RIVER CONSERVATION PLAN FOR RIVER CAUVERY FROM METTUR DAM TO ERODE

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree

of

MASTER OF TECHNOLOGY

in

CONSERVATION OF RIVERS AND LAKES

By

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CANDIDATE'S DECLARATION

I hereby declare that the work which has been presented in the dissertation entitled **"RIVER CONSERVATION PLAN FOR RIVER CAUVERY FROM METTUR DAM TO ERODE"** in partial fulfillment of the requirements 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 2006 to June 2007 under the supervision of Sh. Arun Kumar, Chief Scientific Officer and Head, Alternate Hydro Energy Centre and Dr. D. K. Srivastava, Professor, department of Hydrology, Indian Institute of Technology Roorkee.

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

Place: Roorkee
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CERTIFICATE

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

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ABSTRACT

The Cauvery River is important river in Southern India. It rises in Brahmagiri Range of the Western Ghats in Coorg District of Karnataka. After flowing 802km (381, 357 and 64 km in Karnataka, Tamilnadu and Kerala, respectively), it joins the Bay of Bengal at Kaveripatnam in Tamil Nadu. Some of the important towns along the course of this River are Mysore, Erode, Vellore, Tiruchirapalli and Tanjavure. Various human activities along the course of river viz agriculture, industrialization and other commercial activities have impacts on the quality of Cauvery River.

With growth of various human and economic activities, the water in river Cauvery deterioted in the quality. The Central Pollution Control Board (CPCB) identified a stretch of River Cauvery from Mettur Dam to Erode having BOD more than 6 mg/l, as one of the Polluted stretch in Tamil Nadu. The Tamil Nadu State Pollution Control Board (TN.SPCB) formulated necessary action plan to restore the water quality of the River Cauvery. A sum of Rs.16.58 crores has been spent by different executing agencies of the state, viz., TWAD Board and the concerned Local Bodies. Works on Low Cost Sanitation facility, River Front Development, bathing ghats and wood based crematoria has been also completed. Waste Stabilization pond / Up flow Anaerobic Sludge Blanket process "UASB" have been used for sewage treatment

Due to problem of ground water pollution, the Erode sewage treatment plant waste stabilization pond was kept idle for past one and half years. For Bhavani Town also waste stabilization treatment plant was in complete due to public agitation related to apprehension for ground water contamination. For Pallipalayam town segregation of dyeing effluents from domestic sewage has been proposed in latest project reports. In Komorapalayam town the treatment plant was functioning under trial run by Tamil Nadu Water Supply &Drainage Board (TWAD Board).

In the study area from Mettur dam to Erode Town stretch of river Cauvery about 25 Million cubic metres of waste water is generated per annum from six urban areas. The facilities for total waste water collection are not available in the study area. The existing treatment facilities treat only 51.26% of the waste water and also mostly up to primary level and to some extent to secondary level before discharging in to River Cauvery.

The water quality index classification of CPCB, ISI, and NSFWQI revels that this study reach of river Cauvery is with heavy pollution load and “C”to “D” class of designated best use and NSFWQI 48 to 70 ranges depend up on the up flow in the river as “Bad “to “Medium” quality. The water of the Cauvery River contains high numbers of total coliform and faecal coliform which indicates the presence of pathogens in the river water. Defecation by road sides all along the river bunds and within the river is very high. Therefore, Cauvery river water always spread the water borne diseases in the downstream area after the flood during rainy season.

The effluents and sewage from the various sources affect the flora and fauna of the river water. Abundance of nutrients in the water initiates algal bloom, overgrowth of water hyacinth and wildly growth of other aquatic plants along with the eutrophication hazards creates ecological problems. The polluted water also affects the fish and other aquatic fauna in the river water.

The Tamil Nadu Government recently sanctioned Sewerage schemes including collection system and treatment plant for the municipalities of Mettur, Bhavani Town, Erode and Komorapalayam The flow availability in the Cauvery River downstream of Mettur Dam entirely depends up on the storage position in Mettur Dam as well as inflow of the river. The flow quantity varies in the range of 17 to 100% [1576 M.cum to 9215 M.cum].

Cauvery River flow and water quality data have been analyzed under this study for, a period of 2802 days from June 1999 to January 2007 out of which 815 days virtually there was no flow observed in the river. But the Industrial and Municipal sewages (treated, partially treated and untreated effluents) have been continuously let into the Cauvery River in the study area .Natural sources of contamination like agricultural return run off, carcasses , fishes, decaying vegetations and trees, agricultural excess fertilizers. Pesticides, agricultural wastes, and other natural disturbances in the catchment area, also influences the sub surface flow of the river as well as stagnated low level pockets of river course and it leads heavy pollution and contamination. The accumulated sewage and Industrial effluents stagnating in the river, and it settle its solid matters in the river bed it self. Absence of sufficient fresh water flow to the study area the, as well as quality and reliability of the drinking water resources of 30 lacs population in the study area is under severe threat , considering the requirement of dilution factor as well as self purification capacity of the Cauvery River ecosystem. Drinking water source for 15 districts from Cauvery River from surface water as well as from infiltration wells constructed in the river itself are under severe threat. The water supply sources of Erode, Pallipalayam, Sankagiri, Veearpan chattram Tiruchengodu are surrounded by effluents and sewage due to zero velocity and absence of dilution factor. The sources are now getting contaminated by the stagnated sewage and effluents, and dyes and chemicals present in the stagnated water of River Cauvery during non flow days.

The reduction of the pollution load is necessary for the improvement of river water quality. Therefore, it is necessary to plan and execute the expansion of sewerage systems and the sewerage treatment.

During lean flow and dry periods the assimilation and self purification capacity of the river water is not enough to digest the pollutant load. The discharge of domestic and industrial effluents in to Cauvery River during flow days result in depletion of oxygen in running water. These destroy the flora and fauna of the flow waters in Cauvery River. Further, the rich solids presents settle at the bottom of the river. Continuous settling of these solids at the bottom will affect the fish spawning grounds. High toxic chemicals present in the effluent may have direct impact on the fish diversity of the river.

In order to achieve the water quality standards in the polluted stretch of River Cauvery from Mettur Dam to Erode Town measures of the river eco system are to be taken on urgent basis.

For River Cauvery restoration certain environmental flow for carrying away the pollutants and maintains life of the riverine eco system are required. At present there is no law enforcement, thus requires Government action.

1) A minimum of 27.3 Cumecs as environmental flow for Cauvery River from Mettur Dam was directed by the Hon'ble "Cauvery Water Disputes Tribunal" final orders.
2) The Industries along the river are to adhere strictly "as zero waste industries".
3) Formation of separate Authority with powers to monitor and execute the work with in a targeted time are suggested.
4) The effluents should be utilsed for farming in the suitable irrigation facilities as well as for forestry. Scientifically designed land application systems, based on soil plant assimilative capacity, promotes treatment of wastewater through renovative capacity of living soil filter enabling recycling and reuse of wastewater, and conversion of nutrient energy into biomass there by bringing multiple benefits to society such as food,fuel,fruit,fibre and fodder production, environmental sanitation and ecorestoration.The forestry based land application systems enable of much desired green belt in cities that serve as sinks for green house gases, other air pollutants ,and debilitating noise levels .

