
40	60-70
20	50-60
0	<50

The water quality for different Index values (Ranges) and the respective colour on map and its comparison with designated best use of water is given below.

Table 3.6. Water Quality Index Value

Index value	Water quality	Colour	Designated Best Use
0-25	Very bad	Red	E
26-50	Bad	Orange	D
51-70	Medium	Yellow	C
71-90	Good	Green	B
91-100	Excellent	Blue	A

3.5.2 The National Sanitation Foundation's water quality index (NSFWQI)

Brown et al. (1970) developed a water quality index similar in structure to Horton's index but with much greater rigour in selecting parameters, developing a common scale, and assigning weights for which elaborate Delphic exercises were performed. This effort was supported by the National Sanitation Foundation (NSF). For this reason Brown's index is also referred as NSFWQI.

Table 3.7. List of parameters chosen as most significant by a Delphi conducted By Brown (1970) for the NSFWQI

Parameter	Rank of importance
Dissolved oxygen	1
Biochemical oxygen demand	2
Turbidity	3
Total solids	4
Nitrate	5
Phosphate	6
pH	7
Temperature	8
Faecal coliforms	9
Pesticides	10
Toxic elements	11

To convert the rating into weights, a temporary weight of 1.0 was assigned to the parameter, which received the highest significance rating. All other temporary weights were obtained by dividing each individual mean rating by the highest rating. Each temporary weight was then divided by the sum of all the temporary weights to arrive at the final weight. Table 2 gives the mean rating, temporary weights and final weights of the selected parameters.

The index is give by

$$NSFWQI = \sum_{i=1}^{n} W_i Q_i$$

Where Q_i = The quality of the i^{th} parameter (a number between 0 and 100 read from the appropriate sub index graph).

W_i = The weight of the i^{th} parameter.

Table 3.8. Significance ratings and weights for parameters included in Brown's (NSF) WQI

Parameters	Mean of all significance ratings returned by respondents	Temporary weights	Final weights
Dissolved oxygen	1.4	1.0	0.17
Fecal Coliform density	1.5	0.9	0.15
Ph	2.1	0.7	0.12
BOD (5-day)	2.3	0.6	0.10
Nitrates	2.4	0.6	0.10
Phosphates	2.4	0.6	0.10
Temperature	2.4	0.6	0.10
Turbidity	2.9	0.5	0.08
Total solids	3.2	0.4	0.08
		Total	1.00

3.5.3 McDuffie's River pollution index (RPI)

It is a relatively simple water quality index in which eight pollutant variables are included. Most sub indices are of the general linear form:

$$I_i = 10\frac{X}{X_N}$$

Where,

I_i = subindex of the 1th pollutant variable

x = observed value of the pollutant variable (100 for highly polluted)

x_N = natural level of the pollutant variable (usually 10)

Six of the eight sub indices described by McDuffie and Haney were explicit linear functions, and two (coliform count and temperature) were explicit non-linear functions (Table 6). The index did not include pH or toxic substances. The overall index is computed as the sum of n sub indices times a scaling factor 10 / (n+1)
Sub index functions of McDuffie's index.

$$RPI = \frac{10}{n+1}\sum_{i=1}^{n} I_i$$

The RPI was applied on a test basis using data from New York State's water quality surveillance network and from other sources.

Table 3.9 Parameters and Sub indices

S. No	Parameter	Sub index
1	Percent Oxygen Deficit	I = 100–x, x=DO %
2	Biodegradable Organic Matter	I = 10x, x=BOD_5 (ppm)
3	Refractory Organic Matter	I = 5 (x-y), x=COD, y=BOD_5
4	Coliform Count (no./100 ml)	$I = 10 \frac{\log x}{\log 3}$
5	Nonvolatile Suspended Solids	I = x,
6	Average Nutrient Excess	I = 5 (X/0.2+ Y/0.1) X=Total N Y=Total P
7	Dissolved Salts	I=0.25x x=Specific conductance
8	Temperature	$I = X^2/6 - 65$ X= Temperature

The following table shows the Limitations of the three water quality indices.

Table 3.10 Limitations

Name of Index	Range	Limitations
Horton's Index	0-100	Parameter Ranges are wide and it gives a general idea of water quality also not suitable for accurate analysis.
NSFWQI	0-100	It does not recognize and incorporate specific water functions like drinking water supply, agriculture, industry, etc.,
Mc Duffie's Index	100-1000	Site Specific not suitable for all surface waters.

3.6 SOFTWARES USED FOR ANALYSIS

The NSF-WQI has been calculated based on the software downloaded from Wilkies University Center for Environmental Quality Geo-Environmental Sciences and Engineering Department. Source Code for these Calculators from Source Code: *Keith Alcock's JavaScript Webmaster:* *webmaster@alcoc.vip.bestcom the* other two indices are prepared in excel sheets.

In this Thesis ARC-GIS 8.3 From ESRI was used to prepare the necessary input Maps. GIS Can Be Effectively used for assessing the spatial distribution of water quality indices. The Study area map was digitized and projected in the scale of 1:40,000,00 scale and the sampling locations are marked on its latitude and longitude. The various quality parameters like BOD, DO, and F-Coli are added as attributes.

The spatial variation of water quality parameters was done by Increase Distance Weightage Method. (IDW) It seems GIS a preferred alternative tool for conventional method to show the spatial distribution of water quality.

3.7 CALCULATION OF DO% SATURATION

Oxygen saturation is calculated as the percentage of dissolved O_2 concentration relative to that when completely saturated at the temperature of the measurement depth. Recall that as temperature increases, the concentration at 100% saturation decreases. The elevation of the water bodies, the barometric, pressure and the salinity of the water also affect this saturation, value but to a lesser extent. In most water bodies, the effect of dissolved solutes (salinity) is negligible; but the elevation effect due to decreased partial pressure of oxygen in the atmosphere as you go up (recall the breathing difficulties faced by Mt. Everest climbers) is about 4% per 300 meters (1000 feet). The DO concentration for 100% air saturated water at sea level is 8.6 mg O_2/L at 25°C (77°F) and increases to 14.6 mg O_2/L at 0°C. Use the chart below for nomagrams for calculating saturation.

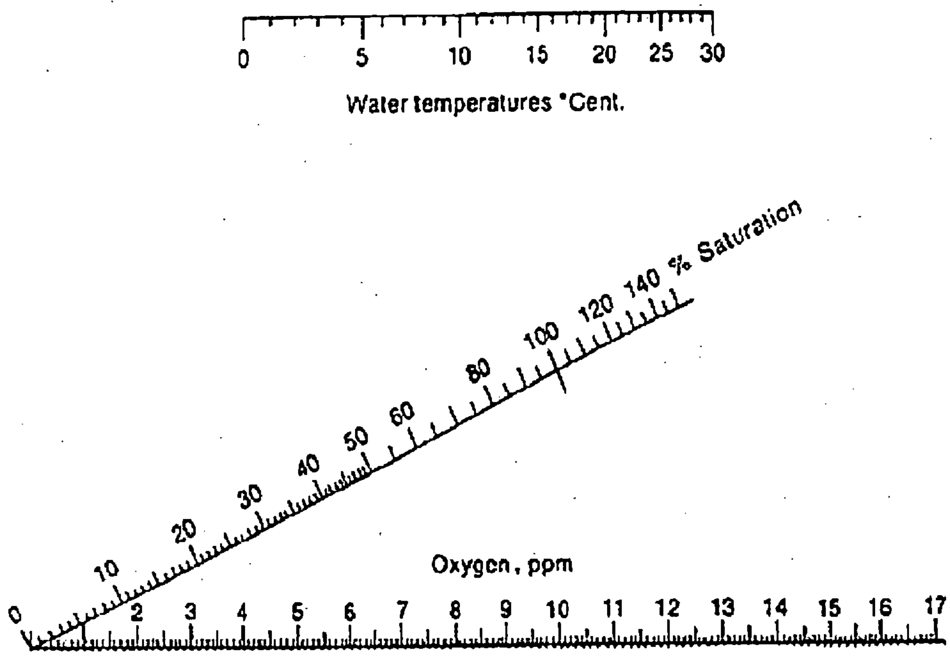


Fig : 3.1 Chart for D.O % Saturation

For a quick and easy determination of the percent saturation value for Dissolved oxygen at a given temperature, use the saturation chart above. Pair up the mg/l of dissolved oxygen measured and the temperature of the water in degrees C, draw a straight line between the water temperature and the mg/l of dissolved oxygen. The percent saturation is the value where the line intercepts the saturation scale.

3.8 COMPARISON OF WATER QUALITY INDICES

3.8.1 Horton's WQI

The Parameter ranges are wide in Horton's water quality index, for small variations in parameter the water quality remains the same. It gives an overall idea and not suitable for precise analysis. It is easy to compute but does not include any toxic chemicals the coefficients M_1, M_2, require some tailoring to fit individual situations.

3.8.2 NSF-WQI

NSF-WQI is a more precise one compared to the other WQ indices. It is suitable for surface waters at any place. All major parameters are included and due weightages are given, the parameter selection and assigning of weights are based on Experts Opinion and hence gives good results. For pesticides and toxic elements it was proposed that if the total contents exceeds 0.1 mg/lit the water quality index is automatically registered zero.

3.8.3 McDuffie's WQI

McDuffie's River pollution Index is a relatively simple index in which eight pollutant variables are included. Six of the eight sub-indices were explicit linear functions and two (Coliform count temperature) were explicit non-linear functions. COD, Nutrients (nitrates and phosphates) are critical parameters slight increase of the parameters varies the index very much. It is not suitable for surface waters at all places and it is site specific. The index does not include PH or toxic substances.

3.9 JUSTIFICATIONS FOR SELECTING NSF-WQI

Among the above three indices in Horton's index the parameter ranges are vide and it is not accurate. Mcduffie's index is site specific and not suitable for all surface waters. NSF-WQI is more accurate well balanced and suitable for analysis of all surface waters. Hence it is chosen for analysis in this Thesis.

CHAPTER-4

WATER QUALITY ASSESSMENT OF RIVER BHAVANI

4.1 GENERAL

Water quality analysis is essential to find the present quality and level of pollution of a water body, the suitability of the water for a particular use, to find the cause for pollution and to take appropriate measures to improve its quality. Monitoring programmes can be designed according to the quality and fund allocations can be made for the programmes.

For river Bhavani the water quality indices have been calculated in the three sampling locations of river Bhavani downstream of Bhavanisagar reservoir and are compared. The data for the years 2000, 2001, 2003, 2004 was collected from Tamilnadu State Pollution Control Board, Chennai, while for the year 2006 the samples were collected and analyzed at Tamilnadu Water Supply and Drainage Board laboratory, Coimbatore.

4.2 WATER SAMPLING LOCATIONS IN RIVER BHAVANI

Water sampling was done in the Bhavani River by the Tamilnadu Pollution Control Board Coimbatore Division, at the sampling points upstream and down streamside of the Industries as indicated in the map.

4.3 PROJECT AREA

The Project area chosen for this work is downstream side of Bhavanisagar Reservoir. The following three water-sampling locations are chosen for analysis and analysis based on the data for the years 2000, 2001,2003,2004,2006

1) Bhavanisagar Dam downstream
2) Sathyamangalam downstream
3) Periyamoolapalayam (P. M. Palayam)

The area chosen is such that where pollution is high. In the upstream side of the reservoir, the water quality is generally good and there is not much change in the quality except pollution, caused by the discharge of domestic sewage, and industrial effluents.

4.4 CALCULATION OF WATER QUALITY INDEX

In this thesis the following three methods were used to calculate water quality indices.

4.4.1 Horton's Water Quality Index

This index is calculated based on the sub indices for various parameters given in the following Table no.4.1 to 4.10 for the years 2000,2001,2003,2004 and 2006 respectively.

TABLE 4.1 ANALYSIS FOR THE YEAR 2000

TABLE:		CALCULATION OF HORTON'S WATER QUALITY INDEX																	
		ANALYSIS FOR THE YEAR 2000																	
RIVER	BHAVANI		SAMPLING STATION:				ALL THREE LOCATIONS												
	Parameter weights& Sub-Index																		
SAMPLING STATION	DO %saturation	Sub-Index	Sewage Treatment	Sub-Index	pH	Sub-Index	TotalColimg/l	Sub-Index	Sp.conductan cemho/cm.	Sub-Index	Carbon Chloroform extract	Sub-Index	Alkalinity	Sub-Index	Chlorides	Sub-Index	Horton's water quality Index	Water Quality
D/S B.S DAM	4	100	4	0	4	100	2	100	1	100	1	100	1	100	1	100	77.78	GOOD
D/S SATHY	4	100	4	0	4	100	2	100	1	100	1	80	1	100	1	100	76.67	GOOD
P.M.Palayam	4	100	4	0	4	100	2	100	1	100	1	80	1	80	1	100	75.56	GOOD

TABLE 4.2 PARAMETERS

	Parameter values							
SAMPLING STATION	DO %saturation	Sewage Treatment	pH	TotalColimg/l	Sp.conductance	Carbon Chloroform extract	Alkalinity	Chlorides
D/S B.S DAM	97	Nil	7.6	550	112	24	72	24
D/S SATHY	76.42	Nil	7.86	873	642	156	100	40
P.M.Palayam	79.73	Nil	7.73	1161	426	112	185	35

TABLE 4.3 ANALYSIS FOR THE YEAR 2001

TABLE:		CALCULATION OF HORTON'S WATER QUALITY INDEX																
		ANALYSIS FOR THE YEAR 2001																
RIVER	BHAVANI		SAMPLING STATION:				ALL THREE LOCATIONS											
	Parameter weights& Sub-Index																	
SAMPLING STATION	DO %saturation	Sub-Index	Sewage Treatment	Sub-Index	pH	Sub-Index	TotalColimg/l	Sub-Index	Sp.conductanc emho/cm.	Sub-Index	Carbon Chloroform extract	Sub-Index	Alkalinity	Sub-Index	Chlorides	Sub-Index	Horton's water quality Index	Water Quality
D/S B.S DAM	4	100	4	0	4	100	2	100	1	100	1	100	1	80	1	100	76.67	GOOD
D/S SATHY	4	100	4	0	4	100	2	100	1	100	1	100	1	40	1	100	74.44	GOOD
P.M.Palayam	4	100	4	0	4	100	2	100	1	100	1	100	1	80	1	100	76.67	GOOD

TABLE 4.4 PARAMETERS

	Parameter values							
SAMPLING STATION	DO %saturation	Sewage Treatment	pH	TotalColim g/l	Sp.conductance	Carbon Chloroform extract	Alkalinity	Chlorides
D/S B.S DAM	85	Nil	7.8	637	124	26	196	52
D/S SATHY	83	Nil	7.2	954	84	18	216	35
P.M.Palayam	88	Nil	7.73	577	192	22	168	60

TABLE 4.5 ANALYSIS FOR THE YEAR 2003

TABLE:		CALCULATION OF HORTON'S WATER QUALITY INDEX																
		ANALYSIS FOR THE YEAR 2003																
RIVER	BHAVANI		SAMPLING STATION:				ALL THREE LOCATIONS											
	Parameter weights& Sub-Index																	
SAMPLING STATION	DO %saturation	Sub-Index	Sewage Treatment	Sub-Index	PH	Sub-Index	TotalColimg/l	Sub-Index	Sp.conductan cemho/cm.	Sub-Index	Carbon Chloroform extract	Sub-Index	Alkalinity	Sub-Index	Chlorides	Sub-Index	Horton's water quality Index	Water Quality
D/S B.S DAM	4	100	4	0	4	100	2	100	1	100	1	100	1	100	1	100	77.78	GOOD
D/S SATHY	4	100	4	0	4	100	2	100	1	100	1	100	1	80	1	100	76.67	GOOD
P.M.Palayam	4	100	4	0	4	80	2	80	1	100	1	100	1	80	1	100	70.00	MEDIUM

TABLE 4.6 PARAMETERS

	Parameter values							
SAMPLING STATION	DO %saturation	Sewage Treatment	pH	TotalColimg/l	Sp.conductance	Carbon Chloroform extract	Alkalinity	Chlorides
D/S B.S DAM	85	Nil	8	724	96	56	76	25
D/S SATHY	95	Nil	8	541	74	72	176	30
P.M.Palayam	80	Nil	8.2	1542	186	62	112	45

TABLE 4.7 ANALYSIS FOR THE YEAR 2004

TABLE:		CALCULATION OF HORTON'S WATER QUALITY INDEX																	
		ANALYSIS FOR THE YEAR 2004																	
RIVER	BHAVANI		SAMPLING STATION:				ALL THREE LOCATIONS												
	Parameter weights& Sub-Index																		
SAMPLING STATION	DO %saturation	Sub-Index	Sewage Treatment	Sub-Index	PH	Sub-Index	TotalCol img/l	Sub-Index	Sp.conductan cemho/cm.	Sub-Index	Carbon Chloroform extract	Sub-Index	Alkalinity	Sub-Index	Chlorides	Sub-Index	Horton's water quality Index	Water Quality	
D/S B.S DAM	4	100	4	0	4	100	2	100	1	100	1	100	1	100	1	100	77.78	GOOD	
D/S SATHY	4	100	4	0	4	100	2	100	1	100	1	100	1	80	1	80	75.56	GOOD	
P.M.Palayam	4	100	4	0	4	80	2	80	1	100	1	80	1	80	1	80	67.78	MEDIUM	

TABLE 4.8 PARAMETERS

	Parameter values							
SAMPLING STATION	DO %saturation	Sewage Treatment	pH	TotalColimg/l	Sp.conductance	Carbon Chloroform extract	Alkalinity	Chlorides
D/S B.S DAM	89	Nil	7.9	352	105	46	54	42
D/S SATHY	100	Nil	7.3	826	62	82	118	142
P.M.Palayam	84	Nil	8.1	453	185	102	142	194

TABLE 4.9 ANALYSIS FOR THE YEAR 2006

TABLE:		**CALCULATION OF HORTON'S WATER QUALITY INDEX**															
		ANALYSIS FOR THE YEAR 2006															
RIVER	**BHAVANI**		**SAMPLING STATION:**				**ALL THREE LOCATIONS**										
	Parameter weights& Sub-Index																
SAMPLING STATION	DO %saturation	Sub-Index	Sewage Treatment	Sub-Index	pH	Sub-Index	TotalColimg/l	Sub-Index	Sp.conductance mho/cm	Sub-Index	Carbon Chloroform extract	Sub-Index	Alkalinity	Sub-Index	Chlorides	Sub-Index	Horton's water quality Index	Water Quality
D/S B.S DAM	4	100	4	0	4	100	2	100	1	100	1	100	1	100	1	100	77.78	GOOD
D/S SATHY	4	100	4	0	4	80	2	100	1	100	1	100	1	100	1	100	73.33	GOOD
P.M.Palayam	4	100	4	0	4	100	2	100	1	100	1	100	1	100	1	100	77.78	GOOD

TABLE 4.10 PARAMETERS

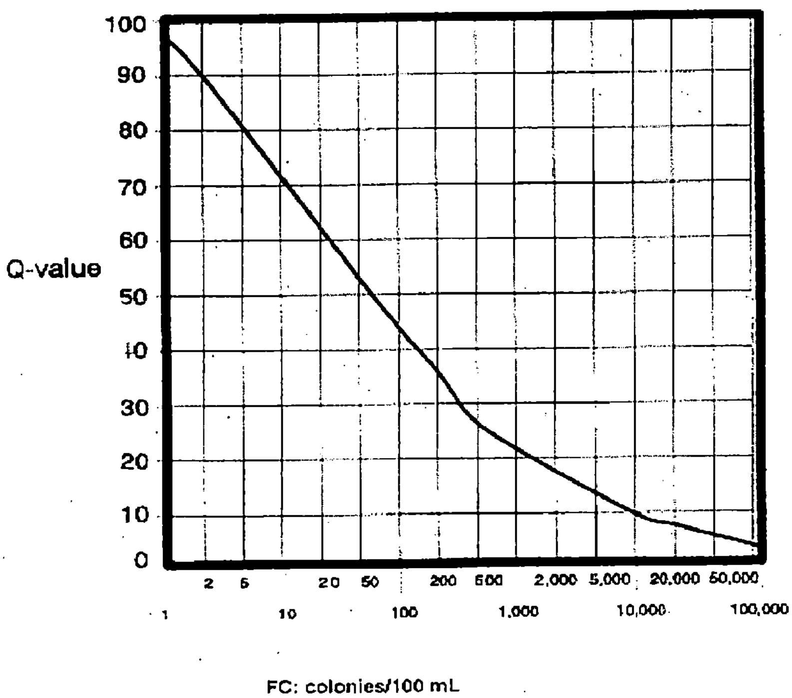
SAMPLING STATION	DO %saturation	Sewage Treatment	pH	TotalColimg/l	Sp.conductance	Carbon Chloroform extract	Alkalinity	Chlorides
D/S B.S DAM	70	Nil	7.36	180	68	32	40	18
D/S SATHY	75	Nil	8.45	920	65	85	60	9
P.M.Palayam	73	Nil	7.4	120	58	96	50	12

4.4.2 National Sanitation Foundation Water Quality Index

This water quality index is calculated using the software. The NSF-WQI has been calculated based on the software downloaded from Wilkies University Center for Environmental Quality Geo-Environmental Sciences and Engineering Department. Source Code for these Calculators from Source Code: *Keith Alcock's JavaScript Webmaster:* *webmaster@alcoc.vip.bestcom*

1) Sub-Index: Fecal Coli

Chart 2: Fecal Coliform (FC) Test Results



Note: If the number of fecal coli form colonies is greater than 100,000, the quality index equals 2.