Cauvery River restoration Project from reach Mettur Dam to Erode Town (62 kms) has been estimated at 130.00 crores and two years for its restoration including formation of separate authority for the above restoration programme along with release of minimum environmental flow as directed by the Hon'ble "Cauvery Water Disputes Tribunal" final orders through out the year .

If the River Restoration project of Cauvery has taken up as per this dissertation plan and allocation of funds as required including formation of separate authority it yields very good return and the ecology of the area also conserved.

All the river action programmes are become successful and yield very good desired results provided we maintain minimum environmental flow in the rivers.

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NOTATIONS AND ABBREVIATIONS

Symbol / Abbreviation	Meaning / Explanation
M.T.P	Mettur Thermal Power
Amm. N.	Ammonical Nitrogen
APHA	American Public Health Association
AWWA	American Water Works Association
BCL	Brahmaputra Carbon Ltd.
BOD	Biological Oxygen Demand
TNPCB	Tamil Nadu Pollution Control Board
TWAD Board	Tamil Nadu Water Supply And Drainage Board
CEQ	Council of Environmental Quality
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
DBU	Designated Best Use
DO	Dissolved Oxygen
DW	Descriptor Words
FC	Faecal Coliform
HOP	High Organic pollution
IV	Index Value
ISI	Indian Standard Institute
MOP	Moderate Pollution
MPN	Most Probable Number
NOSLP	No Or Slight Pollution
NSFWQI	National Sanitation Foundation Water Quality Index
NTU	Nephelometric Turbidity Unit
OECD	Organisation for Economic Cooperation and Development
O&G	Oil and Grease
OP	Organic Pollution
ODR	Odour
pH	Negative Log of Hydrogen Ion Concentration
RPI	River Pollution Index

SPC	Specific Conductance
SS	Sampling Station
TC	Total Coliform
TDS	Total Dissolved Solids
TEMP.	Temperature
TKN	Total Kjeldahal Nitrogen
TN	Total Nitrates
TP	Total Phosphates
TS	Total Solids
TSS	Total Suspended Solids
TUR	Turbidity
VLOP	Very Light Organic Pollution
WPCF	Water Pollution Control Federation
WQI	Water Quality Index

CHAPTER-1

INTRODUCTION

1.1 GENERAL

The rapid industrialization and urbanization and extensive use of fertilizer and agro-chemicals along with other chemicals have put in severe strain on the river eco-system. Gradually, increasing pollution of river water has become a matter of great concern in recent years. Basically, the growing population and subsequent urbanization and industrialization are main unabated polluting causes of the rivers in the world.

Industrialization and urbanization are growing hand in hand to form modern technological society. Subsequently, it affected adversely the neighboring water resources along with the natural environment. The growth of modern technology and industry has initiated to increase the population in urban settlements.

The urban area occupies roughly 0.3 % of world's geographical area and about 40% of the World's population resides in this urban area. The dynamics of industrialization and increase of population has led to the growth of the large modern urban complexes. Consequently, high density of population, high consumption of energy, large amount of solid wastes generation, discharge of domestic sewage and industrial effluents are the distinctive character of both industrialization and urbanization. The river, therefore, has been affected by the above causes in respect of the morphological and ecological aspects.

1.2 RIVERS

Rivers are the most important freshwater resource for man. Social, economic and political development has, in the past, been largely related to the availability and distribution of fresh waters contained in riverine systems. A simple evaluation of surface waters available for regional, national or tran's boundary can be based on the total river water discharge. The Colorado River, U.S.A, and Cauvery River in India are the examples where extraction of water has virtually depleted the final discharge to the ocean.

The flow has been almost completely extracted and distribution in to nearby states. Any increase in extraction and use would require diversion of a similar water quantity to guarantee the minimum flow required to meet all the water demands of the region. Upstream use of water must only be undertaken in such a way that it does not affect water quantity, or quality, for downstream users. Use of river water is, therefore, the subject of major political negotiations at all levels. Consequently, the river water managers require high quality scientific information on the quantity and quality of the waters under their control. Provision of this information requires a network of river monitoring stations in order:

- To establish short- and long-term fluctuations in water quantity in relation to basin characteristics and climate.
- To determine the water quality criteria required to optimize and maintain water uses, and
- To determine seasonal, short-and long-term trends in water quantity and quality in relation to demographic changes, water use changes and management interventions for the purposes of water quality protection.

1.3 RIVER CLASSIFICATION

Rivers are complex systems of flowing waters draining specific land surfaces which are defined as river basins or watersheds. The characteristics of the river, or rivers, within the total basin system are related to a number of features. These features include the size, form and geological characteristics of the basin and the climatic conditions which determine the quantities of water to be drained by the river net work. Rivers can be classified according to the type of flow regime and magnitude of discharge. The flow regime may be subject to considerable modification by natural impoundments, lakes, and dams. Flow characteristics may also be changed by canalization, or requirements for water uses, such as withdrawal for irrigation or other water supply needs, or by changes in flood characteristics due to modifications of the soil infiltration as a result of agriculture and urbanization.

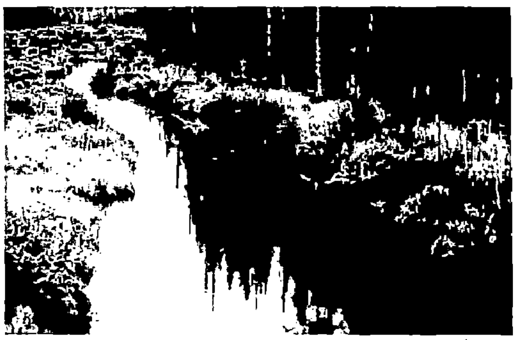
The classification of rivers according to their discharge is generally more satisfactory but has not, to date, been completely defined and accepted. However, there are certain specified discharge rates that are widely used to characterize river discharges and their annual variations. These include the average peak discharges, the monthly or annual average discharge and the average low discharge. A size classification based on discharge, drainage area and river width is given in Table (1.1)

River discharge particularly in arid and sub-tropical regions, may range from zero in the dry season to high discharge rates in large rivers during the rainy seasons. Very large rivers may also traverse many climatic zones and can have less variability than might be expected for the climatic conditions at the final point of discharge, such as the Mississippi and Nile rivers. River drain watersheds of varying dimensions, this area are directly related to the discharge and width. Efficient drainage is achieved by means of a dendritic network of streams and rivers. As these increases in size from small to large, and then to the main river channel, the order in which they appear is a function of the watershed size.

River systems represent the dynamic flow of drainage water, which is the final product of surface run-off, infiltration to ground water and groundwater discharge. The general relationships between these and the nomenclature for a river transect are summarized in Figure (1.1, 1.2)

Table 1.1: Classification of rivers based on discharge characteristics and the drainage area and river width

River size	Average discharge Cumecs	Drainage area square km	River width m	Stream order
Very large rivers	>10000	>1000000	>1500	>10
Large rivers	1000-10000	100000-1000000	800-1500	7 to11
Rivers	100-1000	10000-100000	200-800	6to9
Small rivers	10-100	1000-10000	40-200	4to7
Streams	1.0-10	100-1000	8.0-40	3to6
Small streams	0.1-1.0	10-100	1.0-8.0	2to5
Brooks	<0.1	<10	<1.0	1to3



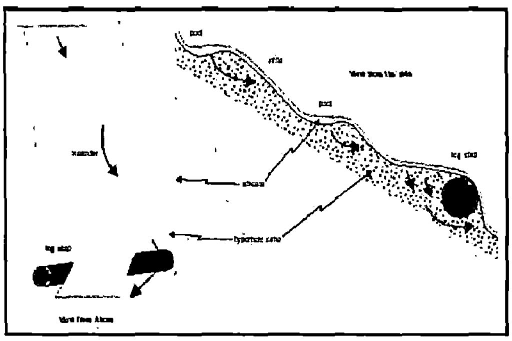


Figure 1.1 & 1.2: River Transect

1.4 INDIAN RIVER SYSTEM

India is a land of many rivers and mountains. Its geographical area of about 329 M.ha is 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 riverbanks grow and develop at a faster rate.

1.5 WATER SCENARIO OF INDIA

India supports 16% of the world's population in about 2% of the world's land area and contains about 4% of the world's fresh water resources. India is basically an agrarian society with its economy highly dependant on irrigated agriculture. The largest use of fresh water in India is, thus, for irrigation. There are a total of 113 major and minor river basins which form the lifeline of thousands of cities, towns and villages in India [23]. Of these, there are 13 major rivers which share 83% of the total drainage, contribute 85% of the total surface flow and also accommodate 80% of the total population [A]. The details of the major river basins in India are given in Table 1.2 and Figure 1.3 shows the drainage map of India.

Table 1.2: Details of major river basins in India

S. No.	Name of the River	Length in India (Km.)	Basin Area in India (Sq. Km.)	Average annual Discharge (MCM)	Place of origin	Destination
1	Ganga	2525	861404	493400	Gangotri Glacier Uttar Kashi, U.P.	Bay of Bengal
2	Indus	1270	321290	91455	Near Mansarovar Lake, Tibet	Arabian Sea
3	Godavari	1465	312812	105000	Nasik, Maharastra	Bay of Bengal
4	Krishna	1400	258948	67675	Mahabaleshwar Maharashra	Bay of Bengal
5	Brahmaputra	720	187110	510450	Kailash Range, China	Bay of Bengal
6	Mahanadi	857	141600	66640	Raipur, M.P	Bay of Bengal
7	Narmada	1312	98796	40705	Amarkantak, M.P.	Arabian Sea
8	Cauvery	800	87900	20950	Coorg, Karnataka	Bay of Bengal
9	Tapi	724	65145	17982	Batul, M.P.	Gulf of Khambhat
10	Pennar	597	55213	3238	Chennakesva Hills, Karnataka	Bay of Bengal
11	Brahmani	800	39033	18310	Ranchi, Bihar	Bay of Bengal
12	Mahi	533	34842	8500	Ratlam, M.P.	Gulf of Khambhat
13	Sabarmati	300	21674	3200	Aravali Hills Gujarat	Gulf of Khambhat

Source: [Ministry Water Resource Govt. of India]

India receives an average annual rainfall of about 4000 billion m^3 from the monsoons. The rainfall is highly erratic and unevenly distributed throughout the country. This has led to increased irrigation and ground water extraction. Of the total rainfall received, 1869 billion m^3 is lost as natural run-off in the streams and rivers, 432 billion m^3 goes for recharging the ground water and only about 690 billion m^3 of the surface water can be utilized. Table 1.2 shows the water availability in the country.

These statistics show that India has a good supply of fresh water but this is far from the truth. Almost 200 million Indians do not have access to safe and clean drinking water and an estimated 90% of the country's water sources are polluted to a great extent [3]. Ground water has been grossly exploited and at a number of places in the country, the amount of water withdrawn exceeds the amount that is recharged.

Table 1.3: Water availability in India

S. No.	Source of water availability	Quantity (Billion cubic meters)
1	Average annual precipitation	4000
2	Average annual water run-off potential	1869
3	Utilizable surface water	690
4	Replenish able ground water	432

Source: [Ministry of Water Resource Govt. of India]

In India, water quality has deteriorated steadily with time. With increase in population, the demand of fresh water also increased which in turn, led to the increased generation of wastewater. Rapid urbanization in the last century has led to the Metropolitan and other bigger cities getting choked with myriad environmental problems such as water supply, wastewater and solid waste generation and their collection, treatment and disposal. A study conducted by the Central Pollution Control Board in 2003-04 indicates that about 26,254 million litres per day of waste water are generated in the 921 Class I cities and Class II towns in India (having more than 70% of urban population) with treatment facilities available for about 7044 million litres per day only [4]. Table 1.3 below shows the trend of water supply, waste water generation and treatment available in Class I cities and Class II towns in India.

Table 1.4: Trend of water supply, waste water generation and treatment in Class I cities/ II towns

Parameters	Class I Cities						Class II towns	
	1978-79	1989-90	1994-95	2003-04	1978-79	1989-90	1994-95	2003-04
Number	142	212	299	423	190	241	345	498
Population (millions)	60	102	128	187	12.8	20.7	23.6	37.5
Water supply (mld)	8,638	15,191	20,607	29,782	1,533	1,622	1,936	3,035
Wastewater generation (mld)	7,007 (81%)	12,145 (80%)	16,662 (81%)	23,826 (80%)	1,226 (80%)	1,280 (79%)	1,650 (85%)	2,428 (80%)
Wastewater treated (mld)	2,756 (39%)	2,485 (20.5%)	4,037 (24%)	6,955 (29%)	67 (5.44%)	27 (2.12%)	62 (3.73%)	89 (3.67%)
Wastewater untreated (mld)	4,251 (61%)	9,660 (79.5%)	12,625 (76%)	16,871 (71%)	1,160 (94.56%)	1,252 (97.88%)	1,588 (96.27%)	2,339 (96.33%)

Source: [Ministry Water Resource Govt. of India]

1.6 NATIONAL RIVER CONSERVATION PLAN (NRCP)

The Ministry of Environment and Forests, Government of India, started a programme for cleaning up of rivers in the country with the implementation of the Ganga Action Plan (GAP) in 1985. A Central Ganga Authority (CGA) was set up under the Prime Minister with the members being the Chief Ministers of the concerned states, Union Ministers and Secretaries of the concerned Central Ministries along with experts in the field of water quality. GAP was extended to GAP Phase – II in 1993 and then to NRCP in 1995. GAP Phase – II was merged into NRCP in 1996. The objective of the NRCP was to improve the water quality of major rivers as the major fresh water source in the country, through the implementation of pollution abatement schemes. Since then, a single scheme of NRCP is under implementation as a Centrally Sponsored Scheme. The CGA was renamed as National River Conservation Authority (NRCA) with a larger mandate to cover all the programmes supported by the National River Conservation Directorate (NRCD).