Fecal coli form: (colonies/100 ml)

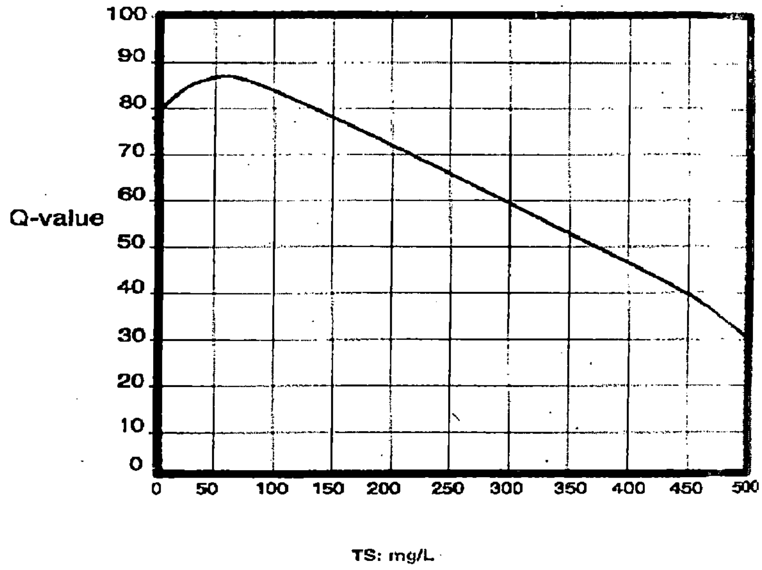
Water quality index:

This index varies from a minimum of 2 to a maximum of 100 based on the number of colonies present in the sample.

This index initially increases from 80 to 85 and then reduces to30 as the Total solids increases from 0 to 500

2) Sub-Index: Total Solids

Chart 9: Total Solids (TS) Test Results

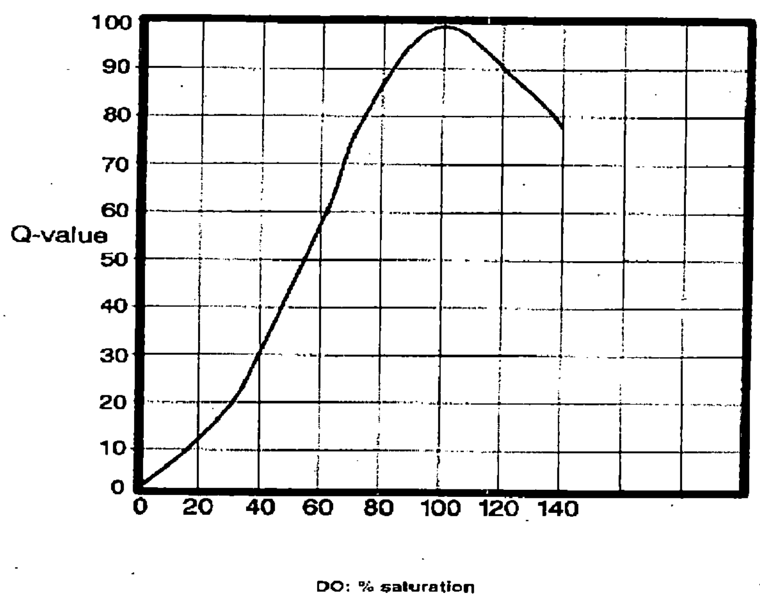


Note: if TS > 500.0, Q = 20.0

3) Sub-Index: DO sat (%)

Weighting Curve Charts

Chart 1: Dissolved Oxygen (DO) Test Results



Note: if DO % saturation > 140.0, Q = 50.0

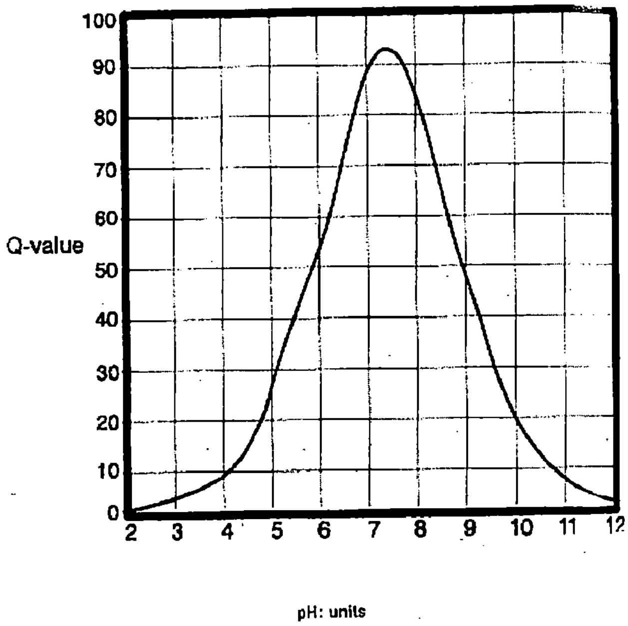
Note: If dissolved oxygen is greater than 140%, the quality index equals 50.

The sub-index value increases from 0 to 100 % as the saturation % increases and then falls down and equals to 50% beyond 140% of DO saturation.

The sub-index ranges from 2 to 12 of the pH value and it is maximum at 7.5. Beyond 12 and below 2 its value is 0.

4) Sub-Index: pH

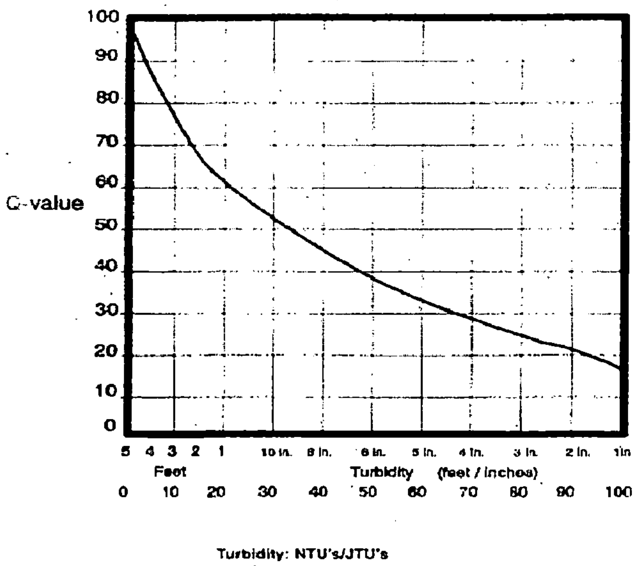
Chart 3: pH Test Results



Note: If pH is less than 2.0 or greater than 12.0,the quality index equals 0.

5) Sub-Index: Turbidity

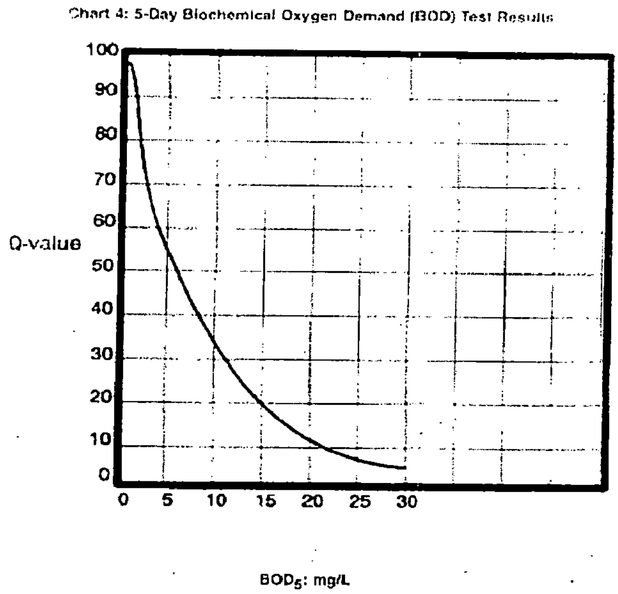
Chart 8: Turbidity Test Results



Note: If turbidity is greater than 100 ntu, the quality index equals 5.

As Turbidity increases the sub-index value falls down and minimum at 100ntu.Its value is maximum at Turbidity value is 0.

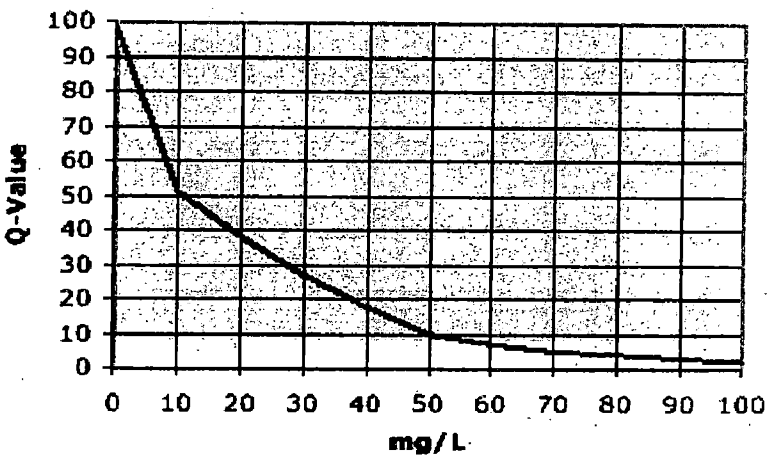
6) Sub-Index: BOD



Note: If biochemical oxygen demand is greater than 30 ppm, the quality index equals 2.
The sub-index value falls down from 100 to 2 as the BOD level increases from 0 to 30 ppm. Beyond 30 ppm its value is equal to 2.

7) Sub-Index: Nitrate

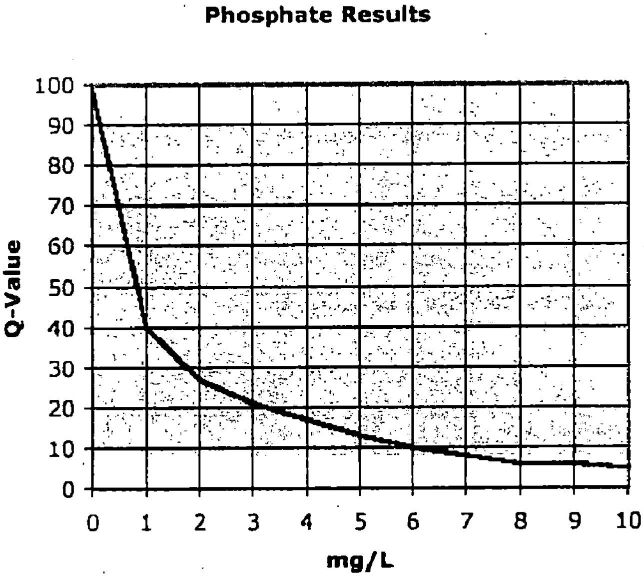
Nitrate Results



(If Nitrates > 100.0, Q=1.0)

Note: If nitrate nitrogen is greater than 100 ppm, the quality index equals 1.
The sub-index value for Nitrates falls down from 100 to a minimum of 1 as the nitrate concentration increases from 0 ppm to 100 ppm.

8) Sub-Index: Total Phosphate

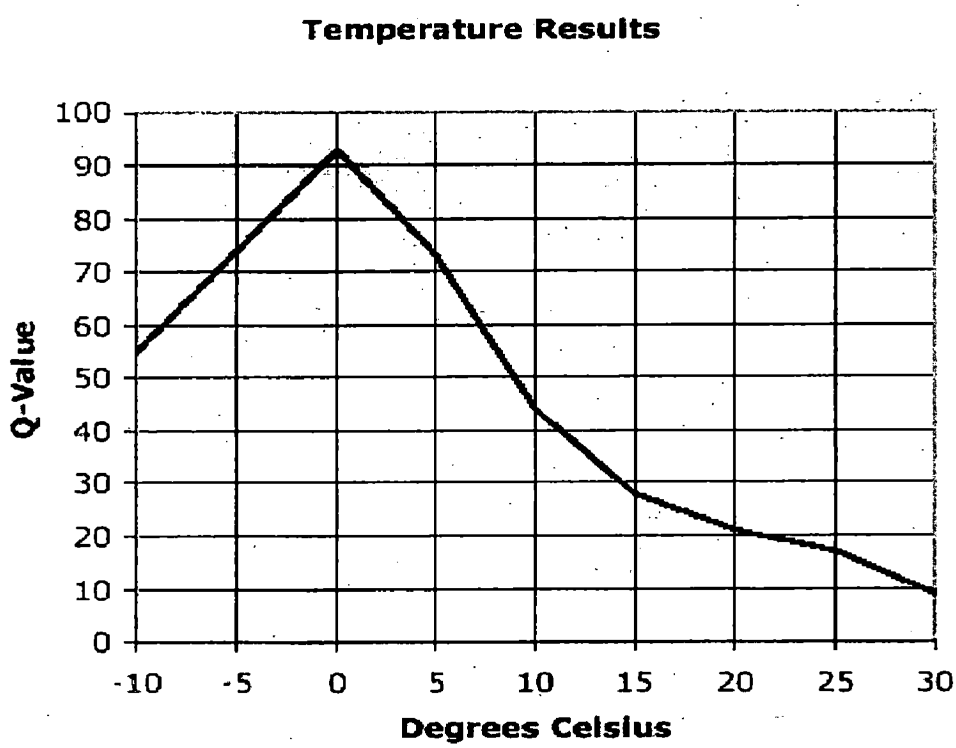


(Note: If phosphate > 10.0, Q=2.0)

Note: If total phosphate is greater than 10 ppm, the quality index equals 2.

The sub-index value for phosphate decreases from 100 to 2 as the phosphate concentration increases from 0 to 10 ppm. Beyond 10ppm its value is equal to 2

9) Sub-Index: Temperature:



The sub-index value is maximum for 0 degree temperature variation and falls down for both increase or decrease of temperature. Its value is minimum beyond

A variation of 30-degree increase or 10-degree decrease.

4.4.2.1 Calculation of Sub-indices

The Sub-indices are calculated for the above parameters for NSF-WQI for the years 2000,2001,2003,2004,2006 using the software and they are given in the Table below.

Table No: 4.11 Sub-Indices for the year-2000

Location				Parameters					
	DO	F-Coli	PH	BOD	Temp.change	Total-P	Nitrates	Turbidity	Total Solids
D/S B.S.DAM	99	49	92	70	93	83	96	94	70
D/S SATHY	83	32	88	5	93	26	29	89	20
P.M.PALAYAM	87	35	91	5	93	27	34	90	20

Table No: 4.12 Sub-Indices for the year-2001

Location				Parameters					
	DO	F-Coli	PH	BOD	Temp.change	Total-P	Nitrates	Turbidity	Total Solids
D/S B.S.DAM	91	37	90	95	93	87	66	96	79
D/S SATHY	89	32	92	97	93	54	96	96	83
P.M.PALAYAM	93	37	80	96	93	45	69	96	67

Table No: 4.13 Sub-Indices for the year-2003

Location				Parameters					
	DO	F-Coli	PH	BOD	Temp.change	Total-P	Nitrates	Turbidity	Total Solids
D/S B.S.DAM	91	29	84	82	93	83	96	95	75
D/S SATHY	98	37	84	78	93	59	96	93	81
P.M.PALAYAM	87	22	77	80	93	35	94	92	53

Table No: 4.14 Sub-Indices for the year-2004

Location				Parameters					
	DO	F-Coli	PH	BOD	Temp.change	Total-P	Nitrates	Turbidity	Total Solids
D/S B.S.DAM	94	39	87	78	93	93	97	95	74
D/S SATHY	99	28	93	80	93	79	97	91	83
P.M.PALAYAM	90	37	80	69	93	56	97	90	56

Table No: 4.15 Sub-Indices for the year-2006

Location				Parameters					
	DO	F-Coli	PH	BOD	Temp.change	Total-P	Nitrates	Turbidity	Total Solids
D/S B.S.DAM	75	72	93	96	93	100	65	93	84
D/S SATHY	81	37	68	76	93	95	65	88	84
P.M.PALAYAM	79	72	93	69	93	100	65	93	84

TABLE NO 4.16 Water Quality Analysis of River Bhavani (NSF-WQI) For the Year 2000

SAMPLING STATION	DO,ppm	DO,%saturation	F-COLI, mpn/100 ml	pH	BOD-5, mg/lit	TEMP-CHANGE deg C	TOTAL-P, mg/lit	NITRATE,mg/lit	TURBIDITY,ntu	T-SOLIDS ,mg/lit	NSF-WQI	COLOUR ON MAP	REMARKS
D/S OF B.S.DAM	7.79	97	64.9	7.6	2.51	0	0.285	1.08	1.69	217.2	**82**	**GREEN**	**GOOD**
D/S OF SATHY	5.58	76.42	360	7.86	95.42	0.1	2.24	27.66	3.69	1034	**53**	**YELLOW**	**MEDIUM**
P.M.Palayam	5.86	79.73	259	7.73	60.41	0.114	1.98	22.56	3.2	742.55	**55**	**YELLOW**	**MEDIUM**

TABLE NO 4.17 Water Quality Analysis of River Bhavani (NSF-WQI) For the Year 2001

SAMPLING STATION	DO,ppm	DO,%saturation	F-COLI, mpn/100 ml	pH	BOD-5, mg/lit	TEMP-CHANG Edeg C	TOTAL-P, mg/lit	NITRATE,mg/lit	TURBIDITY,ntu	T-SOLIDS, mg/lit	NSF-WQI	COLOUR ON MAP	REMARKS
D/S OF B.S.DAM	6.6	85	209	7.8	1	0	0	4.71	1	153.6	**80**	**GREEN**	**GOOD**
D/S OF SATHY	7	83	334	7.2	0.6	0	0	0.84	1	105.7	**79**	**GREEN**	**GOOD**
P.M.Palayam	7.2	88	206	8.1	0.9	0	0	4.22	1	242.9	**74**	**GREEN**	**GOOD**

TABLE NO 4.18 Water Quality Analysis of River Bhavani (NSF-WQI) For the Year 2003

SAMPLING STATION	DO,ppm	DO,%saturation	F-COLI, mpn/100 ml	pH	BOD-5, mg/lit	TEMP-CHANGE deg C	TOTAL-P, mg/lit	NITRATE,mg/lit	TURBIDITY,ntu	T-SOLIDS, mg/lit	NSF-WQI	COLOUR ON MAP	REMARKS
D/S OF B.S.DAM	6.6	85	484	8	1.9	0	0.28	0.97	1.5	177.1	**78**	**GREEN**	**GOOD**
D/S OF SATHY	7.2	95	214	8	2.1	0	0.52	0.99	2	121.8	**78**	**GREEN**	**GOOD**
P.M.Palayam	6.1	80	973	8.2	2	0	1.24	2.12	2.5	351.4	**69**	**YELLOW**	**MEDIUM**

TABLE NO 4.19 Water Quality Analysis of River Bhavani (NSF-WQI) For the Year 2004

SAMPLING STATION	DO,ppm	DO,%saturation	F-COLI, mpn/100 ml	pH	BOD-5, mg/lit	TEMP-CHANGE deg C	TOTAL-P, mg/lit	NITRATE,mg/lit	TURBIDITY,ntu	T-SOLIDS, mg/lit	NSF-WQI	COLOUR ON MAP	REMARKS
D/S OF B.S.DAM	6.7	89	175	7.9	2.1	0	0.18	0.071	1.2	185.5	**81**	**GREEN**	**GOOD**
D/S OF SATHY	7.7	100	514	7.3	2	0	0.32	0.025	2.8	100.8	**80**	**GREEN**	**GOOD**
P.M.Palayam	6.4	84	206	8.1	2.6	0	0.58	0.179	3.1	326.9	**73**	**GREEN**	**GOOD**

TABLE NO 4.20 Water Quality Analysis of River Bhavani (NSF-WQI) For the Year 2006

SAMPLING STATION	DO,ppm	DO,%saturation	F-COLI, mpn/100 ml	pH	BOD-5, mg/lit	TEMP-CHANGE deg C	TOTAL-P, mg/lit	NITRATE,mg/lit	TURBIDITY,ntu	T-SOLIDS, mg/lit	NSF-WQI	COLOUR ON MAP	REMARKS
D/S OF B.S.DAM	5.1	70	10	7.36	0.8	0	0	5	2	98	**84**	**GREEN**	**GOOD**
D/S OF SATHY	5.8	75	200	8.45	2.2	0	0.13	5	4	97	**74**	**GREEN**	**GOOD**
P.M.Palayam	5.6	73	10	7.4	2.6	0	0	5	2	95	**82**	**GREEN**	**GOOD**

The above water quality indices are calculated for the yearly average Data, for the three sampling Locations.