The functions of the NRCA are as follows:

(1) To lay down, promote and approve appropriate policies and programmes (long and short-term) to achieve the objectives.
(2) To examine and approve the priorities of the NRCP.
(3) To mobilize necessary financial resources.
(4) To review the progress of implementation of approved programmes and give necessary directions to the Steering Committee, and
(5) To make all such measures as may be necessary to achieve the objectives.

GAP Phase – I was started in 1985 as a 100% centrally funded scheme. The main objective was to improve the water quality of the River Ganga to acceptable standards by preventing the pollution load from reaching the river. Under GAP Phase– I pollution abatement works were taken up in 21 Class – I towns in Uttar Pradesh, Bihar and West Bengal. GAP Phase – I was extended to GAP Phase – II, approved in stages between 1993 and 1996. It covered the River Ganga and its major tributaries, viz. Yamuna, Gomati and Damodar. This plan covered pollution abatement works in 95 towns along the polluted stretches of these 4 rivers spread over 7 states. The total approved cost of this action plan was approved on 50:50 cost sharing basis between the Centre and the State Governments.

It was later felt that the river conservation activity needed to be extended to other rivers in the country as well. Accordingly, GAP was merged into a National River Conservation Plan (NRCP) in 1995 on 50:50 cost sharing basis between Centre and State Governments. The Ganga Project Directorate was converted into the National River Conservation Directorate (NRCD) for servicing the National River Conservation Authority and the Steering Committee. It covered pollution abatement works in 46 towns along the polluted stretches of 18 rivers spread over 10 states. The GAP Phase –II was merged with NRCP in 1996.

NRCP was converted into a 100% centrally funded scheme in November 1998 with only the land cost to be borne by the States. However, in March 2001, it was decided to adopt an integrated approach for the river cleaning programme and that all future programmes will be shared on a 70:30 cost sharing basis between the Centre and State Governments respectively.

The activities covered under the NRCP include the following:

(1) Interception and Diversion works to capture the sewage flowing into the river through open drains and divert them for treatment.
(2) Sewage Treatment Plants for treating the diverted sewage.
(3) Low Cost Sanitation works to prevent open defecation on river banks.
(4) 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.
(5) River Front Development works such as improvement of bathing ghats.
(6) Public awareness and public participation.
(7) HRD, capacity building, training and research in the area of River Conservation.
(8) Other miscellaneous works depend upon location specific conditions including the interface with human population.

The criteria for funding of schemes under NRCP are as follows:

(1) NRCD/Government of India shall bear up to 70% of the Project cost.
(2) States and Local Bodies shall bear 30% of the Project cost of which the share of public would be a minimum of 10% to ensure public participation in the project.

India is blessed with many rivers. In which 12 of them are classified as major rivers whose total catchment area comes around 252.8 Million hectare (M.ha). Of the major rivers, the Ganga - Brahmaputra 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.

Rivers having several and variety of benefits to the common people are even considered as Gods and worshipped by the people in India.

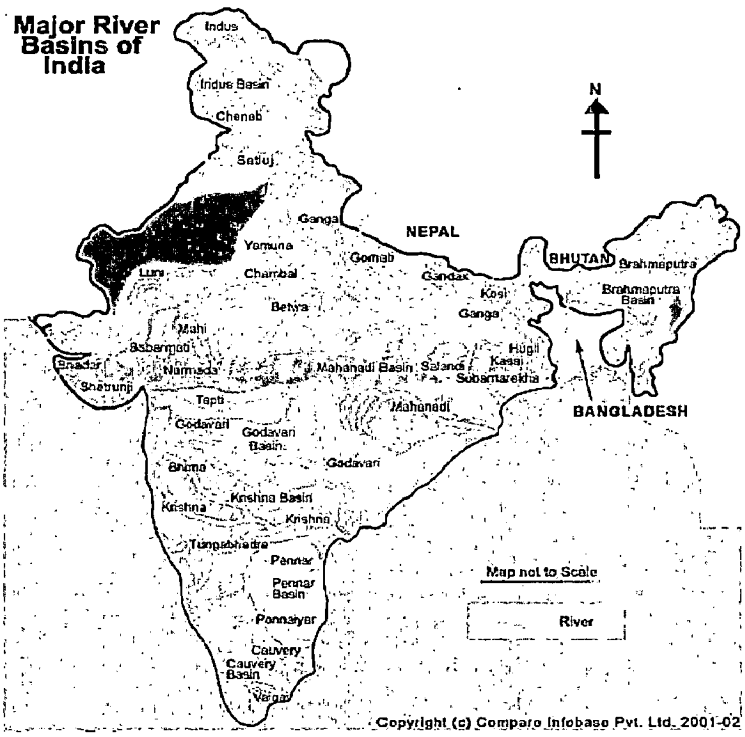


Figure 1.3 : Indian river system

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

1.7 WATER BODIES

Inland Water resources of the country are classified as rivers and canals; reservoirs; tanks & ponds; 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.

1.8 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 Km^3. 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 Km^3 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 utilizable water comes around 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 Km^3 of total potential of 1869 Km^3 can be put to beneficial use, 690 Km^3 being due to surface water resources. Again about 40 percent of utilizable surface water resources are presently in Ganga-Brahmaputra-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. Ministry of Water Resource Govt. of India)

1.9 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.. 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.

1.10 WATER AVAILABILITY

The table 1.5 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.1.5: 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: Tamil Nadu Water Supply and Drainage Board).

Table.1.6: 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 $Km.^3$	
	(ii) Ground Water Resources	432 $Km.^3$	
5	To be utilizable water Resources		1122

The table 1.6 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)

Tamil Nadu accounts for 4 percent of the total land area of India and 6 percent of the total population, but only were having 3 percent of the water resources of the country. Most of Tamil Nadu is located in the rain shadow region of the Western Ghats and hence receives limited rain fall from the South West monsoon.

1.11 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 there under
- 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

1.12 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.