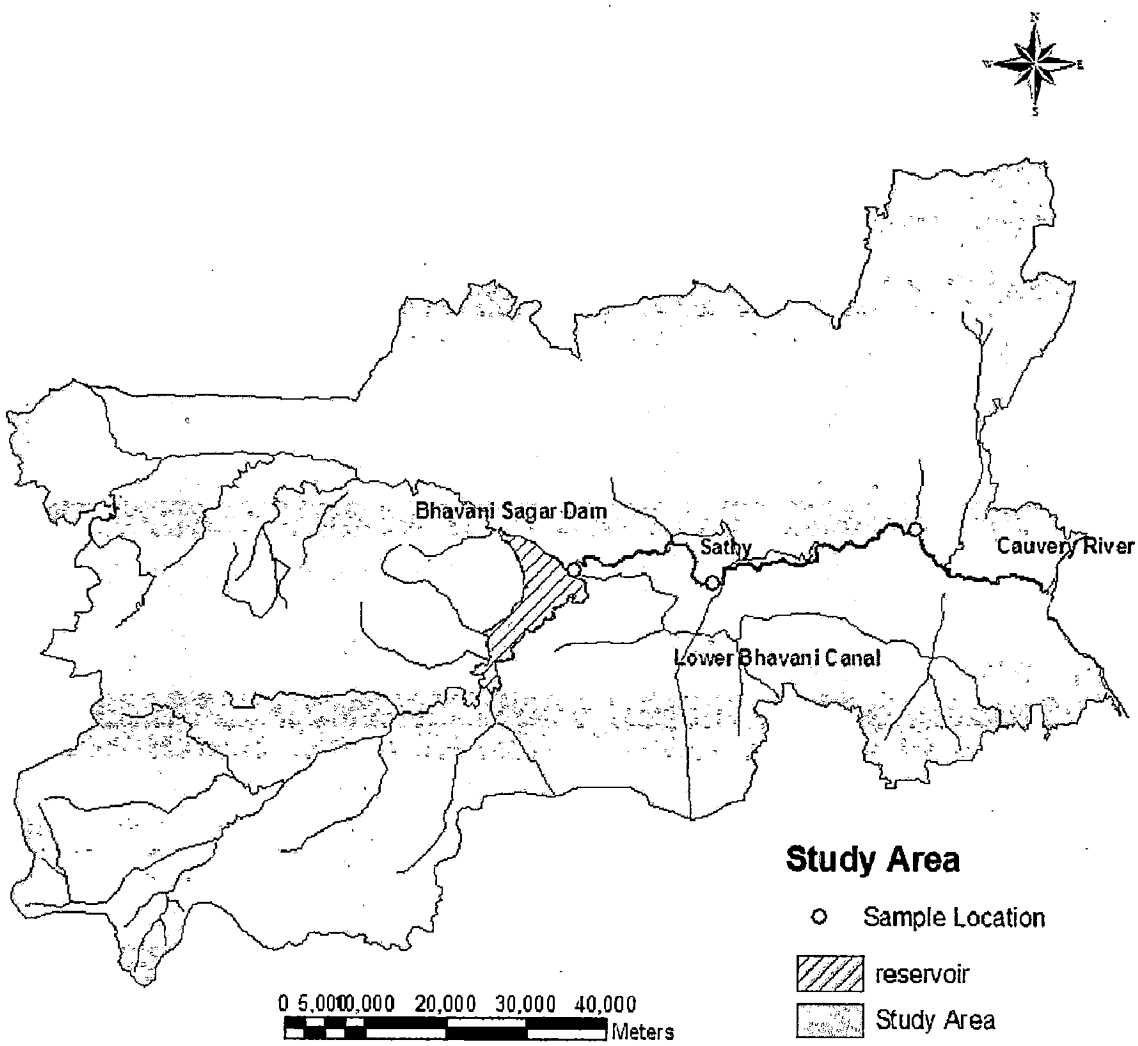


Fig.No.4.1 Study Area and Sampling Points of river Bhavani

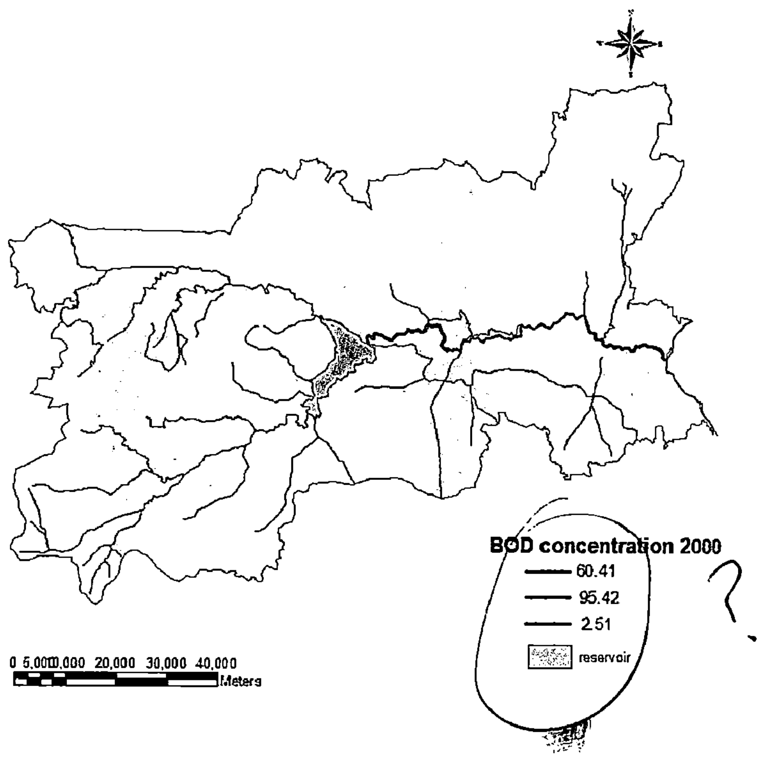


Figure.No.4.2 BOD concentration for year 2000

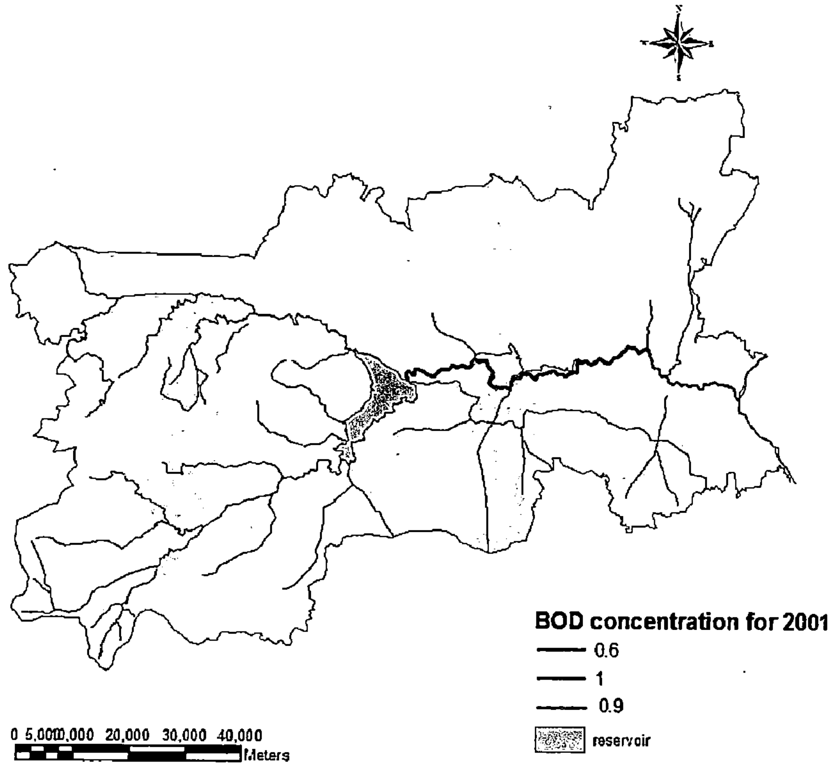


Fig. No.4.3 BOD concentration for year 2001

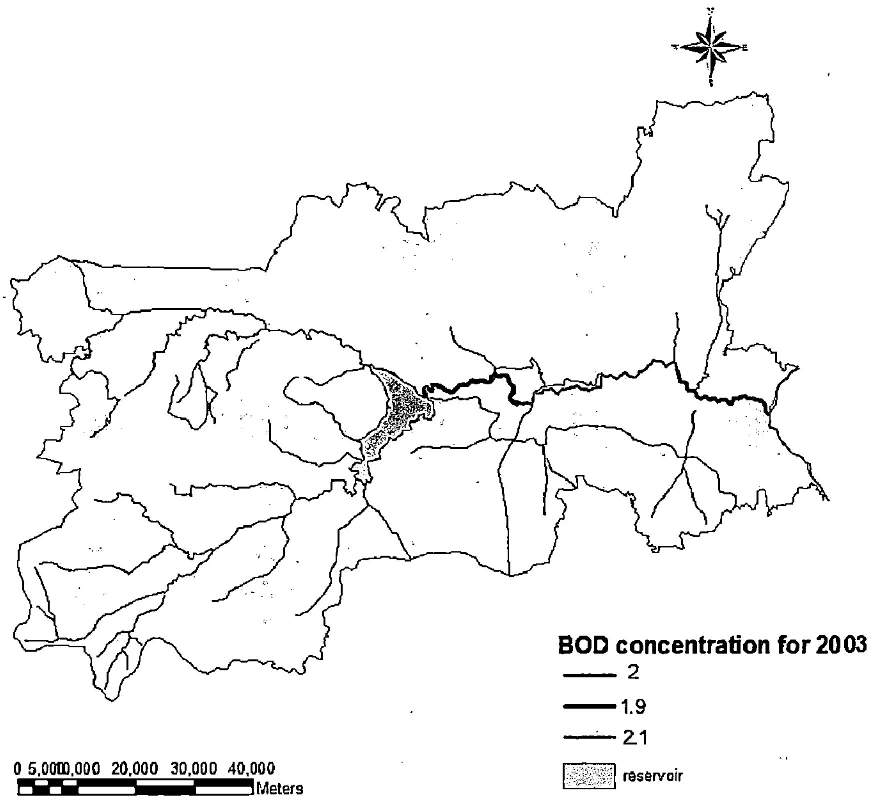


Figure.No.4.4 BOD concentration for year 2003

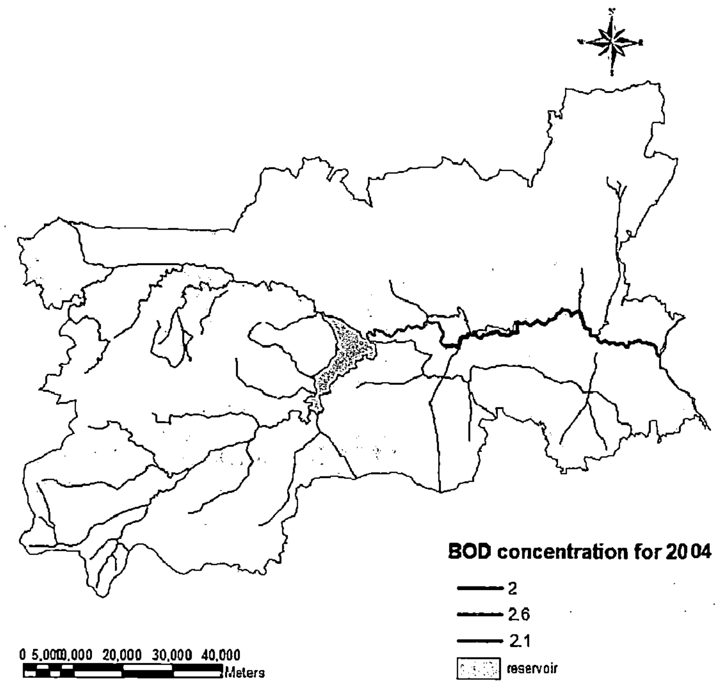


Fig. No.4.5 BOD concentration for year 2004

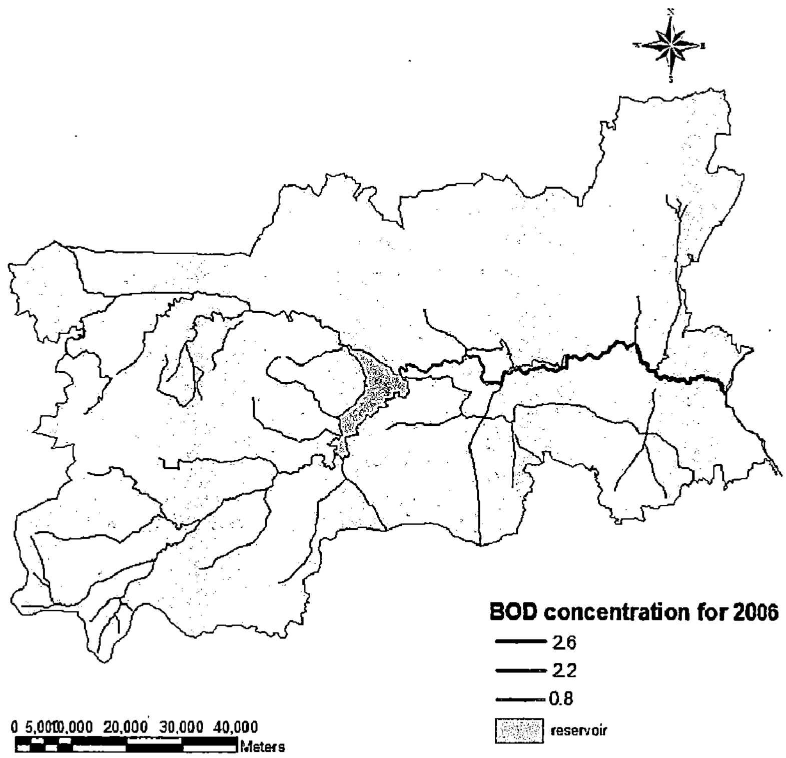


Fig. No.4.6 BOD concentration for year 2006

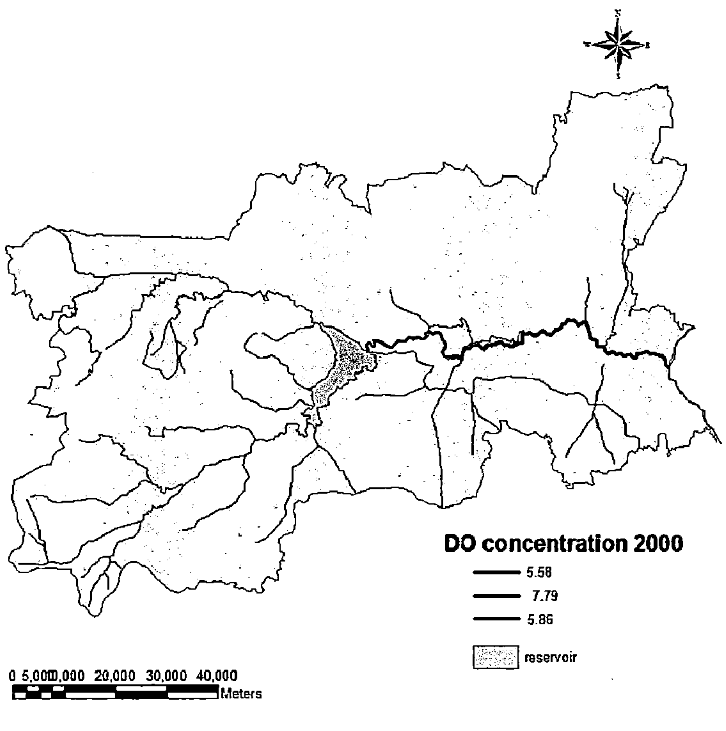


Fig. No.4.7 DO concentration for year 2000

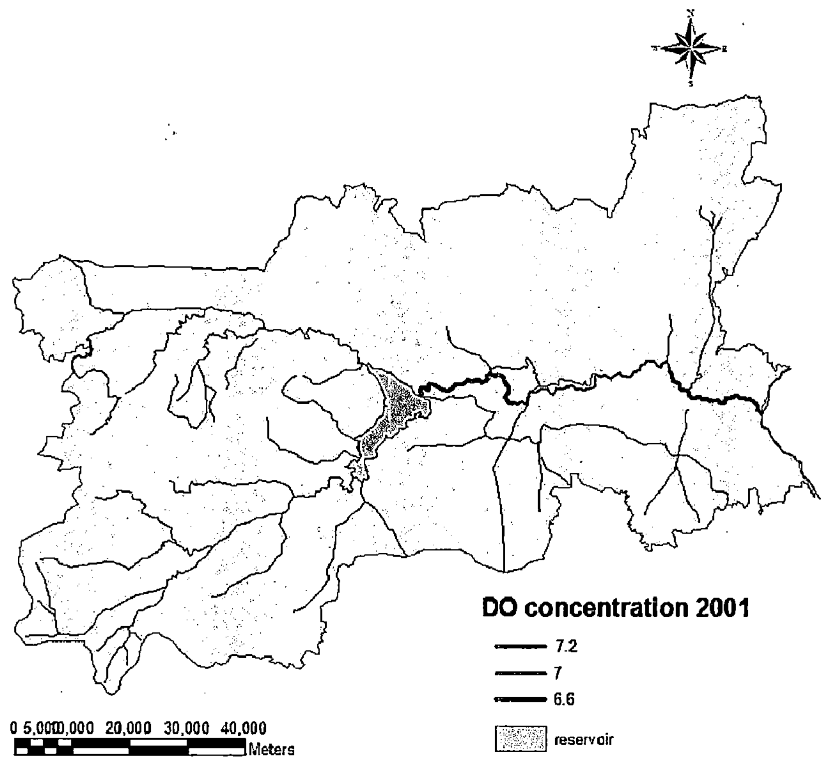


Fig. No.4.8 DO concentration for year 2001

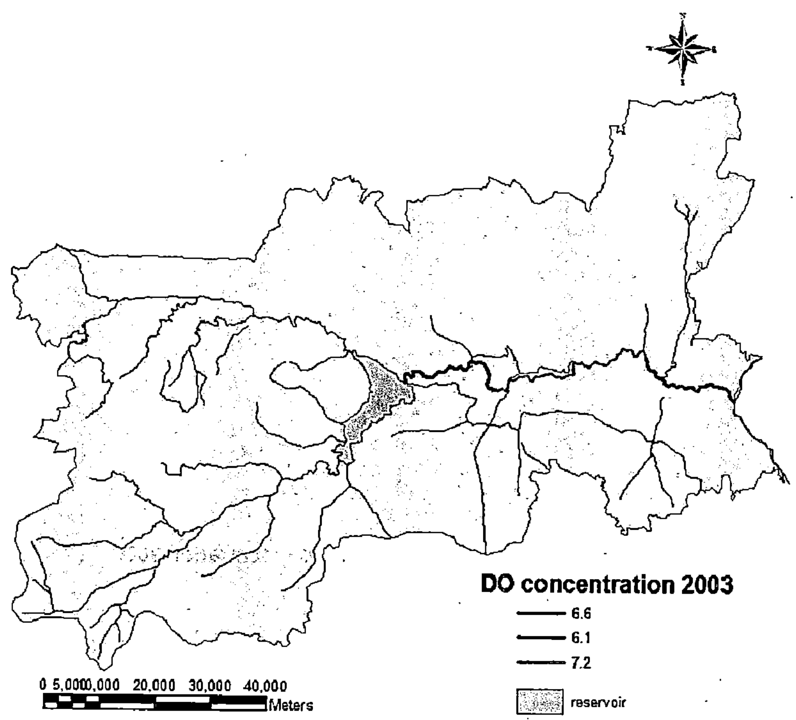


Fig. No.4.9 DO concentration for year 2003

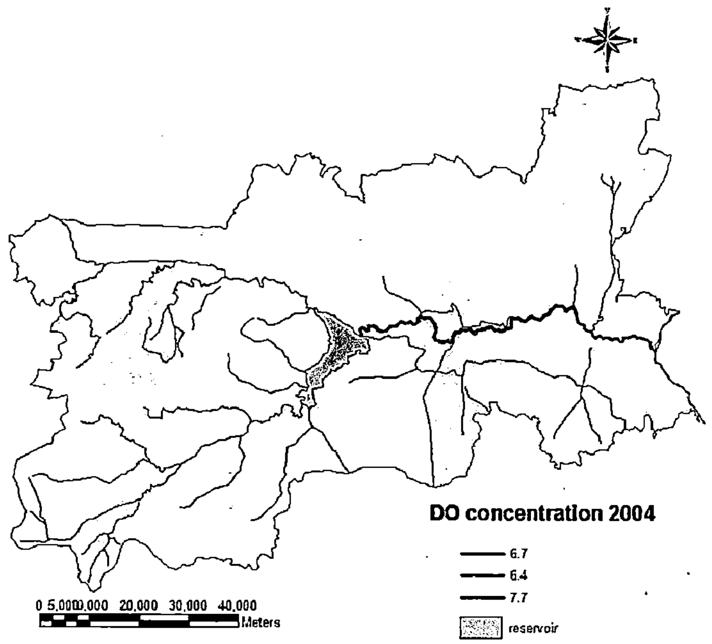


Fig. No.4.10 DO concentration for year 2004

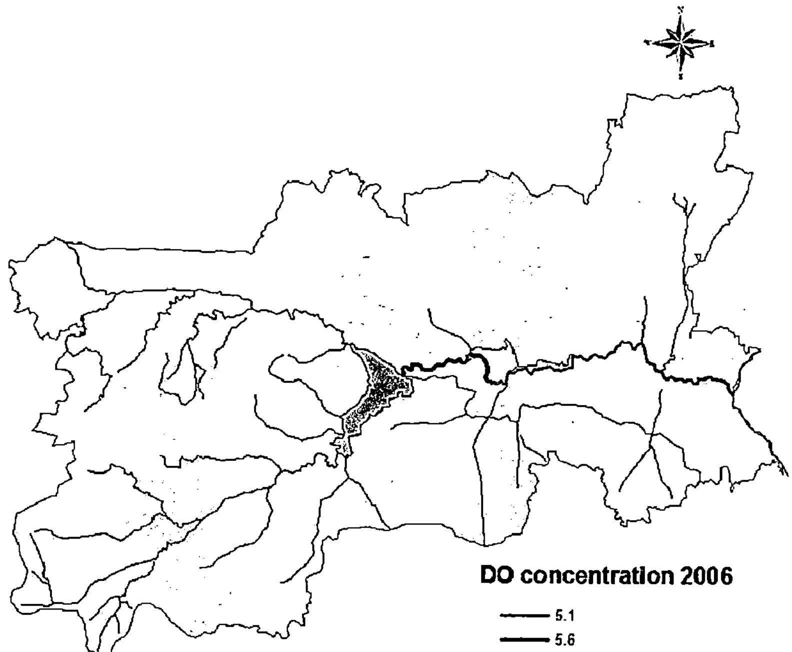


Fig. No.4.11 DO concentration for year 2006

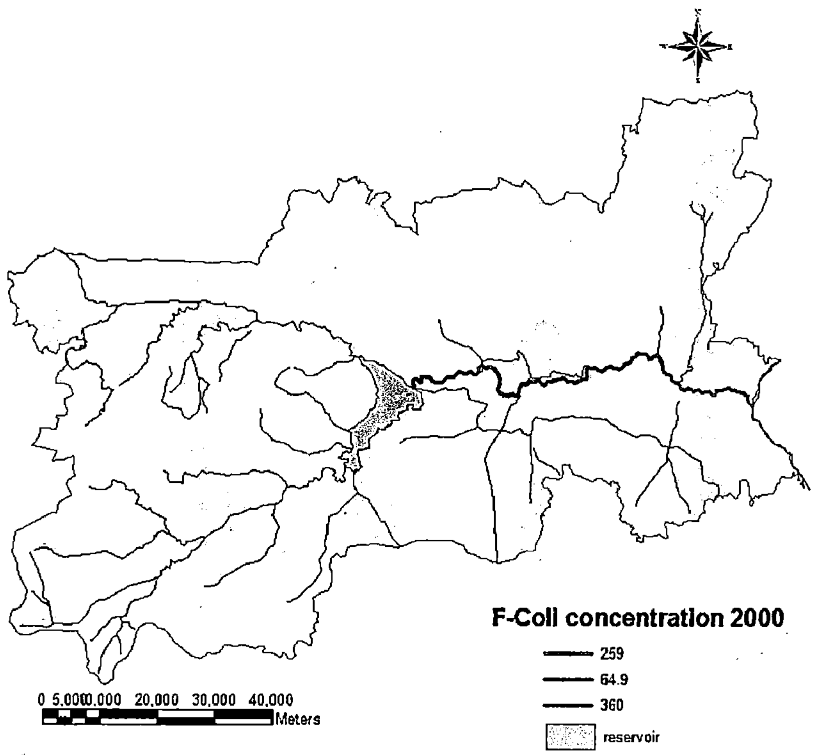


Figure.No.4.12 F-Coli concentration for year 2000

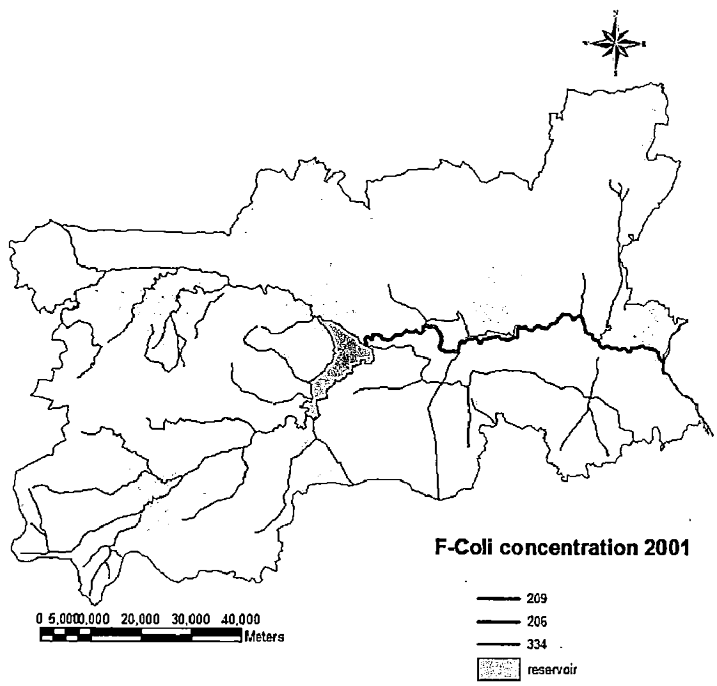


Figure.No.4.13 F-Coli concentration for year 2001

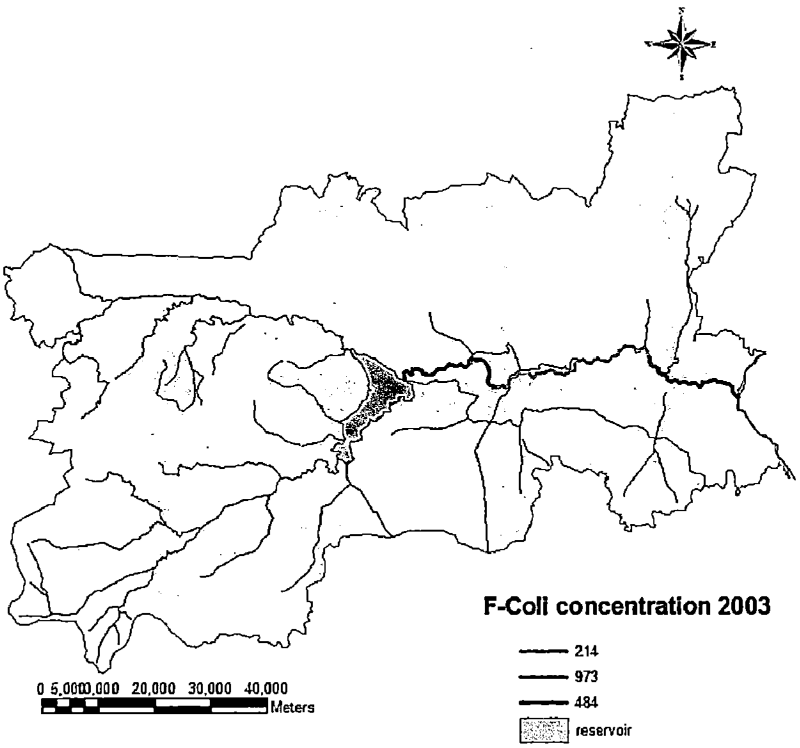


Figure.No.4.14 F-Coli concentration for year 2003

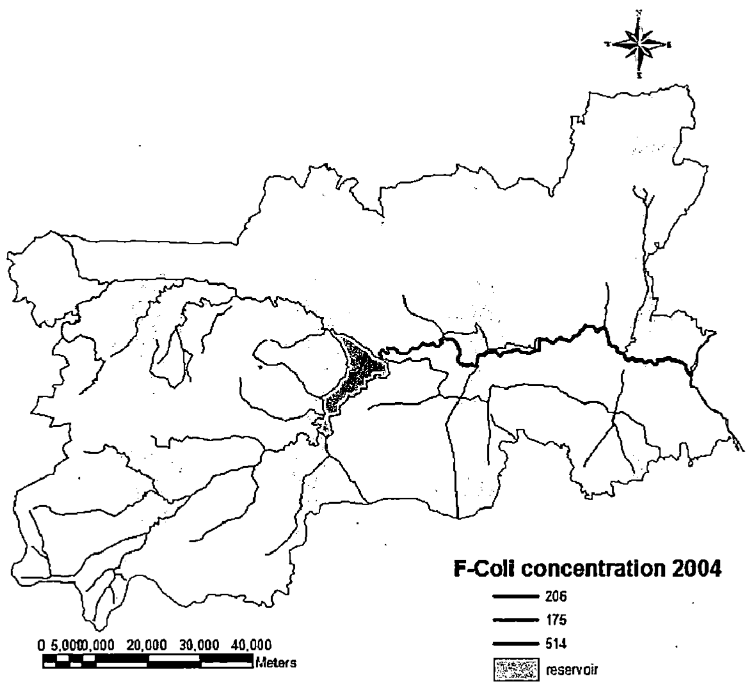


Figure.No.4.15 F-Coli concentration for year 2004

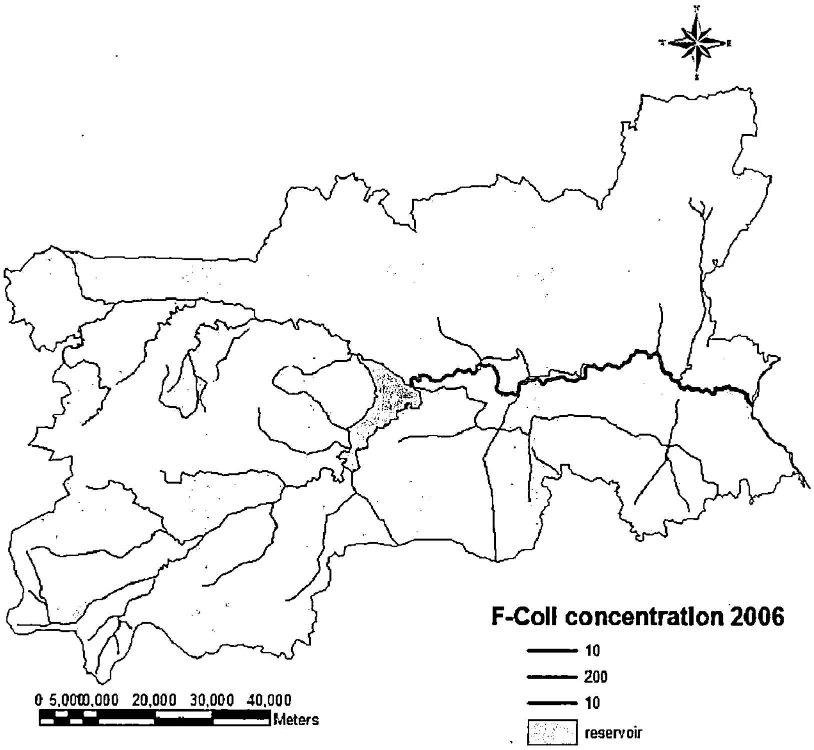


Figure.No.4.16 F-Coli concentration for year 2006

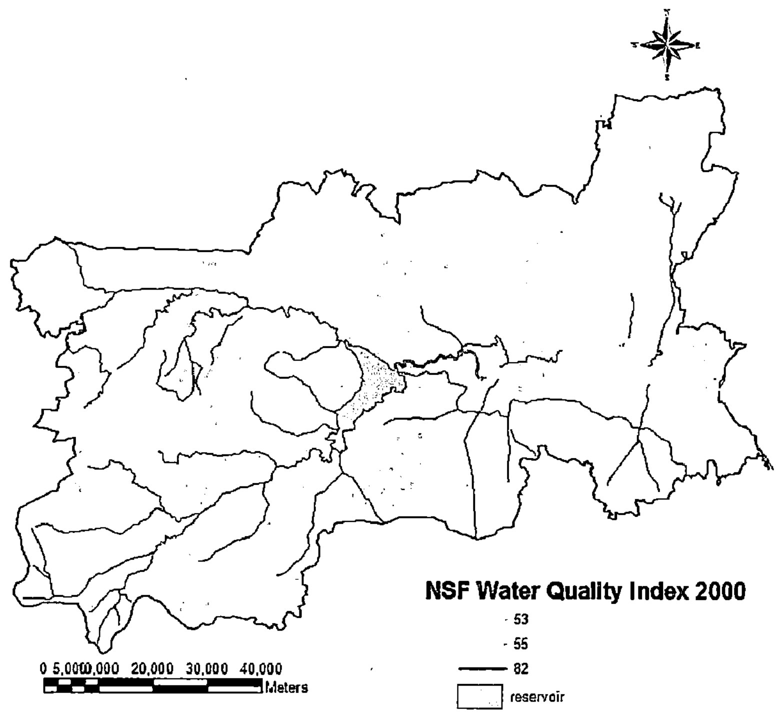


Figure.No.4.17 NSF water quality index for year 2000

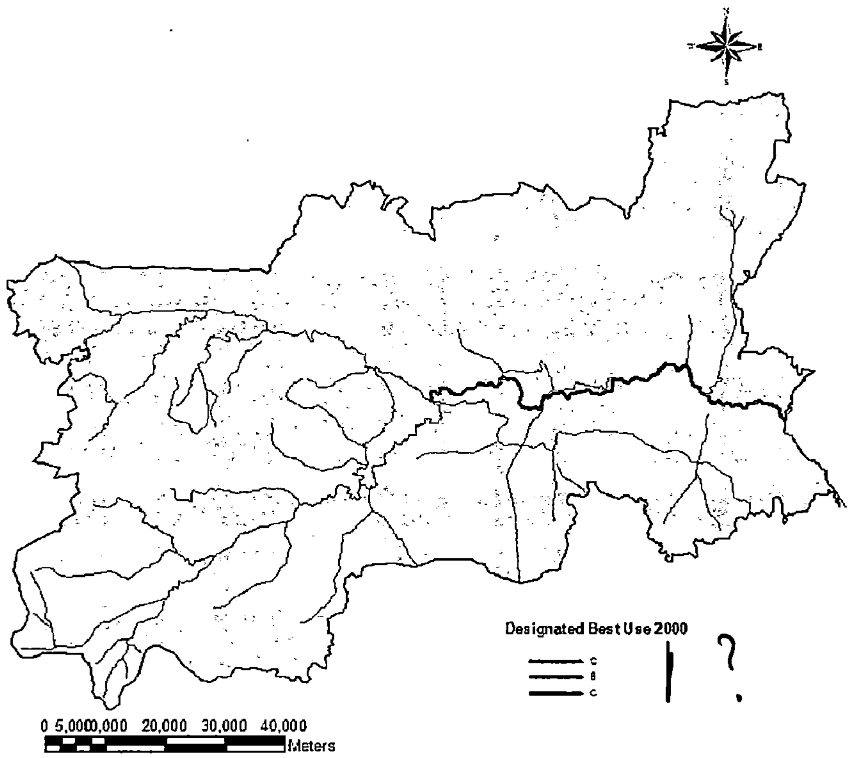


Figure.No.4.18 Designated best use for year 2000

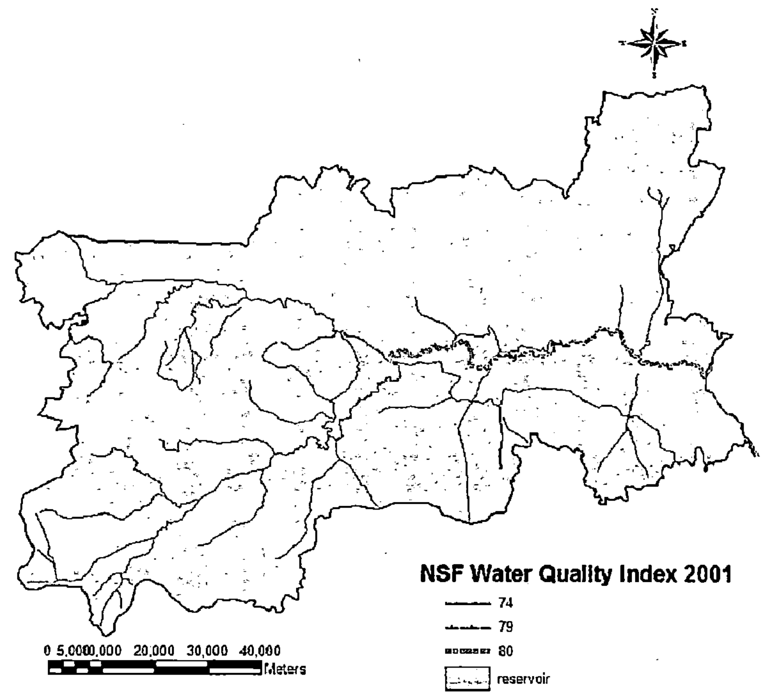


Figure.No.4.19 NSF water quality index for year 2001

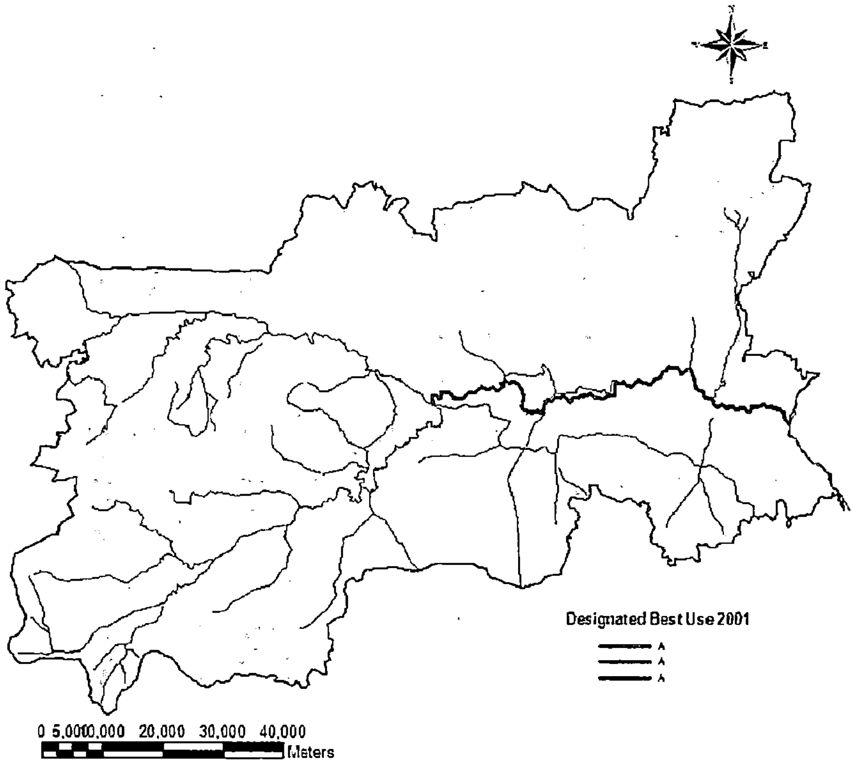


Figure.No.4.20 Designated best use for year 2001

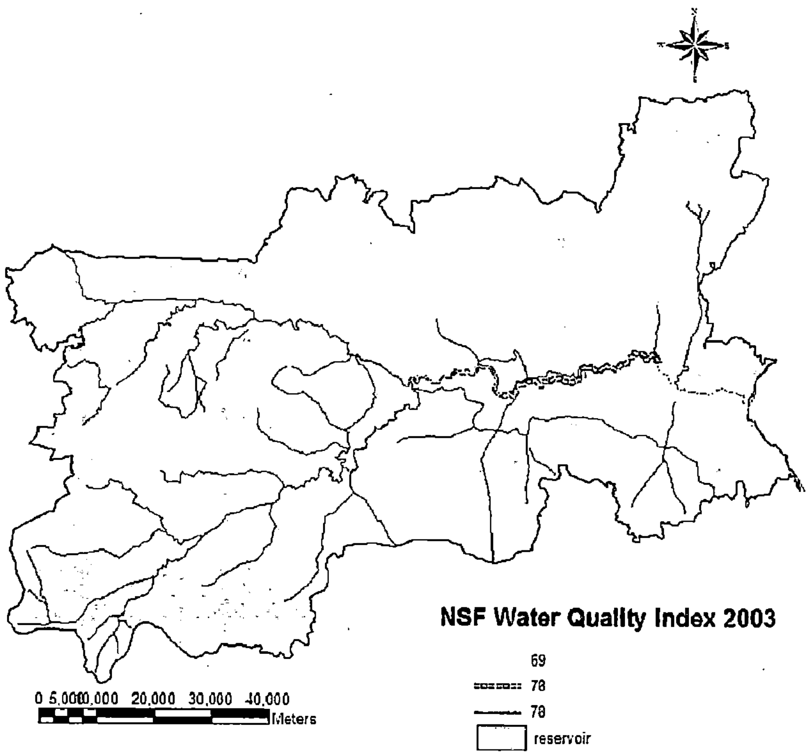


Figure.No.4.21 NSF water quality index for year 2003

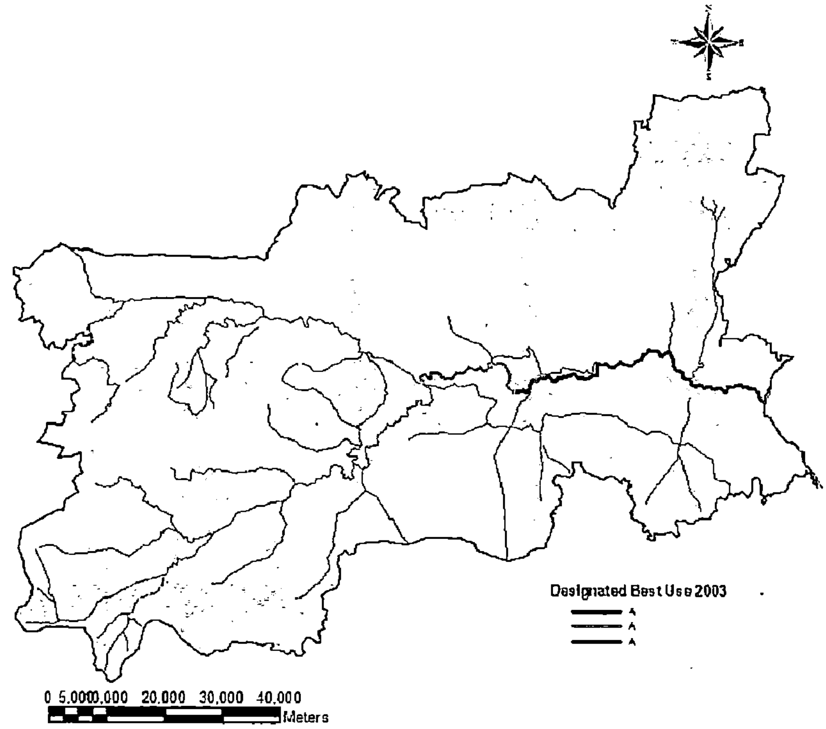


Figure.No.4.22 Designated best use for year 2003

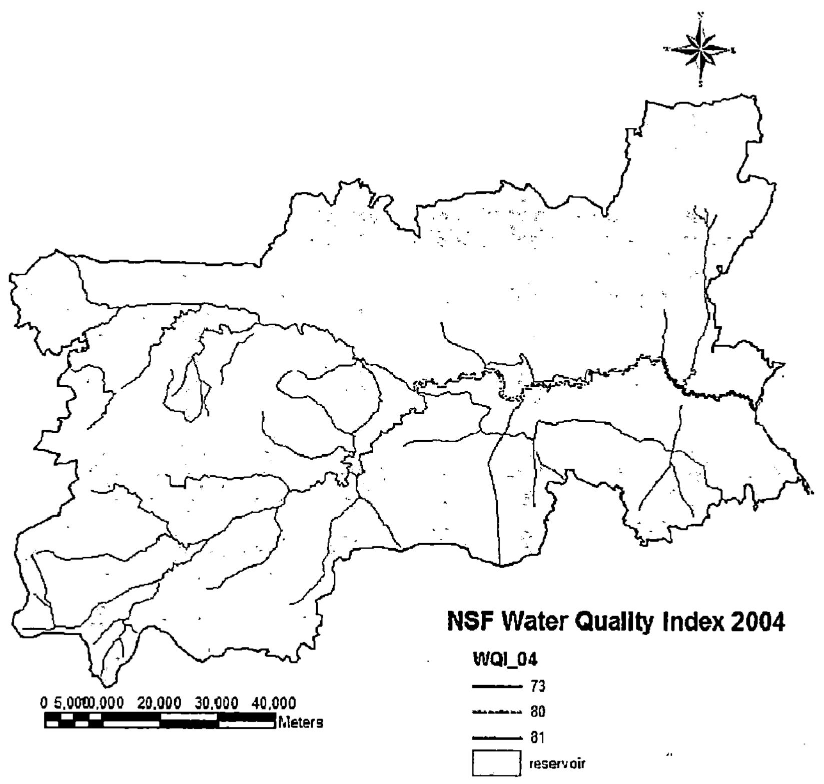


Figure.No.4.23 NSF water quality index for year 2004

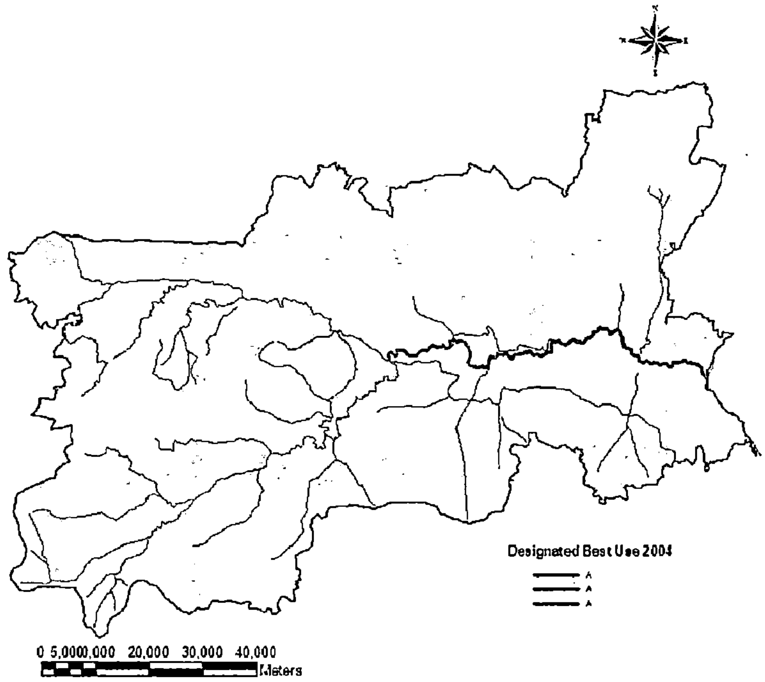


Figure.No.4.24 Designated best use for year 2004

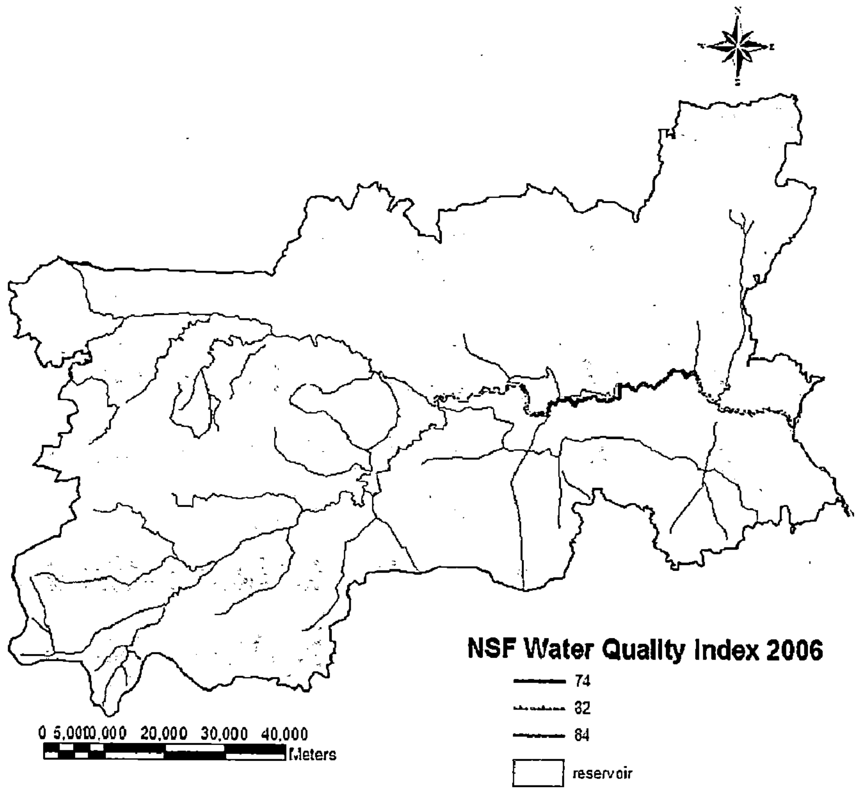


Figure.No.4.25 NSF water quality index for year 2006

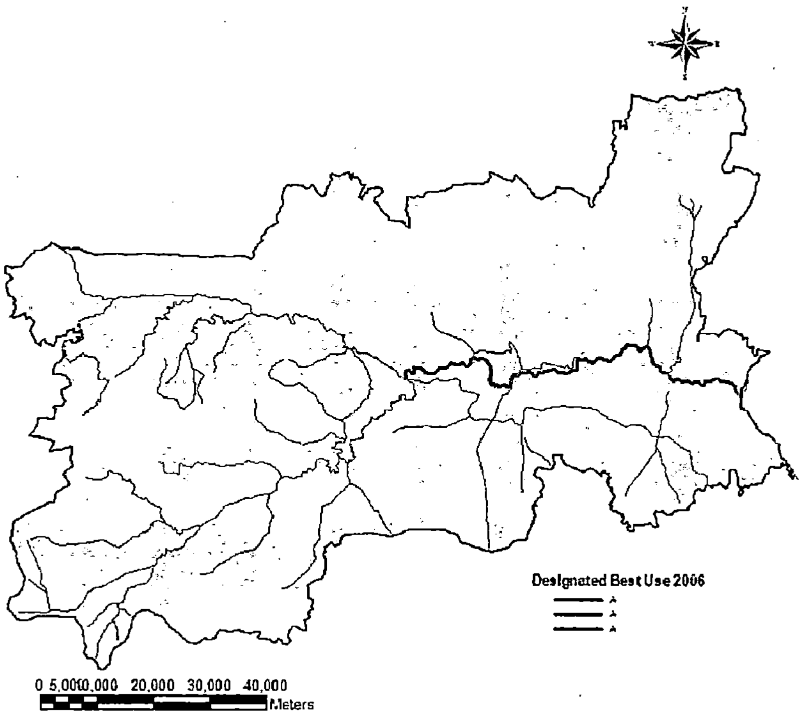


Figure.No.4.26 Designated best use for year 2006

4.4.3 Mc Duffie's River Pollution Index

This index is calculated for various parameters, which are tabulated below for the year 2000,2001,2003,2004 and 2006,vide Table.no.4.21 to 4.25

TABLE NO 4.21 Water Quality Analysis of River Bhavani (McDuffie'sWQI) For the Year 2000

SAMPLING STATION	DO %saturation	SI	BOD-5 mg/l	SI	COD mg/l	SI	TotalC olimg/l	SI	NSS	SI	TOT-Nmg/l	T.PO4 mg/l	SI	Spcond umho/cm.	SI	TEMP deg C	SI	Range 100-1000 Mcduffie's RPI -2000	Water Quality
D/S B.S DAM	97	3	2.51	25	24	107.5	550	57.4			1.08	0.285	41.25	112	28	30	85	434.0442	Average
D/S SATHY	76.42	23.6	95.42	954	156	302.9	873	61.6			27.66	2.24	803.5	642	161	29	75	2976.859	Verypoor
P.M.Palayam	79.73	20.3	60.41	604	112	258	1161	64.2			22.56	1.98	663	426	107	31.3	98	2267.922	Verypoor

TABLE NO 4.22 Water Quality Analysis of River Bhavani (McDuffie'sWQI) For the Year 2001

SAMPLING STATION	DO %saturation	SI	BOD-5 mg/l	SI	COD mg/l	SI	TotalC olimg/l	SI	NSS	SI	TOT-Nmg/l	T.PO4 mg/l	SI	Spcond umho/cm.	SI	TEMP deg C	SI	Range 100-1000 Mcduffie's RPI -2000	Water Quality
D/S B.S DAM	85	15	1	10	26	125	873	61.6			4.71	0	117.8	124	31	30	85	556.7385	Average
D/S SATHY	83	17	0.6	6	18	87	1240	64.8			0.84	0	21	84	21	30.2	87	379.8022	Average
P.M.Palayan	88	12	0.9	9	22	105.5	2042	69.4			4.22	0	105.5	192	48	31.5	100	562.1882	Average

TABLE NO 4.23 Water Quality Analysis of River Bhavani (McDuffie's WQI) For the Year 2003

AMPLING TATION	DO %saturation	SI	BOD-5 mg/l	SI	COD mg/l	SI	TotalColimg/l	SI	NSS	SI	TOT-Nmg/l	T.PO4 mg/l	SI	Spcond umho/cm.	SI	TEMP deg C	SI	Range:100-1000	
																		Mcduffie's RPI -2000	Water Quality
/S B.S AM	85	15	1.9	19	56	270.5	896	61.9			0.97	0.28	38	96	24	30.2	87	644.5427	Average
/S SATHY	95	5	2.1	21	72	349.5	796	60.8			0.99	0.52	51	74	18.5	29.5	80	731.99	Poor
.M.Palaya	80	20	2	20	62	300	1478	66.4			2.12	1.24	115	186	46.5	31.4	99	834.075	Poor

TABLE NO 4.24 Water Quality Analysis of River Bhavani (McDuffie's WQI) For the Year 2004

AMPLING TATION	DO %saturation	SI	BOD-5 mg/l	SI	COD mg/l	SI	TotalColimg/l	SI	NSS	SI	TOT-Nmg/l	T.PO4 mg/l	SI	Spcond umho/cm.	SI	TEMPdeg C	SI	Range 100-1000	
																		Mcduffie's RPI -2000	Water Quality
/S B.S AM	89	11	2.1	21	46	219.5	706	59.7			0.071	0.18	10.8	105	26.3	29.8	83	539.0498	Average
/S SATHY	100	0	2	20	82	400	873	61.6			0.025	0.32	16.6	62	15.5	29.4	79	741.0323	Poor
.M.Palaya	84	16	2.6	26	102	497	1673	67.6			0.179	0.58	33.5	185	46.3	30.5	90	970.41	Poor

TABLE NO 4.25 Water Quality Analysis of River Bhavani (McDuffie'sWQI) For the Year 2006

SAMPLING STATION	DO %saturation	SI	BOD-5 mg/l	SI	COD mg/l	SI	TotalColimg/l	SI	NSS	SI	TOT-Nmg/l	T.PO4 mg/l	SI	Spcond umho/cm.	SI	TEMP deg C	SI	Mcduffie's RPI - 2000	Water Quality
D/S B.S DAM	70	30	0.8	8	32	156	1323	65.4			5	0	125	68	17	30.1	86	609.2832	Poor
D/S SATHY	75	25	2.2	22	85	414	935	62.3			5	0.13	131.5	65	16.3	29.4	79	937.5942	poor
P.M.Palayam	73	27	2.6	26	96	467	1523	66.7			5	0	125	58	14.5	30.8	93	1024.141	V.Poor

CHAPTER- 5

RESULTS AND DISCUSSIONS

5.1 GENERAL