1.13 PRESENT STUDY

The CPCB has Identied in the year1988-1989 itself that the Mettur Dam to Erode reach of River Cauvery is one among the 10 identified highly polluted stretches of Indian River System . Where ever gaps are observed especially with respect to pollution related indicators like Biochemical Oxygen Demand (BOD), the water body is identified as polluted. The respective Pollution Control Board has been requested to formulate action plan to restore the water quality of such highly polluted water bodies. In order to achieve the compliance of the water quality criteria in the Cauvery River following investigations are carried out:

- Inventory of sources which are discharging effluent in those stretches;
- Action Plan preparation to control the discharge of untreated effluent and implementation of the same; and,
- Location specific effluent standard based on water quality modelling exercise for the polluting sources.

The Department of Environment has been implementing a 100% Centrally sponsored scheme, 'Abatement of Pollution in five stretches of Cauvery River in Tamil Nadu' at an overall project cost of Rs.36.28 crores since 1996-97, the project period being ten years. A sum of Rs.16.58 crores has been spent by the executing agencies, viz., TWAD Board and the concerned local bodies, and this amount has been utilized fully. The scheme will be continued during 2007-2008 for Erode, Komorapalayam, Bhavani, and Pallipalayam. Interception and diversion of sewage works in Komorapalayam and Erode have been completed and other works are in progress.

In the study area from Mettur dam to Erode stretch 25 Million cubic metres of waste water have been generated per annum respectively from six urban areas. The facilities for waste water collection are totally nil. The existing treatment facilities treat only 35.11MLD or 12.815 Million cubic metres of generated wastewater only 51.26% of the waste water and also mostly up to primary level and to some extent to secondary level before discharging to River Cauvery.

Due to problem of ground water pollution, the treatment plant of Erode Waste stabilization pond was none functioning for past one and half years, For Bhavani Town treatment plant was none functioning due to public agitation related to ground water contamination. For Pallipalayam for want of segregation of dyeing effluents the D.P.R has to be finalized. Regarding Komorapalayam the treatment plant was functioning and trial run by Tamil Nadu Water Supply &Drainage Board.

Due to Public agitation and ground water contamination from the treatment site in Erode, and Bhavani Town, the above two treatment plants are kept idle for more than one and half years. The Tamil Nadu Government now sanctioned Sewerage schemes including collection system and treatment plant for the following municipalities Mettur, Bhavani Town, Erode and Komorapalayam. A distinction may be made between the amount of water needed to maintain an ecosystem in close to pristine condition, and what which might eventually be allocated to it, following a process of environmental, social and economical assessment.

Cauvery River flow pattern is controlled by Mettur Dam Water releasement regulations, Necessary inflow, and evaporation and quality of river water are monitored by State Government P.W.D Cauvery Division Mettur.The Central Water Commission Gauge Station at Urachikottai D/S of Mettur Dam also monitors the flow measurements and quality of Cauvery River water.

In general, there are three ways to improve the water quality of the Cauvery River

1) Reduction of pollution load
2) Increase of flow rate
3) Enhancement of the self-purification function of the River

Regarding the pollution load (BOD, in particular), the following are involved in BOD overload: the confluence of Bhavani River water , Drainage Channels water of Mettur,Komarapalayam,Bhavani,Erode, Veearpan chattram, and Pallipalayam Municipalities and drainage from wastewater treatment plants from Komorapalayam Wastewater Treatment Plant. Eutrophication symptoms were also observed from Bhavani Town. It seems that due to eutrophication, the oxygen concentration has risen up to 20 mg/lit, the observations were taken during day time, when photosynthetic effects were prominent.

Regarding the pollution load (BOD, in particular), the following are involved in BOD overload: the confluence of Bhavani River water , Drainage Channels water of Mettur,Komarapalayam,Bhavani,Erode, Veearpan chattram, and Pallipalayam

Municipalities and drainage from wastewater treatment plants from Komorapalayam Wastewater Treatment Plant.

The reduction of the pollution load is of primary importance for the improvement of river water quality. Therefore, it is necessary to promote the expansion of sewerage systems and the introduction of advanced water treatment technology in treatment plants.

An increase in flow rate during irrigation water release in Cauvery River the water quality gets improved significantly. In non flow season and the minimum lean flow periods the assimilation and self purification capacity of the river water is not enough to digest the pollutant load. The Self-purification Rivers is based on the self-purification function it varies depending on the biota that inhabits the rivers. Generally, rivers themselves are turbulent enough to allow for rapid mixing and dilution of the effluent. Mixing of the effluent occurs in rivers at various degrees. In rivers, complete mixing is likely to occur upon entry, provided that the stream volume and flow are greater than the volume of effluent being discharged. In larger streams, the effluent may form a plume, and complete mixing may be reached only over a long distance.

By analyzing the field data's and flow and water quality records available from State PWD and Central Water Commission Gauge Station Urachikottai. The relation between fresh water flow ,pollution load, assimilation capacity of the river, dilution factor available during, non flow days as well as calculating minimum environmental flow needed for the river Cauvery to maintains its riverine ecosystem and sustain the life of the river to avail its resources with out contamination.

It is also to explore the possibilities to reuse the treated effluents from local bodies to By farming suitable effluent irrigation or sewage farming and effluent forestry so as to minimize the pollution load to the Cauvery river by method of analyzing the present pollution load and available effluents from treatment plants in the study area.

In this dissertation preparation of necessary outline proposal for river restoration including land area required for farming, river shoreline development, and Solid waste management, Construction of toilets, Public awareness and creation of separate authority for Cauvery River Restoration Programme are to be focused here.

CHAPTER-2

REVIEW OF LITERATURE

2.1 INTRODUCTION

The environmental issues had dominated after Stockholm conference in 1972 and this has led to growing realization of the problem of water pollution, resulting in a rapid proliferation of hydro biological studies. As a result, rivers are being studied for the past several years by various departments and researchers of different discipline. Besides this, various conference were held to focus the attention of the Central and State Government and particularly of the public toward the deteriorating condition of our rivers. The growth of literature and data based on water pollution with special reference to urbanization and industrialization has been influenced after the implementation of the Ganga Action Plan, 1985.

2.2 GENERAL

The growing population and subsequently urbanization and industrialization are unabatedly polluting the rivers. The quality of the river water starting from the sources to the sea is a mirror of the human activities. The water is drawn for use such as drinking, washing, agriculture, industries and other purposes and return to the river as an effluent along the flow path. As a result, due to increasing industrialization and urbanization and other anthropogenic activities, fresh water is becoming an increasingly scarce resource. As population and development pressure continue to grow, most of our water bodies have become polluted (Saluja and Jain, 1998)]. Murugesan and Sukumaran (1999) noted that rapid population growth, increasing living standard, wide sphere of human activities, growing urbanization and industrialization have resulted in greater demand of good quality water, while on the other hand pollution of water resources is also increasingly steadily in the future days. The riverine resources of India containing 113 river basins out of which 14 are major, 44 medium and remaining 55 are minor rivers.