The Results of the water quality indices calculated in chapter-4 are given in the following Tables 5.1 to 5.5. The water quality is generally improving from the year 2000 onwards. Horton's and NSF water quality indices give almost similar results while McDuffie's index gives a different result from the other two indices.

5.2 COMPARISON OF WATER QUALITY INDICES USED

The water quality indices calculated by the three methods in chapter-4 are compared and their merits and demerits are discussed below. The data collected from TNPCB and lab reports for this year are given in the annexure.

Table 5.1-Year 2000

Sl. No.	Range / Location	Water Quality Index					
		Horton's WQI 0-100	Quality	NSF-WQI 0-100	Quality	Mcduffie's WQI (100-1000)	Quality
1	D/S of BhavaniSagar Dam	78	Good	82	Good	434	Average
2	D/S of Sathy	77	Good	53	Medium	2976	Very poor
3	P.M.Palayam	76	Good	55	Medium	2267	Very poor

Table 5.2 -Year 2001

Sl. No.	Range / Location	Water Quality Index					
		Horton's WQI 0-100	Quality	NSF-WQI 0-100	Quality	Mcduffie's WQI (100-1000)	Quality
1	D/Sof BhavaniSagar Dam	77	Good	80	Good	557	Average
2	D/S of Sathy	74	Good	79	Good	380	Good
3	P.M.Palayam	77	Good	74	Good	562	Average

Table.5.3-Year 2003

Sl. No.	Range / Location	Water Quality Index					
		Horton's WQI 0-100	Quality	NSF-WQI 0-100	Quality	Mcduffie's WQI (100-1000)	Quality
1	D/S of BhavaniSagar Dam	78	Good	78	Good	645	Average
2	D/S of Sathy	77	Good	78	Good	731	Average
3	P.M.Palayam	70	Medium	69	Medium	834	Poor

Table 5.4-Year 2004

Sl. No.	Range / Location	Water Quality Index					
		Horton's WQI 0-100	Quality	NSF-WQI 0-100	Quality	Mcduffie's WQI (100-1000)	Quality
1	D/Sof BhavaniSagar Dam	77	Good	81	Good	539	Average
2	D/S of Sathy	76	Good	80	Good	741	Average
3	P.M.Palayam	68	Medium	73	Good	970	Poor

Table 5.5-Year 2006

Sl. No.	Range / Location	Water Quality Index					
		Horton's WQI 0-100	Quality	NSF-WQI 0-100	Quality	Mcduffie's WQI (100-1000)	Quality
1	D/Sof BhavaniSagar Dam	78	Good	84	Good	609	Average
2	D/S of Sathy	73	Good	74	Good	938	Poor
3	P.M.Palayam	77	Good	82	Good	1024	Very Poor

5.3 DISCUSSIONS

The three water quality indices are analyzed below and their variations are discussed in this topic.

5.3.1 Analysis of Horton's Water Quality Index

In Horton's water quality index, the sub index ranges are wide and hence for small variations in parameter the water quality index does not change. It gives only a general idea of the water quality. It is easy to calculate and does not include pesticides, heavy metals and toxicants. It is not suitable for accurate analysis.

This index has been analysed for the years 2000,2001,2003,2004,2006 for the parameters, DO, Total Coliform and both DO& Total coli form and shown in the graphs below. The removal of DO shows much reduction in the index and total coliform shows increase in the index value. The removal of both the parameters further reduces the index value.