The fourteen major river basin account for 83 % of the total area of the basin and contributes 85 % of the total surface flow and covers 80% of the total length (Nilay Chaudhuri, 1983)]. A river basin of 720000 km^2 catchments area characterizes the major rivers (Rao, 1979; Jhingran, 1991 and Gopakumar et al., 2000) .

The main cause of river pollution is due to discharge of industrial effluent, domestic sewage, agrochemical and other human activities. Due to river pollution, marine organisms have been decreased by 40% in the last two decades. Regarding to the human health, number of diseases affecting heart, kidney and bones are caused due to pollution of the aquatic system. Nearly 20 lakh people are dying annually due to polluted water in India. The polluted water takes the life of one child in every minute in India.

The Central Pollution Control Board (CPCB) has brought out the amount of deterioration of water quality over the years as per analysis of river water from 1986 to 1977. The Board also indicated that mean **BOD values** have gone up in the entire major river during the last two decades. Water quality assessment in respect of BOD values indicates that Kerala is at the bottom and Maharashtra at the top in 1997.

Regarding to coli form bacteria, the most affected states are Assam, Uttar Pradesh, Gujarat and Tamil Nadu. In respect of chemical pollution, Gujarat ranks first and next followed by Maharashtra, Andhra Pradesh, Tamil Nadu, Uttar Pradesh and Punjab. Recent survey has revealed that almost all major river in India have become highly polluted (Mahajan, 1988)].

Earlier, the World Health Organization (WHO, 1985) found that more than 1000 organic compounds are present in river water and effluents.

The confluence of such effluents has great impact on the physico chemical and biological character of the river system. The nature and health of the aquatic communities indicate an expression of the quality of water. The gradual increasing high values of physico chemical parameters might have eliminated all the indigenous life leading to the formation of biological desert. (Rana and Palria, 1982).

2.3 SOURCES OF POLLUTION

Pollution of river water associated with industrial and sewage discharge is a global problem. It is reported that about 70% of the available water in India (Citizens report, 1982) is polluted. The chief sources of pollution are identified to be industrial pollution constituting 8-16% of the waste water and sewage comprises 84-92% (Chaudhuri, 1982). The sources of river pollution in India are tabulated in Table 2.1.

Table 2.1: Sources of river pollution in India

Sl. No.	Name of the river	Sources of pollution
1	Ganga	Industrial, urban and agricultural activities.
2	Yamuna, Delhi	Sewage, DDT factory and other industries and power plant
3	Kali, Meerut (UP)	Sugar mills, distilleries, paint, soap, silk, yarn, tin and glycerin industries
4	Bajora, Bareilly (UP)	Synthetic rubber factories
5	Ganga, Kanpur	Jute, chemical, metal, surgical, tanneries, and sewage
6	Gomti, Lucknow (UP)	Paper and pulp mills and sewage
7	Suvaon, U.P	Sugar mills
8	Siwan, Bihar	Paper, sulphur, cement & sugar mills
9	Damodar, Bokaro	Fertilizers, steel mills, coal and paper plant
10	Sone, Bihar	Cement, pulp and paper mills
11	Hooghly, Kolkata	Paper & pulp, power plant, jute, textile, chemical, paint, varnishes, metal, steel, oil, rayon, soap and
12	Bhadra, Karnataka	Pulp, paper and steel industries
13	Cauvery (Tamil Nadu)	Sewage, tanneries, distilleries, paper and rayon mills
14	Godavari	Paper mills
15	Kulu, Mumbai	Chemical, rayon and tanneries
16	Brahmaputra	Oil drilling, refineries, paper mills and sewage
17	Barak	Paper mills
18	Digboi river	Refineries
19	Dilli	Fertilizers

Source: Central Pollution Control Board.

2.4 EFFECTS ON RIVER WATER

With the rapid industrialization and urbanization during the last 50 years, most of the Indian rivers are subjected to indiscriminate discharge of effluents affecting water quality and aquatic life (Verma and Shukla, 1969) . Increasing pollution of rivers and other water bodies has become a matter of great concern in recent years (Ambasht, 1990; Dikshith et al., 1990). The industrial effluent, domestic and municipal sewage produce hazardous effects on aquatic life and ecosystem of the receiving water bodies (Ajmal et al., 1985; Neman and Lal, 1985).

The effect on river water due to discharges of industrial effluents and domestic waste water are considered on the following parameters:

1. Effect on physico chemical parameters of the river water,
2. Effect on flora and fauna of the river aquatic system,
3. Eutrophication of the river.
4. Effect on bacteriological parameters,
5. Effect on self purification capacity of the river.

River systems have been dramatically altered by dams and reservoirs, canalization, and land use developments throughout their drainage basins. Some species of flora and fauna have disappeared; exotic species have invaded; the functional characteristics of the river systems have been disrupted; and there has been a reduction in landscape quality and loss of wilderness areas. The need to restore rivers and their water resources because of their existing needs for water supply, irrigation, industrial , for hydro-electric energy and the increasing needs of rapidly growing populations and their likely increase in per capita resource demands. However, there is arising a strong concern for ecosystem sustainability in the face of both socio-economic development and climate change. The restoration of rivers degraded by past urban, industrial and agricultural developments is now a priority for the developed nations.

2.5 NATURAL CONCENTRATIONS IN RIVERS

In any region not yet affected by human activity, the variability in natural water quality depends on the combination of the following factors.

The occurrence of highly soluble or easily weathered minerals of which the order of weathering is halite > gypsum > calcite > dolomite pyrite>olivine.

- The distance to coastline,
- The precipitation/river run-off ratio, and
- The occurrence of peat bogs, wetlands and marshes which release large quantities of dissolved organic matter.
- Other factors includes the ambient temperature, thickness of weathered rocks, organic soil cover etc.

(Meybeck and Helmer, 1989).

2.6 VARIATIONS OF WATER QUALITY AND RIVER DISCHARGE

Water quality variability depends on the hydrological regime of the river, i.e. the water discharge variability, the number of floods per year and their importance etc. During flood periods, water quality, usually shows marked variations due to the different origins of the water: surface run-off, sub-surface run-off (i.e. water circulation within the soil layer), and ground water discharge. Surface run-off is generally highly turbid and carries large amount of total suspended solids, including particulate organic carbon (POC) .Sub surface run-off leaches dissolved organic carbon and nutrients (N and P) from soils, where as ground waters provide most of the elements resulting from weathering. Changes in discharge, when compared to the simultaneous change in concentration of various substances, are of great value in indicating the major source of substances. This is illustrated by the curves of concentration versus discharge. Thomas, R.B.1986. "Calibrating SALT ", a sampling scheme to improve estimates of suspended sediment yield. In: D .Lerner, Monitoring to Detect changes in water quality series.