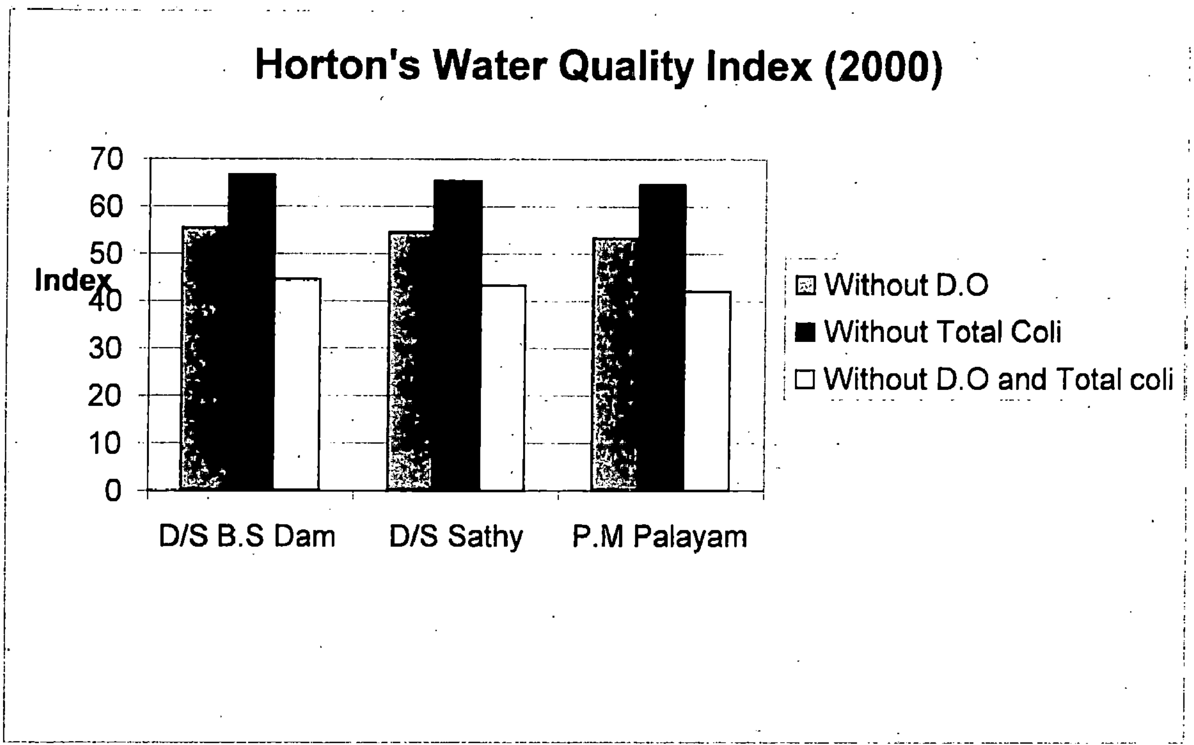


Fig 5.1 Analysis of Horton's Water Quality Index 2000

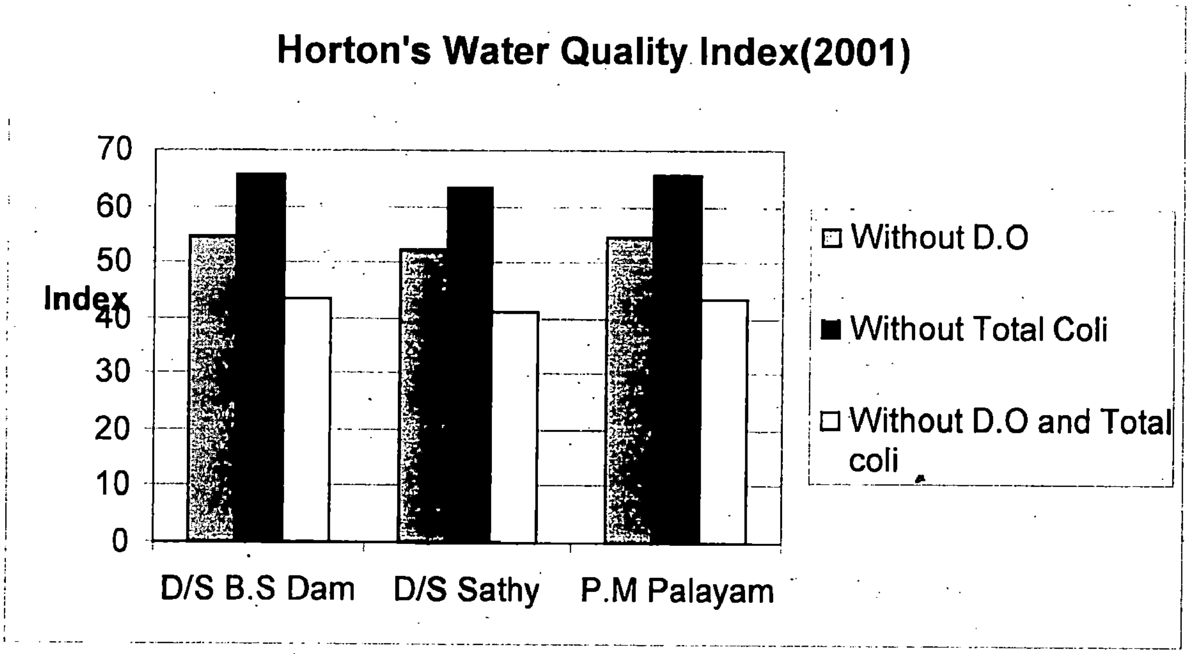


Fig 5.2 Analysis of Horton's Water Quality Index 2001

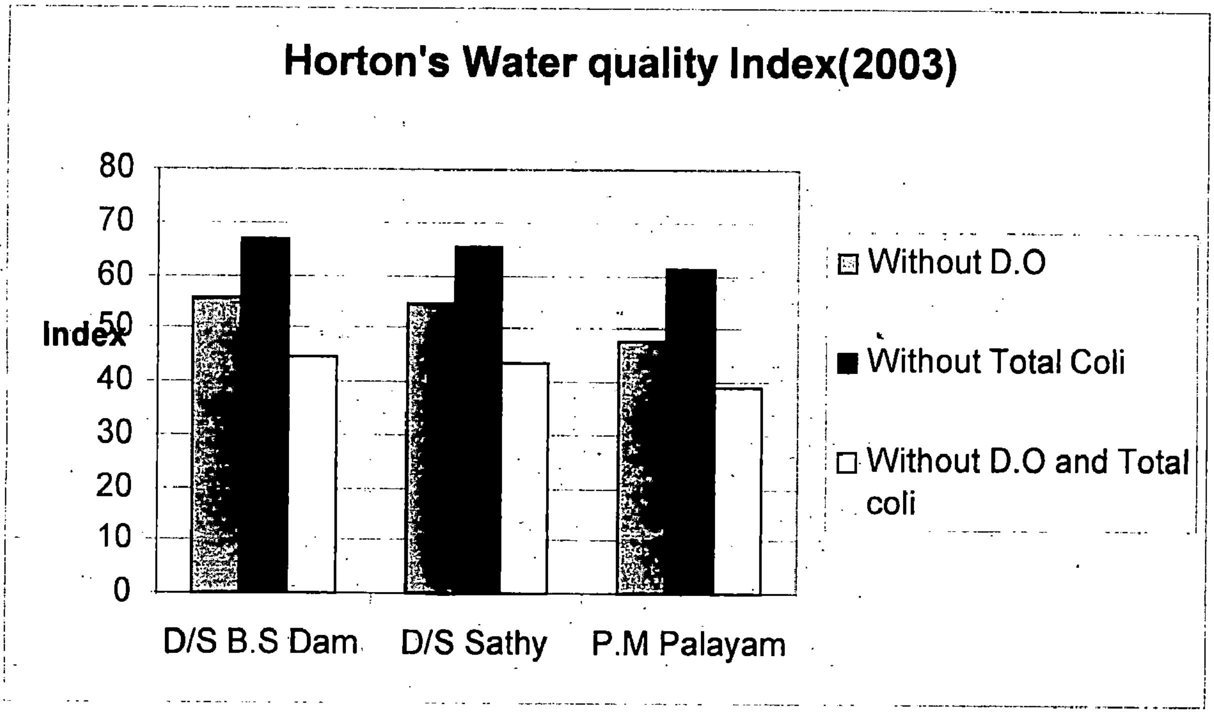


Fig 5.3 Analysis of Horton's Water Quality Index 2003

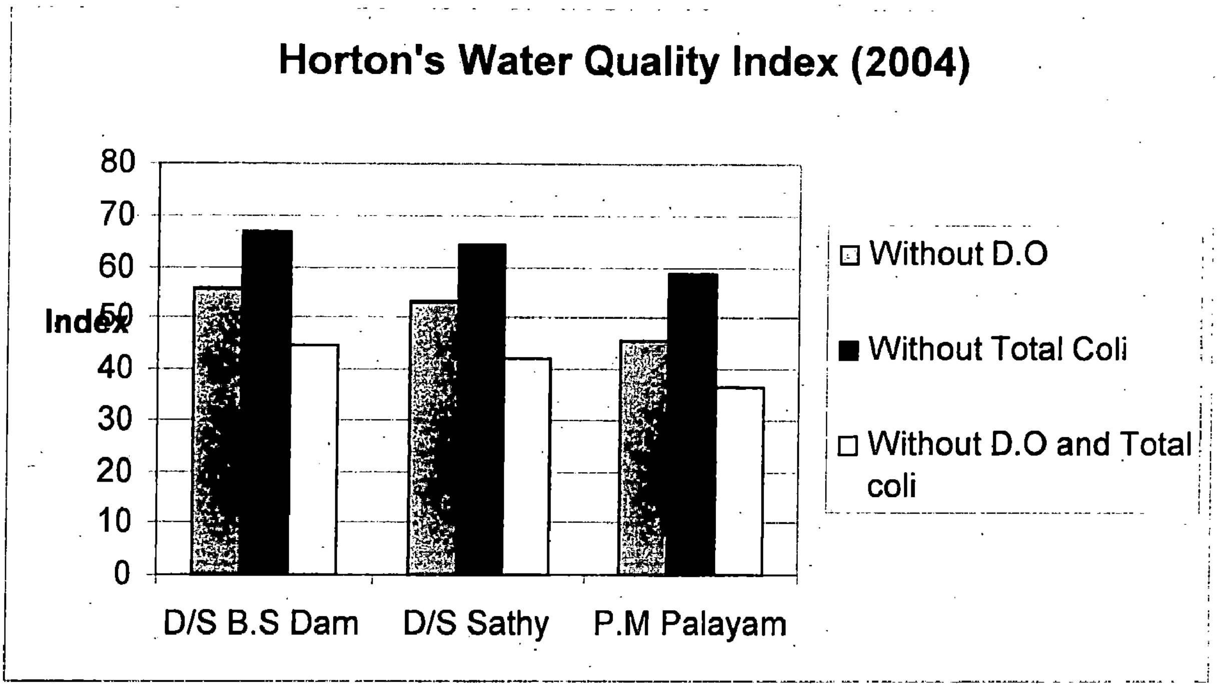


Fig 5.4 Analysis of Horton's Water Quality Index 2004

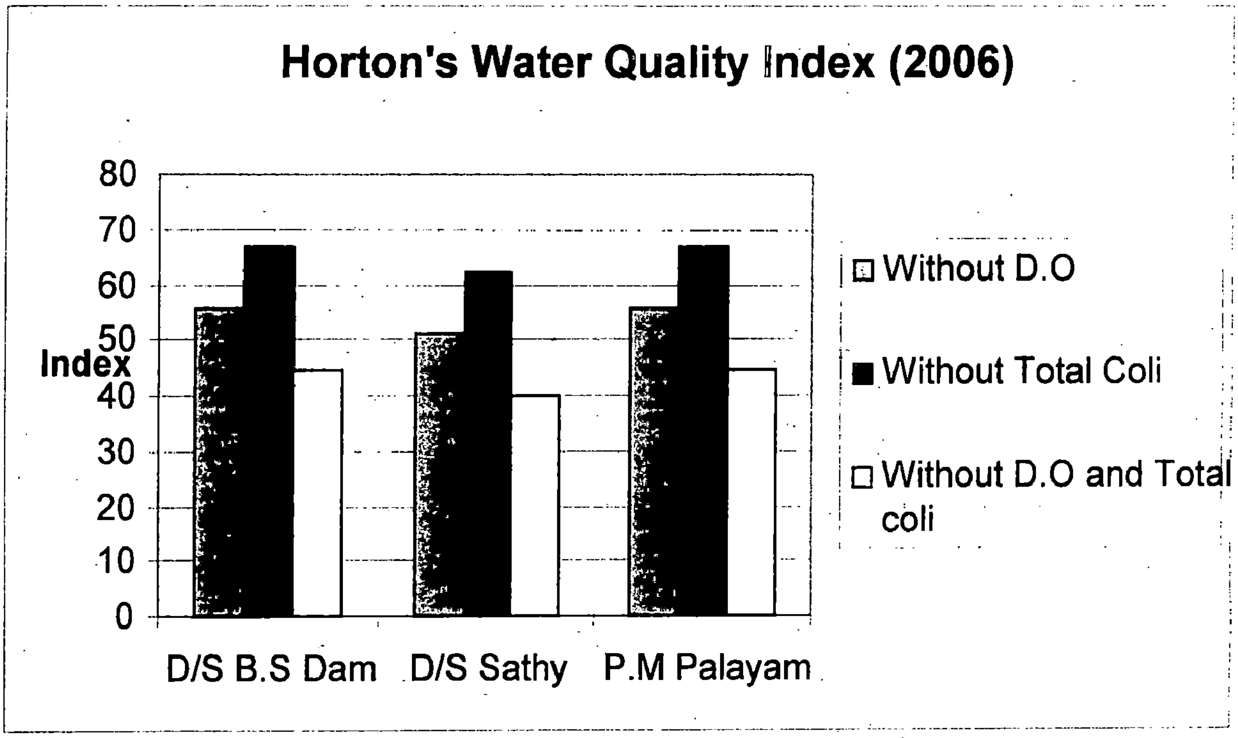


Fig 5.5 Analysis of Horton's Water Quality Index 2006

5.3.2 Analysis of NSF Water Quality Index

In NSF water quality index is suitable for all surface waters. It gives accurate results than the other methods. The weightages are properly assigned for the parameters.

This index has been analysed for the years 2000,2001,2003,2004,2006 for the parameters, DO, Fecal Coliform, BOD and all the three parameters and shown in the graphs below. The removal of individual parameter or all the three parameters do not show much variation in the index value. It is increasing without F-coli and BOD and reduces without all three parameters.

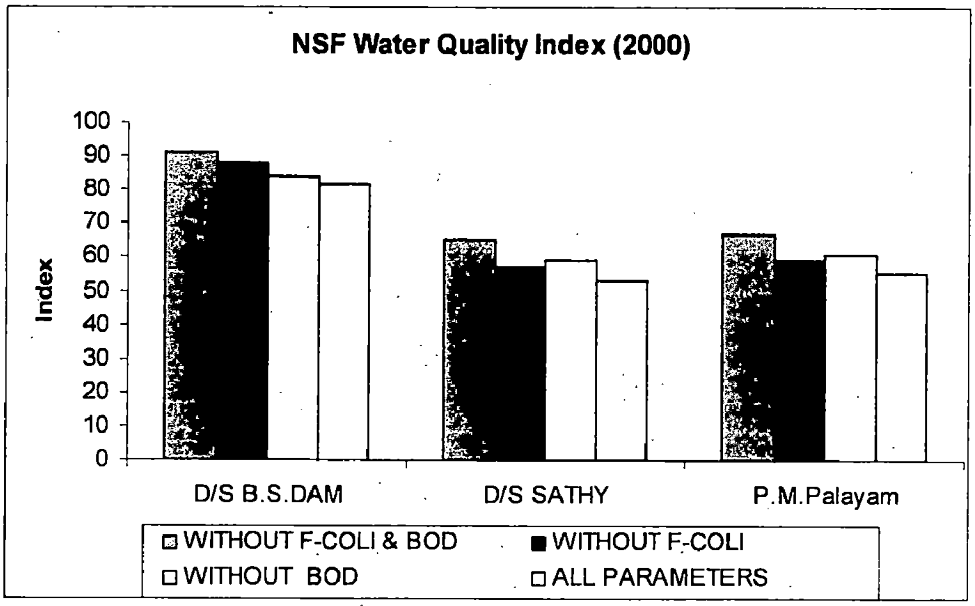


Fig 5.6 Analysis for the Year 2000

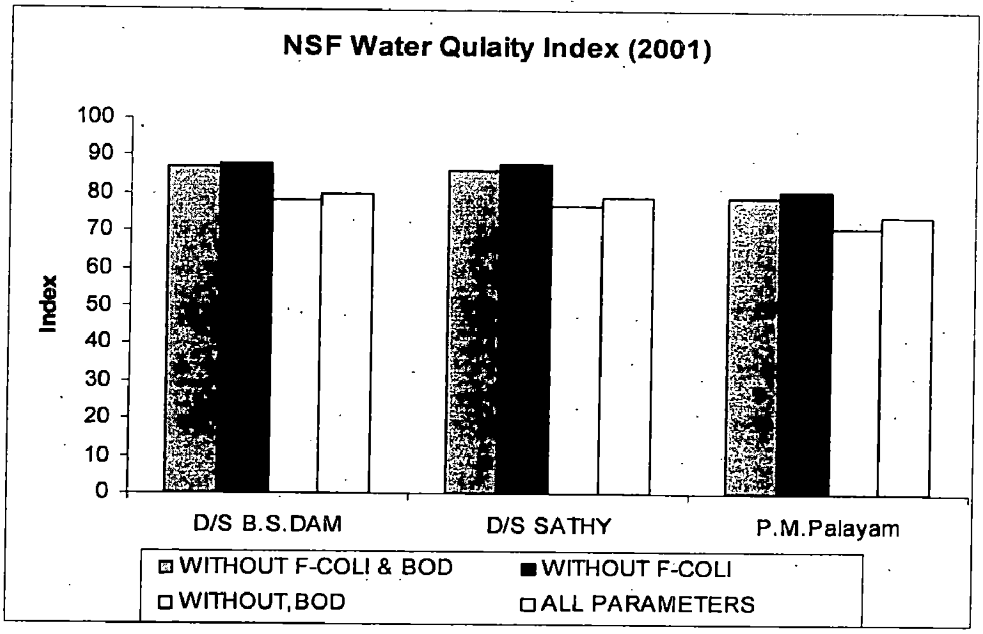


Fig 5.7 Analysis for the Year 2001

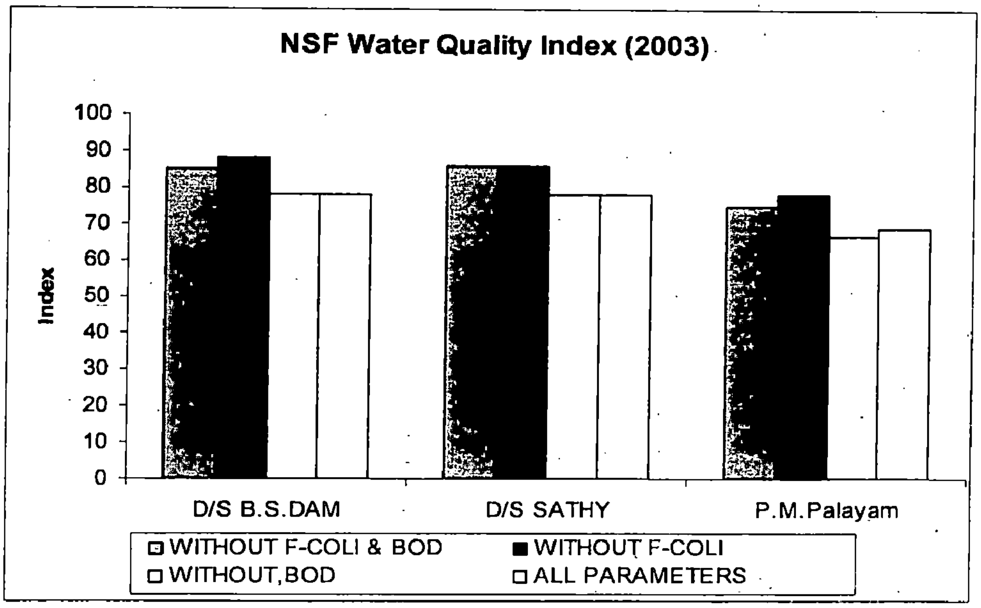


Fig 5.8 Analysis for the Year 2003

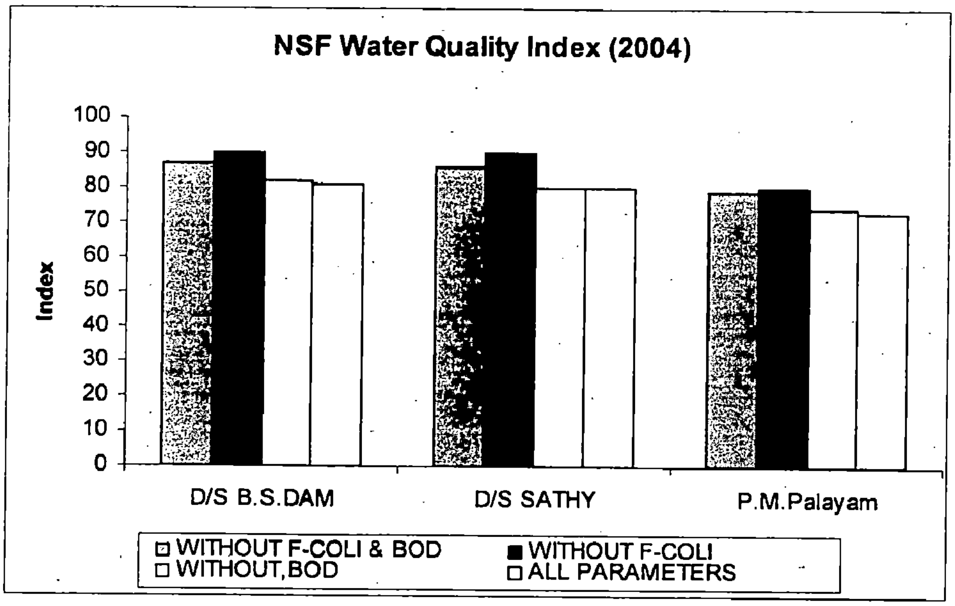


Fig 5.9 Analysis for the Year 2004

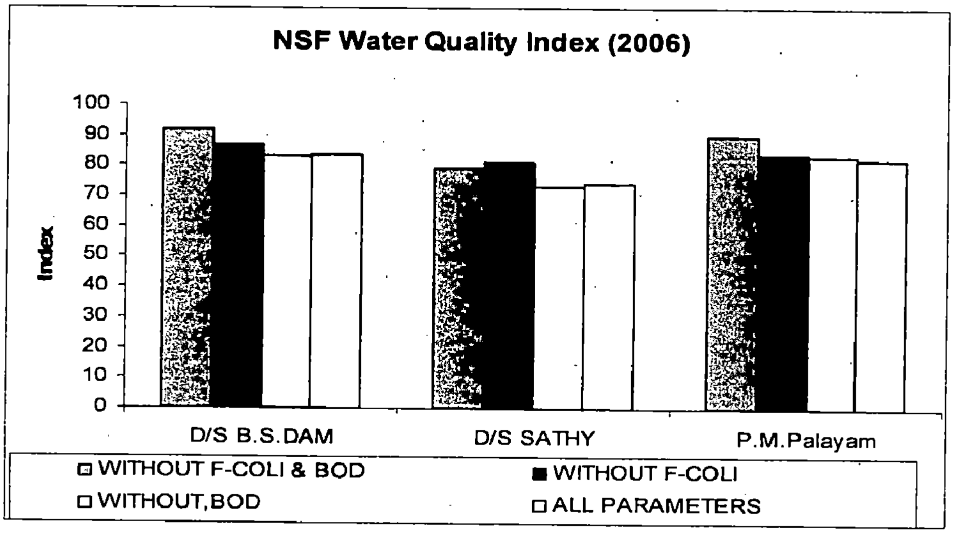


Fig 5.10 Analysis for the Year 2006

5.3.3 Analysis of Mc Duffie's Water Quality Index

In Mc. Duffie's water quality index BOD, COD, & Nutrients (nitrates and phosphates) are critical parameters slight increase of the parameters varies the index very much. It is not suitable for surface waters at all places and it is site specific. The index does not include PH or toxic substances and also site specific not suitable for all surface waters.

This index has been analysed for the years 2000,2001,2003,2004,2006 for the parameters, Total phosphates & Nitrates, BOD and both the two parameters and shown in the graphs below. The removal of BOD shows more increase in index value than the removal of nitrates and phosphates and removal of both the parameters shows reduction in the index value.

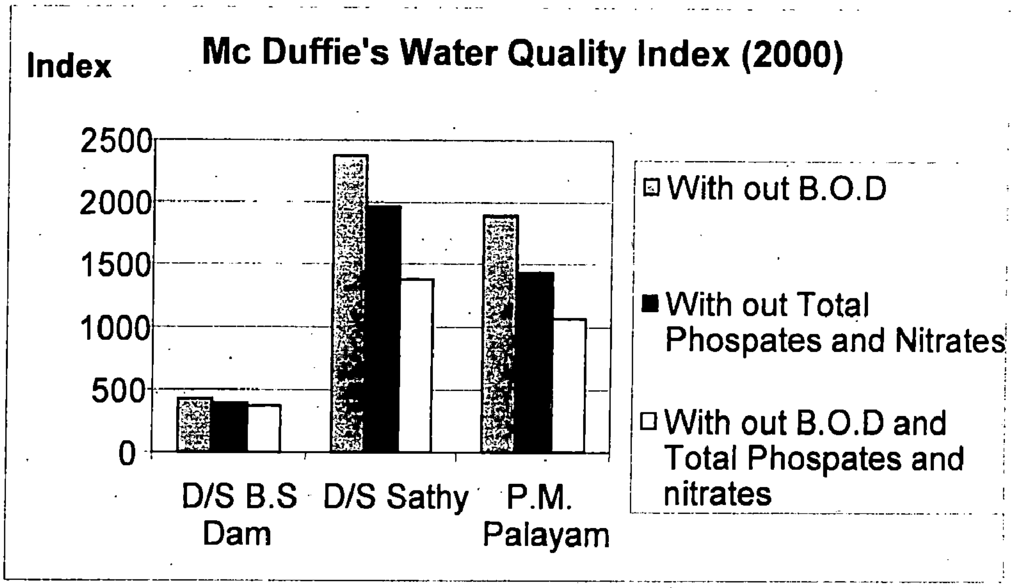


Fig 5.11 Analysis for the Year 2000

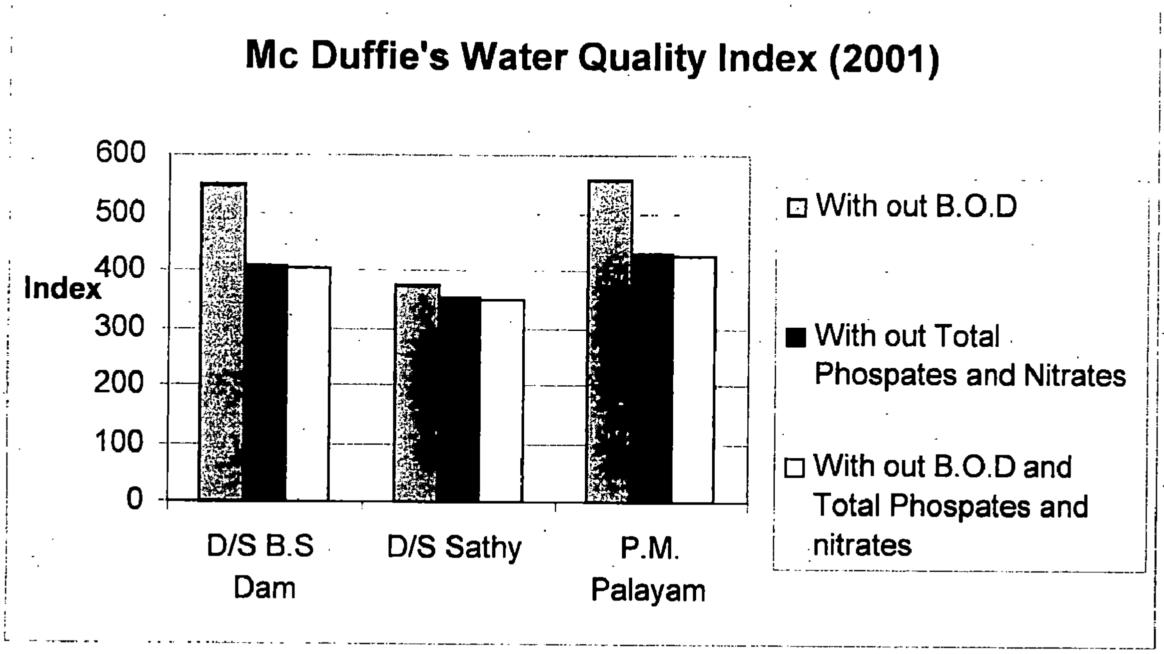


Fig 5.12 Analysis for the Year 2001

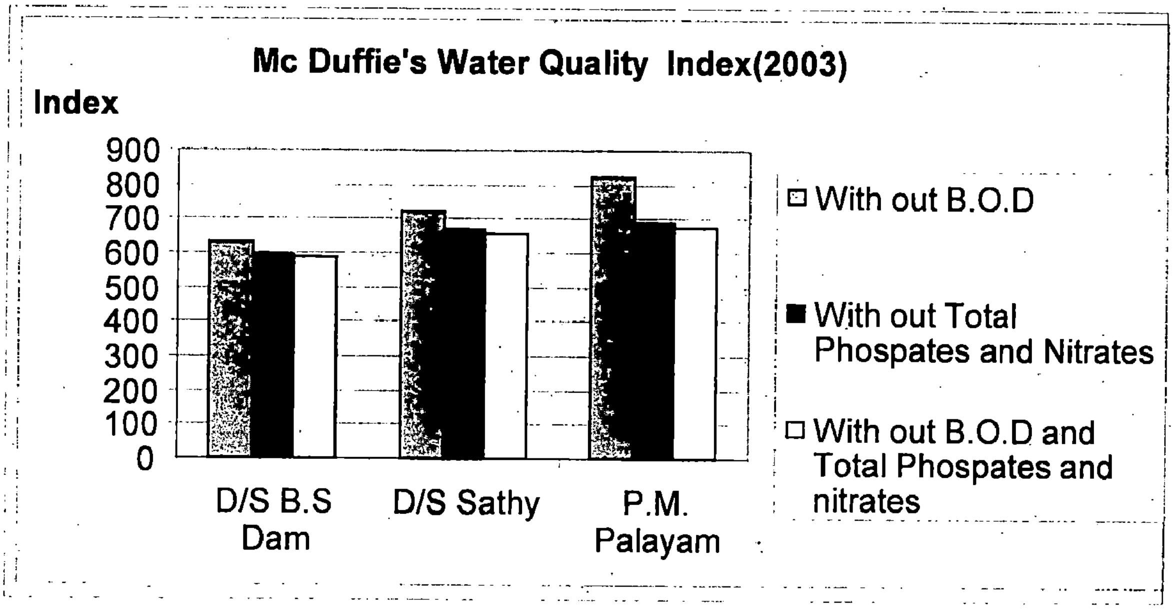


Fig 5.13 Analysis for the Year 2003

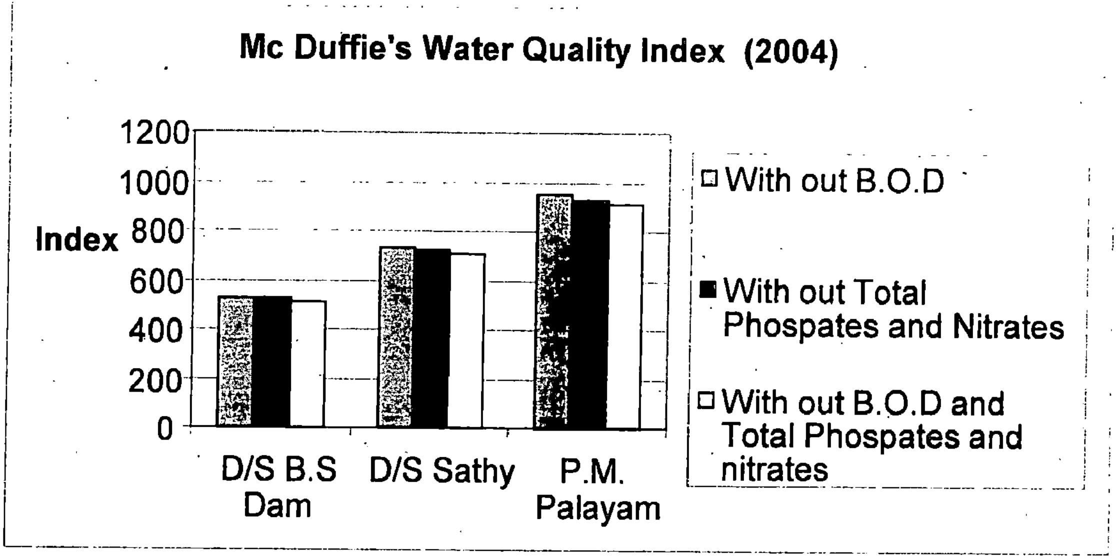


Fig 5.14 Analysis for the Year 2004

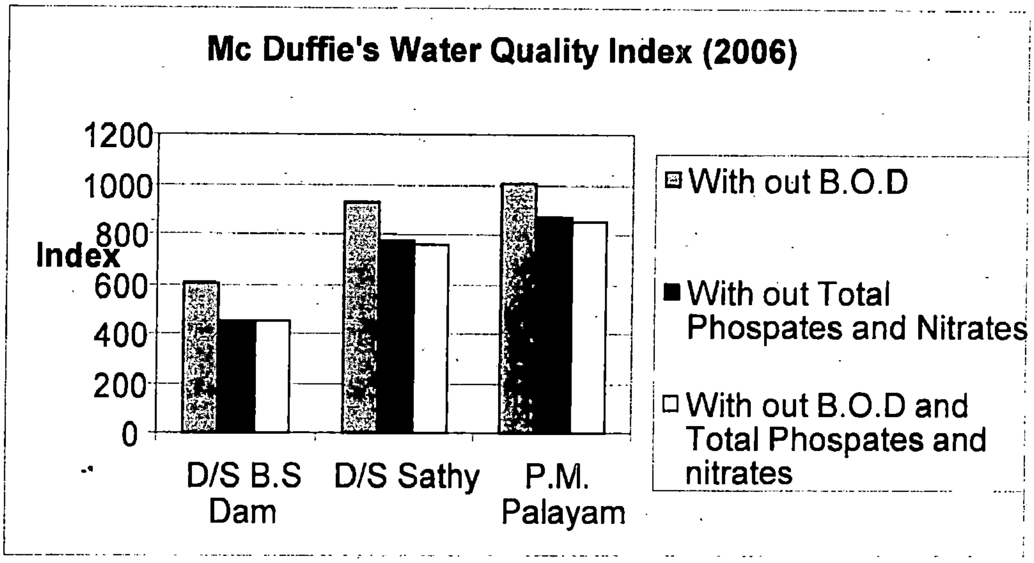


Fig 5.15 Analysis for the Year 2006

McDuffie's water quality index has been analysed for the parameters, BOD, Total phosphates and Nitrates and both the two parameters. The removal of BOD increases the index value, but the removal of nitrates and phosphates, and combination of two Parameters reduces the index value.

CHAPTER- 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 GENERAL

The following conservation measures are suggested, to improve the present conditions of the Bhavani river basin.

6.1.1 Conservation of Bio-diversity

Tamilnadu is endowed with a rich bio-diversity. Of the total recorded forest area in the State, 2917 sq.km. or 12.8% of the total forest area is dedicated towards Wildlife Conservation covering five national parks, six wildlife sanctuaries and twelve bird sanctuaries. Conservation of flora and fauna will continue to be the main objective in creation of sanctuaries, national parks and biosphere reserves. Efforts will also be made to increase the extent of protected areas under wildlife management to 25% of the total forest area of the State. Many medicinal plants and plants of genetic importance will also be conserved in these areas.

6.1.2 Water augmentation

There are 32 river systems, 11 Major reservoirs, 2679 canals and 38863 tanks in Tamilnadu. Majority of the catchments lie in forest areas. To improve the forest, an integrated Watershed development programme is being implemented with afforestation and soil and water conservation measures in the affected watersheds, to increase the ground water level, regulate water-flow in streams, rivers etc and improve fertility of the land below. The agrarian economy will be benefited by augmentation of the water availability.

6.1.3 Extension Forestry

In order to reduce pressure on forest for fuel, fodder and other requirements of the rural people and to enhance the overall green cover, extension forestry works will be undertaken. Biological up gradation and Ecological Restoration through Joint forest management. Heavy biotic pressure from about 3072 abutting villages is the main cause of degradation of forests. Biological up gradation and ecological restoration of these degraded forestlands is being attempted through "*Joint Forest Management*" for sustained benefit flow to the people. There is 3,250 square kilometre of degraded forestland to be ecologically rehabilitated in the State.

6.1.4 Forest Protection

To check the destruction of valuable forest products including sandalwood and other scheduled timber several measures have been taken. Efforts to strengthen the infrastructure for protection and equipping the protection staff with facilities like firearms, vehicles, wireless equipments etc., will continue. The forest wealth of the State is vulnerable to damage and destruction by illicit felling of trees, ganja cultivation, fire, encroachment and poachers of wildlife. To protect the forest, it is proposed to strengthen the forest infrastructure.

Tamilnadu has its Gene pool garden in the Western Ghats with 4000 tree species, mostly endemic and endangered, out of which 1000 species are targeted for ex-situ conservation during this year by research wing of Forest Department. Further, the research wing of Forest Department is developing Post Harvest technology for utilizing the under exploited timber species for furniture and house hold timber

6.1.5 Common Effluent Treatment Plants

TNPCB plays an important role in establishment of Common Effluent Treatment Plants (CETPs) for clusters of small polluting industries in various parts of the state. Tamilnadu is a pioneering state in India in establishing CETPs. So far, proposals for 48 CETPs have been formulated. Of these, 32 CETPs are under operation and the remaining CETPs are under various stages of implementation. The details of CETPs are as follows.

Table 6.1 **Common Effluent Treatment Plants in Tamilnadu**

Sl.No.	Sector	No. of CETPs formed	NO. of ETPs under operation
1	Tanneries	23 Schemes	12 Schemes
2	Textile Bleaching and Dyeing	23 Schemes	18 Schemes
3	Hotels and Lodging Houses	1 Scheme	1 Scheme
4	Hospitals (Common facility)	1 Scheme	1 Scheme
	Total	48 Schemes	32 Schemes

(Source: Tamilnadu Pollution Control Board)

Among the number CETP's formed the number of CETP's under operation are less, necessary action must be taken to provide CETPs to all small-scale industries and also the operation of the CETPs should be monitored closely.

6.1.6 Cleaner Technologies

In the long run, the needs of both development and environment can be best served by moving towards cleaner technologies. Industrial units manufacturing caustic soda, cement, Sulphuric acid and other inorganic chemicals, as also thermal power plants and heat treatment plants, have started switching over to cleaner technologies. There has been progress in the recovery of materials from wastes. Examples include chrome from tannery effluent, acid from illmenite and ammonia from fertilizers. Out of 16 distilleries 12 distilleries have gone for biocomposting of their effluents with press mud of sugar factories for achieving zero discharge of trade effluents. The other four (4) distilleries are also in the process of similar measures.

The leather tanning industries and textile processing industries have installed pollution control measures to treat the trade effluent for achieving the standards prescribed by the Board. Generally all standards are being met except Total Dissolved Solids (TDS). To tackle this problem these industries is being encouraged to go in for tertiary treatment including Reverse Osmosis (RO), etc., this is an expensive method of treatment.

6.1.7 Municipal Solid Wastes Management

With increasing urbanization and rising levels of municipal solid wastes, an urgent task is to evolve scientific approaches to segregate, handle and dispose the solid wastes in urban areas. In this regard, the project of conducting feasibility studies on solid waste management for the local bodies of Udhagamandalam, Kodaikkanal, Palani, Thiruchendur, Kanyakumari, Rameswaram, Mamalapuram and Kuttralam in Tamilnadu, which are all centres of tourism, has been started.

With the rapid spread of consumerism, the tradition of preserving and reusing objects of utility several times over and the philosophy of conservation of resources are being eroded rapidly. A wasteful 'use and throw' culture has emerged in our midst. An important and dangerous aspect of this phenomenon is the increasing use of throwaway plastics. Recognizing the enormous environmental hazards arising from the use of plastics, which are basically non-biodegradable, many advanced countries have banned the production and use of a variety of plastics and severely restricted the use of others.

6.1.8 Bio Medical Wastes Management

There are 242 Government hospitals and 1,405 private hospitals. The Indian Medical Association (IMA) has requested government and private hospitals to take time-bound action for identifying sites and setting up common facilities for management of biomedical wastes. A few sites have been identified. The TNPCB has conducted training in management of biomedical wastes for its own staff, members of IMA and other medical and Para medical personnel.

It is recommended that incineration of biomedical wastes should not be resorted to, except for body parts and human tissues. The safe methods are autoclaving and sanitary landfills for disposal of biomedical wastes. In Bio-medical waste management segregation, collection, storage, treatment and disposal of biomedical wastes, are to be done with proper care, and it should not lead to spreading of diseases.

6.1.9 Soil and Water Conservation Programme

The majority of the catchment area of river Bhavani is in western ghats and falls under forest area hence Soil and Water Conservation Programmes has to be taken up in the districts of Coimbatore, Erode, and Nilgiris. These programmes should be related to reduce soil erosion, afforestation, water conservation and wildlife protection. The soil conservation works are executed with a contribution of 10% from the beneficiaries for the works executed on patta lands and a contribution of 5% for SC / ST farmers and for works executed in community lands.

The Hill Area Development Programme is implemented in the Nilgris district. The district has been delineated into 75 watersheds. Of these watersheds, highly degraded watersheds are to be taken up for treatments. Soil and Water Conservation works, landslide treatment works and river training works are to be taken up under this programme.

6.2 Environmental Awareness and Public Participation

All Government Schemes, Programmes requires public support, awareness and their participation for their success and sustainability. The River conservation Programmes need much more public awareness, their support, opinion and their participation in the programme. In Pollution control Programmes the sustainability depends much on the public participation.

Public participation, for controlling pollution will include the element of enhancing the general level of awareness about the effects of rising pollution and measures capable of being taken by the citizens for abatement of pollution and including community spirit. Special programmes are required for generating awareness focusing on specific and varies target groups.

6.2.1 Role of Public

It is very important to involve Public in all pollution control programmes without their participation it is difficult to achieve success. The public must be given all Information about pollution control and their opinion should be obtained, analysed and incorporated. They should have the ownership of the pollution control programs for its success and sustainability. The public should be made aware of all hazards of pollution.

The following can be done for protection of environment:

1. Educate at school level about the pollution problem and the harmful effects of pollution.
2. We should minimize the use plastic cover for different purposes.
3. Buy only environment friendly products i.e. the products, which are not reducing the natural resources.
4. Not to waste water for various purposes.
5. To plant and grow trees in the house garden.
6. To Support the NGO's financially which are rendering service to the Health and Environment sector.
7. To motivate research on different measures to be taken to solve environmental Problems.
8. To support the initiates taken by the central and state government in protecting our Environment.

6.3 Role of Industries in arresting the pollution

6.3.1 Reduction of pollution load

In order to reduce the treatment costs and complexity of treatment, the pollution load in effluents has to be reduced substantially. Such reductions also result in considerable savings up to 30%. There are more opportunities for reducing the pollution load at almost every stage of industrial processes. Some of the important and practicable remedies are as follows:

6.3.2 Waste segregation

Segregation of the relatively concentrated waste streams and separate treatment results in substantial reduction of pollution load. Segregation is used for. Recovery and reuse, Evaporation, Separate treatment or Biological treatment methods.

6.3.3 Recovery and Reuse of materials

Recovery of some of the valuable materials from the effluent streams substantially reduces the pollution, especially BOD and TDS load. The recovered materials can be reused in the same process.

6.3.4 Substitution of Low Pollution Load Chemicals

The more practicable way of reducing pollution load in effluent streams is the substitution of low pollution load chemicals that contribute to high BOD and organic loading. The factors to be considered during substitution are, the chemical should be easily treatable, it should not be toxic, it should also be amenable for recovery and reuse and should not affect the quality of the fabric. In sizing the starch is replaced by the synthetic sizing agents like PVA and CMC.

This reduces the BOD load as well as odour and also ease the de sizing operations – just detergent / water washing is enough. Hydrogen peroxide may be substituted in place of Sodium per borate, which is used for Oxidation of leuco – vat dyes, so that the detrimental boron can be totally eliminated. Substitution of stream for oxidation of dyes in place of dichromate – acetic acid baths is also reported to reduce BOD load by 5 – 15%.

6.4 OTHER MISCELLANEOUS CONSERVATION MEASURES FOR POLLUTION

6.4.1 Insufficient public awareness

Public should have the general awareness about pollution, need good environment, they need good water quality and good land quality. The farmers are showing much interest in the testing of soil and water for the cultivation. They farmers on one side consume water. On the other side they are polluting water by using excess fertilizers and pesticides on the other side the agricultural wastes are also heavily polluting the environment.

In general, the public is also not much aware about the degradation effects of environment. Everybody has contributed to the pollution of water, land and air. They are not bothered about the degradation of the catchment, industrial pollutions and sewage pollutions in the river basin.

6.4.2 Improper co–ordination among authorities

For any action plan or program, to be successful the baseline data collection of the river is very much essential for perfection. The inflow of water in the river basin, its quantity for utilization for various purposes, the pollution details, the impact of sewage and industrial pollution on water bodies, destruction of biodiversity, the catchment degradation and the siltation and sediment problems, etc should be analyzed in detail. To achieve this there should be proper coordination among the various agencies e.g. TNPWD, TNPCB, Tamilnadu Agriculture University, Scientists, and NGO's, Research students, Industrial owners and farmers, which is totally lacking. Subjective activities related to their own firm or department are the major obstacles in the launch of the programme.

6.4.3 Judicial Use of Chemicals

To cut down the costs of processing and to reduce the pollution load of effluent the limited use of chemicals is advised. It is reported that about 15% of the dye materials is simply wasted by the application of excess quantities which find its way into effluent streams. Closer control of the process will be useful to reduce the consumption of dyes and other chemicals.