2.7 FACTORS AFFECTING BIOLOGICAL COMMUNITIES IN RUNNING WATERS

Flowing waters are complex ecosystems consisting of different habitats (biotopes) and biotic communities (biocoenoses). The physical Structures of the ecosystem may be broadly dived into:

The water body and stream bed (aquatic zone), the water exchange zone (lentic zone and flood plain) and the environment influenced by the water (terrestrial zone). For the purpose of water quality assessment the aquatic zone is most important. The three zones are characterized by specific hydrological features which directly, or in directly, governs the biological communities that thrive there. The characteristics of the habitats vary from the head-waters to the sites of eventual discharge to receiving waters. Consequently, the biological communities also vary, not only from site to site, but along the length of the river. For successful colonization of the water mass, living organisms have to adopt a variety of basic, life strategies, principally:

- To exhibit growth patterns and survival techniques this can withstand the relatively short retention times,
- To exploit "refuge" spaces or boundary layers, or
- To have the ability to swim against the prevailing currents.

For small organisms unable to swim against the current, adaptations include a flattened or spindle –shaped body, as well as adhesive devices and the occupation of the spaces with little or no water flow. In this the organisms are not carried away by the current and can benefit from the flowing water which provides continuous, rapid exchange of oxygen and nutrients.

In considering a flowing water ecosystem, two important aspects must be taken into account.

1. Continuous water flow allows any input, such as an effluent, to have an effect locally as well as along the downstream course of the river.
2. As river water is usually retained within the watercourse for relatively short periods (days to a weeks) before being replaced from other sources, time dependent processes, such as growth or degradation, have only a limited time period within which they can show their effects.

A number of physico-chemical characteristics of particular importance in determining the biological nature of the river systems through their modification of suitable habitats. These characteristics are: Flow rate, Erosion and deposition, substrate nature, light; temperature and oxygen.

2.7.1 Flow Rate

The velocity of water with in a river has direct and indirect effects on the biota. It supports or carries organisms determines the physical structure of the stream bed and has considerable influence on surface exchange of gases. The roughness of the river bottom, as well as the flow pattern arising from it, are important for the formation of habitats in which organisms can survive. In most rivers, discharge varies seasonally, imposing seasonal changes on biological communities.

2.7.2 Erosion and Deposition

Rivers are subjected to continuous change through erosion and deposition. In normal conditions, this can lead to the displacement of the stream bed and the channel line. Such effects may also be artificially magnified by human activities in the terrestrial zone. Erosion which is intensified by human activity leads to the loss of habitats and a reduction in biological communities in the affected reaches of the river. Occasional movement and displacement of deposited sediments and rocks are normal processes inflowing waters, and have little impact on biological communities. Permanent displacement on a large scale (particularly in areas of high erosion) frequently occurs in fast flowing rivers, especially in tropical countries, and tends to prevent colonization by organisms.

2.7.3 Substrate

The substrates available for colonization by biota vary considerably in rivers, such as solid rock, stones, gravel, sand or sludge. Roots, dead wood, as well as submerged spermatophytes, mosses, filamentous algae, reeds and floating leaf plants also form natural substrates. Mobile animals generally prefer the sides of substrates which are sheltered from light and he water current. Consequently, the spaces between and beneath stones are particularly suitable habitats, as are moss layers and the standing crop of water plants. Sheltered spaces with slow flow conditions offer favorable living conditions to many invertebrates and also provide spawning grounds for fish. The pore spaces below the stream bed are also biologically important habitats, providing refuges for the early development stages of invertebrates and fish and a suitable medium for the self-purification processes carried out by micro-organisms.

2.7.4 Light

Light is required for photosynthesis by all river primary producers, i.e. the algae and macrophytes. Sub–surface light is usually exponentially absorbed in its downwards passage through the water column. The depth of the euphotic zone in rivers is highly dependent on the water colour and the amount of suspended sediment present. In lower reaches of a river where the water is deeper, or more turbid, the euphotic zone may be wholly contained within the main water mass.

2.7.5 Temperature

Water Temperature influences the rate of physiological processes of organisms, such as the microbial respiration which is responsible for much of the self-purification that occurs in water bodies. Higher temperature support faster growth rates and enable some biota to attain significant populations. In running water, the temperature normally increases gradually from the source of the river to its mouth. Cooling waters discharged to rivers, e.g. from industrial activities or from power generation, can lead to higher than normal water temperatures. These increased temperatures cause problems for sensitive organisms due to the increased oxygen demand (lowering oxygen saturation) and increased level of toxicity of harmful substances. They are sometimes also responsible for fish kills.

2.7.6 Oxygen

Oxygen is one of the most important factors for water quality and the associated aquatic life. Oxygen deficiency, even if it occurs only occasionally and for short periods, leads to a rapid decrease in the number of aquatic animals present, particularly the clean water species which depend on high oxygen levels, as well as most fish. In slow- flowing or impounded rivers, the effects of eutrophication (nutrient enrichment) can lead to deoxygenation of the sediments and possible remobilization of nutrients and toxic trace elements, particularly from the sediments.[M.Meybeck,G.Friedrich,R.Thomas and D.Chapman].

2.8 PELAGIC COMMUNITIES

The pelagic communities are those swimming or floating organisms associated with free water in the aquatic zone of the river .e.g. plankton and fish. The phytoplankton of rivers and streams are only able to attain obvious population when their growth rates are such that sufficient population doubling times can be attained within the retention periods of the water courses. Increased light, higher temperature and lower turbidity, together with reduced velocity which provides longer watercourse retention times, tend to promote greater phytoplankton growth rates. River management practices such as abstraction or weir controls can lead to increased phytoplankton growth rates. Phytoplankton's are particularly sparse, or absent altogether, in small streams and more free –flowing rivers, particularly where there is little or no natural, or artificial, input of nutrients. In many tropical and sub tropical rivers, phytoplankton communities do not reach high densities due to the very high levels of turbidity caused by suspended solids arising from land –based erosion processes. Submerged vegetation is, therefore, also rare. Zooplanktons are small, to microscopic, animal which feed on primary producers or their products, or on other zooplankton. The juvenile stages of larger zooplankton (1 mm) may last for several days and, therefore, substantial populations can only be produced in rivers with very low velocities and warm water. However, smaller zooplankton such as rotifers can attain quite large population. Fish can be able to exploit all physically accessible river habitats. Their eggs often adhere to stones or weeds, or may be deliberately placed in specially constructed refuges. Consequently, high specific physical conditions are necessary in a river foe successful fish breeding. Fish communities are, therefore, sensitive to modification of river regime (velocity, erosion, etc.) as well as to the input of toxic substances.

Migratory fish which return from the sea to spawning grounds in upstream stretches of rivers and their tributaries can be prevented from reaching their spawning grounds by physical barriers or chemical barriers along their migratory route.

Physical barriers consist of weirs, locks and dams and chemical barriers are stretches of highly toxic or anoxic water in the river. The removal or bypassing, of barriers to fish migration is fundamental to the restoration of water quality to a level which is acceptable by naturalists, fisherman, and the general public.