6.4.4 Economy in Water Usage

If lower quantities of water were used for processing, the lesser quantities of effluent would be generated. Proper planning and management and closer control of processes results in considerable reduction in water requirements. The following measures would be fruitful in the reduction of water consumption. Modulated water use on through put of material (use of less Water for narrow width fabric than for wider fabrics). Reuse of cooling waters wherever possible. Induction of new technique (requiring only little water) such as solvent scouring, solvent dyeing, liquid ammonia dyeing, and heat transfer. Replacing older equipments with new equipments (exclusively designed to reduce water consumption.) and supplementary system to existing machineries. Good manufacturing and maintenance practices.

6.5 Suggestion and Recommendations to Improve the Present Conditions

6.5.1 Incentives to Industries to control pollution

The Pollution Control Legislation stipulates that the industries, which generate pollution, should control it to achieve the standards prescribed there in. Though it is the responsibility of the industries to provide the necessary pollution control equipments in their plants, the Government also provide assistance in this regard.

Industries in the small-scale sector in cluster do not have adequate land or finance to put up individual Effluent Treatment Plants on their own can join together to put up Common Effluent Treatment Plants. TNPCB is assisting the small-scale industries to organize themselves into Associations / Companies for setting up of CETPs. The Government of India and the Government of Tamil Nadu provide financial assistance to the CETP Schemes by way of subsidy upto 50% of the project cost is arranged and the 20% is mobilized as share capital among the beneficiary units. So far 54 CETP Schemes in the sectors of tanneries, textile bleaching and dyeing, hotels and hospitals have been evolved in Tamil Nadu and out of which 26 CETPs have been commissioned.

6.5.2 Eco-Tax

The continuing economic progress as well as the technological innovations involved in it, have increasingly lead to considerable environmental deterioration. As this would cause a negative impact on the environment, it is the responsibility of the polluter to pay for the restoration. The policies for sustainable developments can only be achieved, if there are resources to back the commitment, containing in the envisaged environmental plan. In part, these resources will have to come from levying taxes and charges on polluters, which may be named as Eco-Tax. For example a tax on CFCs would reflect their impact on ozone. The system should encourage manufacturers to seek to reduce wastes and other environmental damages. The fund so collected could be used for the pollution abatement proposals and rehabilitation and reclamation of affected areas.

6.5.3 Eco-Clubs

School children are an important target group. The Eco-club programmes encourage the participation of school children in activities related to environmental protection by creating awareness and motivating interest in ecology.

6.5.4 Training Programmes

In our efforts to raise awareness among the masses, it is very important that the message should reach the specific target groups for its effectiveness. TNPCB's Environmental Training Institute is to be further widened and strengthened.

6.5.5 Need for Quick Redressel of Public Complaints

Environmental protection should be considered as a basic objective to be achieved by every organization / agency. Various Government Agencies / Organizations are involved in handling environmental problems. As there is a lack of proper co-ordination among these agencies / organizations to redress the complaints received from the public, it is necessary to form a Co-ordination among these agencies / organizations to redress the complaints received from the public, it is necessary to form a Co-ordination Committee among these agencies.

6.5.6 Private Sector Participation

The private sector can be made more socially responsive, particularly those manufacturing products, which generate pollution, e.g., automobiles, plastics, etc. Initiatives can include inspection and maintenance camps for vehicles, collection of plastic wastes for recycling, etc. increased public awareness for a cleaner environment will force modifications in overall corporate strategies compelling greater investment in anti-pollution efforts. The Eco-Mark scheme with eco-labeling will have to be deployed for shaping consumer preferences through motivations for a cleaner environment.

6.5.7 Experience Sharing

Experience sharing on methods evolved to combat pollution would greatly help the cause of pollution control and abatement, e.g. interactions between members of Waste Minimization Circles, which is a programme for preventing industrial pollution by technological up gradation. Professional groups, comprising of medical practitioners, lawyers, etc. must share perceptions about issues like health and safety.

CONCLUSIONS

The following Conclusions can be drawn from the Study:

1) Bhavani is the Major tributary to river Cauvery in Tamilnadu, now under severe environmental stress hence selected for this Study.
2) The main pollution activities are disposal of untreated domestic sewage and partly treated/ untreated effluents from Industries.
3) Hence Data has been collected from selected sampling points, where the pollution activities are high and analyzed using water quality indices (Horton's, NSF, and McDuffie's indices) and Mapping has been done with NSF-WQI.
4) The liquid wastes from the Towns has to be collected treated using suitable methods(Land treatment, UASB/ASP/Pond processes) and only the treated effluent should be discharged into the river.
5) The solid wastes from the Towns should be collected, separated and the bio-degradable wastes may be disposed by land fillings. The scope for recycling/energy recovery may also be analyzed.
6) Common effluent plants may be installed for all small industries, and they have to be monitored for regular operation.
7) Landscape development in hilly terrains like bench terracing (In Nilgiris Dt) will reduce soil erosion.
8) Good water management practices and crop rotation to be adopted by the Agriculturalists. Excess application of chemical fertilizers and pesticides has to be reduced and farmers must be encouraged to use Bio-fertilizers.
9) Farmers must be taught the necessity of crop rotation to conserve soil fertility.
10) Bhavani being the major tributary to River Cauvery maintaining good water quality will improve the water quality of river Cauvery also.

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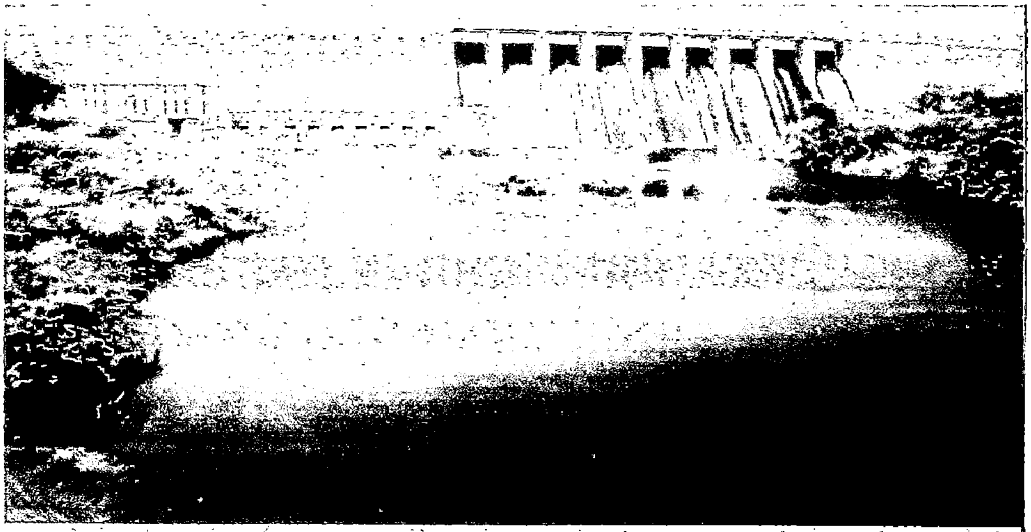
PLATES



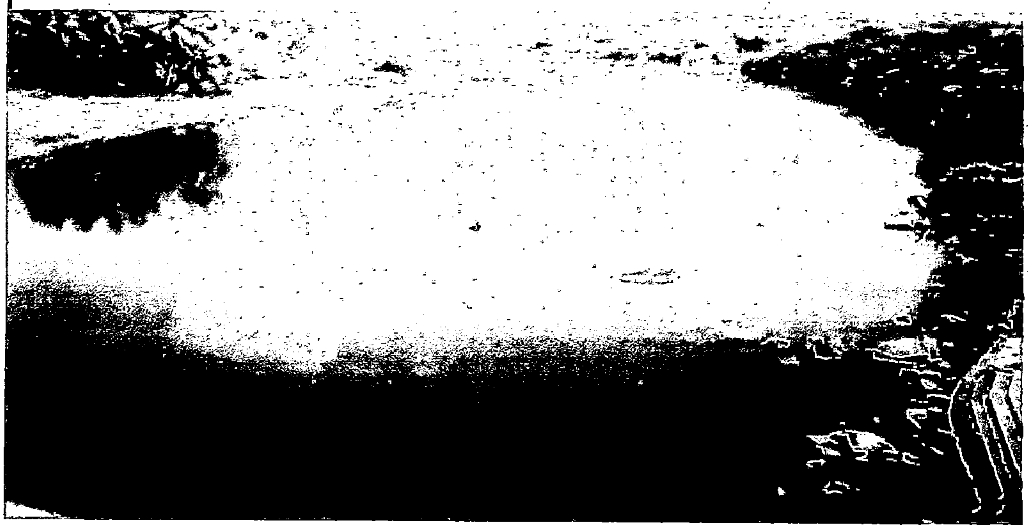
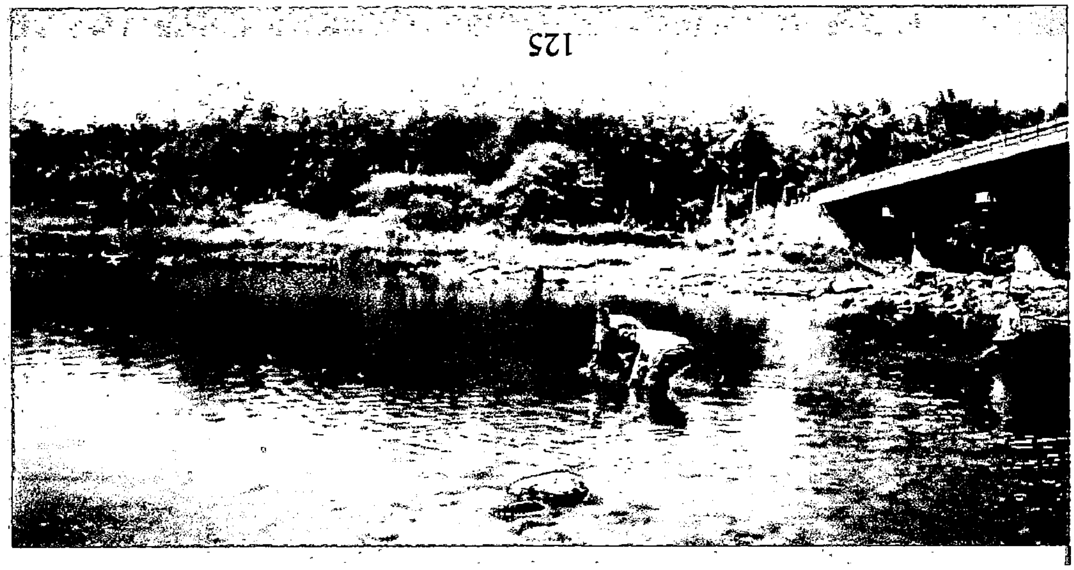
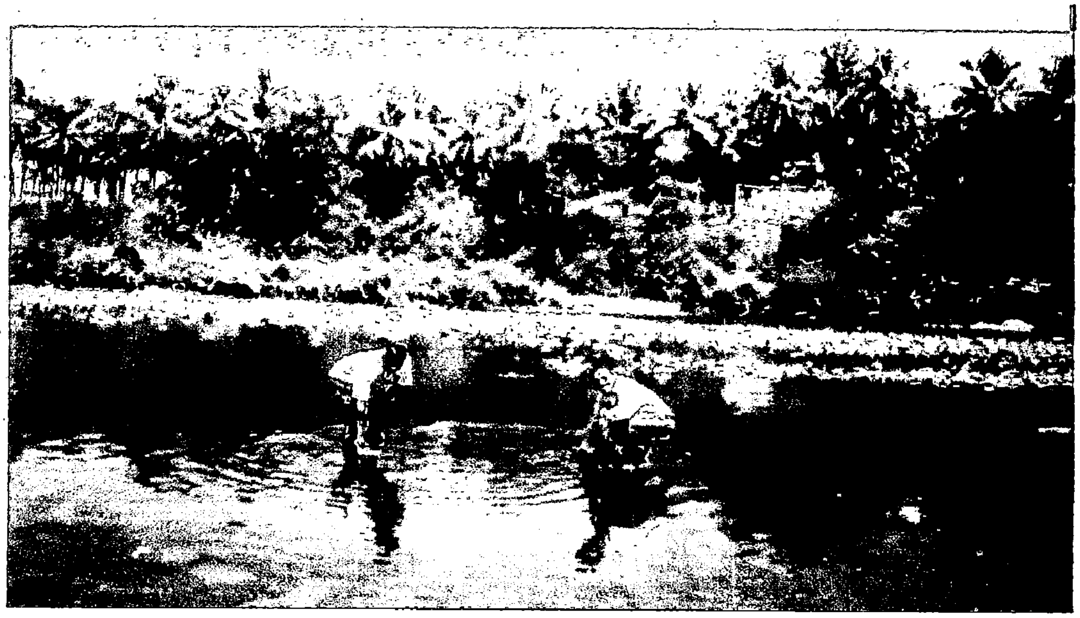


Plate No : 1 Sampling Location D/S of Bhavani Sagar Dam





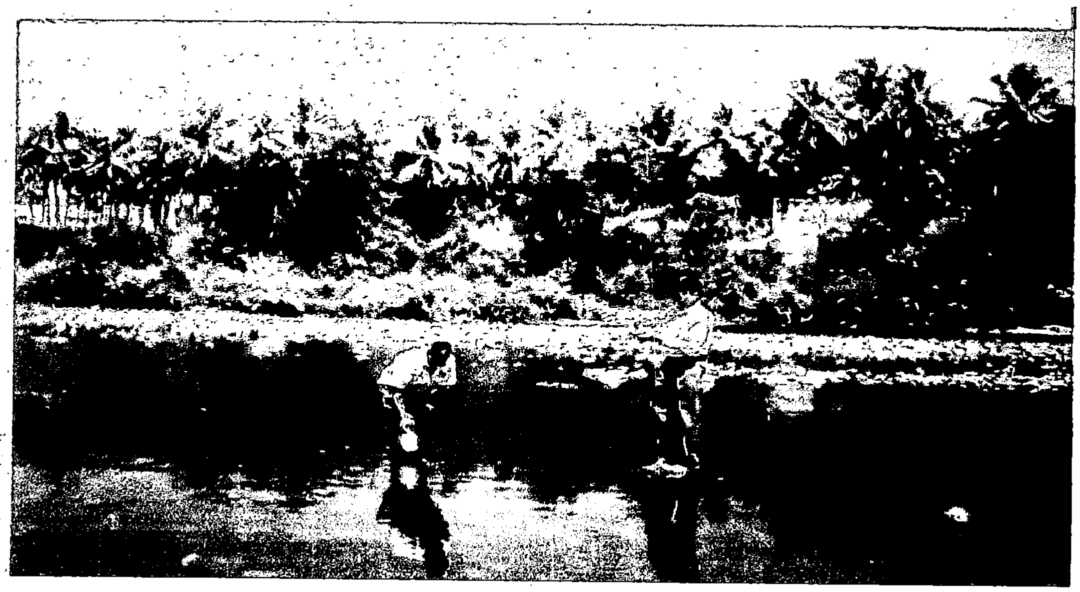


Plate No 2: Sampling Location D/S of Sathy

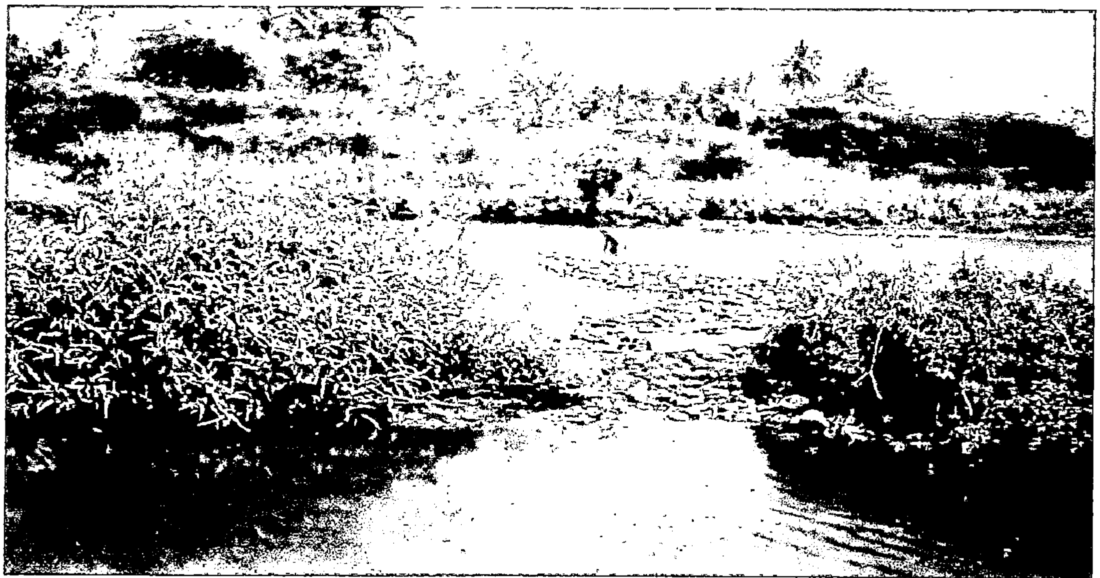


Plate No : 3 Sampling Location at P.M.Palayam

ANNEXURE

Table.No.1 DATA FOR THE YEAR 2000

SAMPLING STATION	DO,ppm	F-COLI, mpn/100ml	pH	BOD-5, mg/lit	COD mg/l	TEMP-CHANGEdeg C	TOTAL-P, mg/lit	N,mg/lit	Turbidity,ntu	T-SOLIDS,mg/lit	Total Colimg/l	Sp.conductance	Carbon Chloroform extract	Alkalinity	Chlorides
D/S OF B.S.DAM	7.79	64.9	7.6	2.51	24	0	0.285	1.08	1.69	217.2	550	112	24	72	24
D/S OF SATHY	5.58	360	7.86	95.42	156	0.1	2.24	27.66	3.69	1034	873	642	156	100	40
P.M.Palayam	5.86	259	7.73	60.41	112	0.114	1.98	22.56	3.2	742.55	1161	426	112	185	35

Table.No.2 DATA FOR THE YEAR 2001

SAMPLING STATION	DO,ppm	F-COLI, mpn/100ml	pH	BOD-5, mg/lit	COD mg/l	TEMP-CHANGEdeg C	TOTAL-P, mg/lit	NITRATE, mg/lit	TURBIDITY,ntu	T-SOLIDS,mg/lit	Total Colimg/l	Sp.conductance	Carbon Chloroform extract	Alkalinity	Chlorides
D/S OF B.S.DAM	6.6	209	7.8	1	26	0	0	4.71	1	153.6	637	124	26	196	52
D/S OF SATHY	7	334	7.2	0.6	18	0	0	0.84	1	105.7	954	84	18	216	35
P.M.Palayam	7.2	206	8.1	0.9	22	0	0	4.22	1	242.9	577	192	22	168	60

Table.No.3 DATA FOR THE YEAR 2003

SAMPLING STATION	DO,ppm	F-COLI, mpn/100ml	pH	BOD-5, mg/lit	COD mg/l	TEMP-CHANGEdeg C	TOTAL-P, mg/lit	NITRATE,mg/lit	TURBIDITY,ntu	T-SOLIDS,mg/lit	TotalColimg/l	Sp.conductance	Carbon Chloroform extract	Alkalinity	Chlorides
D/S OF B.S.DAM	6.6	484	8	1.9	56	0	0.28	0.97	1.5	177.1	724	96	56	76	25
D/S OF SATHY	7.2	214	8	2.1	72	0	0.52	0.99	2	121.8	541	74	72	176	30
P.M.Palayam	6.1	973	8.2	2	62	0	1.24	2.12	2.5	351.4	1542	186	62	112	45

Table.No.4 DATA FOR THE YEAR 2004

SAMPLING STATION	DO,ppm	F-COLI, mpn/100 ml	pH	BOD-5, mg/lit	COD mg/l	TEMP-CHANGE deg C	TOTAL -P, mg/lit	NITRATE, mg/lit	TURBIDITY ,ntu	T-SOLIDS,mg/lit	TotalColimg/l	Sp.conductance	Carbon Chloroform extract	Alkalinity	Chlorides
D/S OF B.S.DAM	6.7	175	7.9	2.1	46	0	0.18	0.071	1.2	185.5	352	105	46	54	42
D/S OF SATHY	7.7	514	7.3	2	82	0	0.32	0.025	2.8	100.8	826	62	82	118	142
P.M.Palayam	6.4	206	8.1	2.6	102	0	0.58	0.179	3.1	326.9	453	185	102	142	194

Table.No.5 DATA FOR THE YEAR 2006

SAMPLING STATION	DO,ppm	F-COLI, mpn/100 ml	pH	BOD-5, mg/lit	COD mg/l	TEMP-CHANGE deg C	TOTAL-P, mg/lit	NITRATE, mg/lit	TURBIDITY ,ntu	T-SOLIDS,mg/lit	TotalColimg/l	Sp.conductance	Carbon Chloroform extract	Alkalinity	Chlorides
D/S OF B.S.DAM	5.1	10	7.36	0.8	32	0	0	5	2	98	180	68	32	40	18
D/S OF SATHY	5.8	200	8.45	2.2	85	0	0.13	5	4	97	920	65	85	60	9
P.M.Palayam	5.6	10	7.4	2.6	96	0	0	5	2	95	120	58	96	50	12