Examples of schemes to restore self sustaining populations of migratory salmonid fish can be found from several countries (Canada, UK, and Japan) as well as for international rivers, such as the Rhine (IKSR).Such schemes provide visible evidence to the general public that river water quality has been improved.
[M.Meybeck, G.Friedrich, R.Thomas and D.Chapman].

2.9 TYPES OF RIVERS

From a biological point of view, flowing water has number of advantages over still water, despite the stress exerted on biota: it is constantly mixed by turbulence providing nutrients, exchange of respiratory gases, and removal of wastes. Flowing water is also fundamental for the downstream and lateral dispersal of attached and suspended algae, macrophytes and invertebrates, despite the high mortality caused by mechanical stress. The principle components of the biotic milieu of river eco systems-hydrology, temperature and channel morphology-reflect regional-scale climate and geology. A river may be viewed as a serious of reaches or sectors each receiving and discharging water, sediments, organic matter and nutrients. Flowing water is also fundamental for down stream and lateral dispersal of attached and suspended algae, macrophytes and invertebrates, despite the high mortality causes by mechanical stress. Food cause hydraulic disturbance but this is important in determining the composition of biotic communities with in the river, the riparian zone and the floodplains.
[G.E.PETTS AND P.CALOW-1994.]

2.10 KEY PROCESSES

Throughout fluvial hydro systems important interactions takes place across the land-water boundary. These interactions are main feast in a number of ways: organic matter inputs, nutrient fluxes; predation by terrestrial birds and mammals etc.In the production zone, river processes are closely tied to hill slope processes. In Floodplain Rivers, the ecological integrity of the system is depending upon the strength of connectivity between the river and the flood plain. This has been described as ``flood pulse `` concept. (Junk et al).

Within river habitats are in large part determined by a range of hydraulic and morphological variables; flow depth, velocity, shear stress; and river width, depth, slope, pattern and substrate characteristics at any point along a river, the channel morphology is adjusted to the supplies of water and sediment from upstream, modified by local conditions. The pattern of velocity variations in space and time has a strong influence on biota, especially benthic invertebrates and algae. River eco systems are structured by flood webs. The role of flood webs is a key topic because of the importance of river communities in both environmental management and assessment. Food web structure obviously relates to the nature of biological interactions such as competition and predation but they too, also relate to environmental characteristics. Habitat diversity, especially the complexity of refugia along the river margins and on, and within, the river bed has an important influence on the shape of the food web.

Primary production can be important in most running waters. It is the Detritus from both allochthonous (wood leaves etc) and autochthonous (dead aquatic animals and plants) sources that is quantitatively the most important fuel for running water food webs. The importance of detritus is that it comprises not only decomposing organisms such as fungi, bacteria, micro invertebrates have received most attention not least because they link the micro-organisms that dominate nutrient cycling on the one hand and fish, often the focus of interest in river management, on the other Disturbances such as floods or erosion play a critical role on organizing communities and eco systems.[Townsend 1989, Rice et al 1990]. And this has important management implications, with regard to the long-term effects of human impacts. The diversity of vegetation patches on floodplain is related to the rejuvenation of successions associated with river erosion and deposition so that the patch mosaic reflects age structure and patch type.

2.11 MANAGEMENT PERSPECTIVE

All levels of conservation require management; controls-and the administration of these controls-on the wide range of human activities that influence river eco systems. These include:

1. Point source pollution controls (especially implementation of effluent discharge standards)
2. Land use regulation includes the definition of production zones for groundwater and the use of buffer zones to minimize diffuse-source pollution.
3. Water allocation to meet seasonally-variable in stream and riparian flow needs
4. River and floodplain management to sustain morphological diversity.
5. Controls on human use of a river for fishing, recreation etc.
6. Controls on biota to prevent over pollution of certain species, including deliberate or accidental introductions and biological invasions.

These management options may be organized in a decision-making framework that focuses on achieving maximum resource development while providing for ecological conservation (PettsG.E1989).At the first level, options for modifying river projects should be considered with the specific aim of maintaining the natural structural and biological dynamics of the fluvial Hydro systems. Water quality controls, flow manipulations and river management are key concerns. The economic and environmental effectiveness of first order management proposals should then be evaluated in relation to second-order options (direct controls on biota and on human uses) [Calow P.Petts G.E [1994].

2.12 THE NATURE OF POLLUTION

Pollution is a term applied to any environmental state or manifestation which is harmful or unpleasant to life, resulting from failure to achieve or maintain control over the chemical, physical or biological consequences or side-effects of human scientific, industrial and social habits, gross contaminations and subsequent deoxygenating by untreated sewage, high organic suspended solids and high ammonia levels, with high biochemical oxygen demand (BOD) were characteristics of such problems. Reduction in fish species, invertebrate species and macrophytes species was followed by a total disappearance of fish, survival of two or three pollution-tolerant invertebrate groups and massive encroachment by one or two species of emergent macrophytes, or dense algal blooms.

2.13 RIVER USES

One of the major corollaries of effluent control policies is that acceptance by society that rivers are suitable environments for getting rid of wastes. The fact that they flow downstream means that, unlike still fresh waters and, to a lesser extent, costal waters any pollutant entering them is washed away from its point of entry.

When humans were ecological rather than global creatures and lived in relatively small numbers in small communities, rivers were able to cope with the biological loads that were discharged into them. Increasingly large communities, increasing densities of pollutions and increasing use of resources have meant that not only are effluent controls necessary, but effluent treatment to limit the effects of discharges is also accepted as a necessity to maintain a reasonable water quality. A reasonable water quality is important in order that we can benefit from rivers by a series of "uses". In the U.K a set of uses have been fixed [Department of the Environment 1992] as follows:

1. Fisheries ecosystem: Six classes suggested from salmonid to no fish.
2. Abstraction for drinking water supply,: related to E.C directions.
3. Agriculture obstruction: Sets of standards for live stock watering and for irrigation.
4. Industrial obstruction: Suitable standards.
5. Special ecosystem: For sites where unusual fauna and /or flora are present.
6. Water sports: Chemical and bacteriological standards related to human health risk.

Each of these uses influences the quality of the river water. At present, rivers are an indispensable receptacle for wastes, but this use differs from those listed above in that quality criteria are applied to the effluents, so that the final quality of receiving river enables it to be suitable for specific purposes. In reality the balance between effluent quality, quantity and river use has been achieved by a combination of historic precedents and economic constraints. The "use" related quality objective system is an attempt to plan this process. (Department of Environment London) River quality (1992).

2.14 CHEMICAL MEASUREMENTS

Pollutants can be measured in two ways: firstly by chemical analysis, and secondly by their effect on the biota present in and around the river.

Measurement by chemical analysis is the most obvious method of assessing pollution and has the great advantage that it can be applied directly to effluents. It can be applied to simple chemicals such as metals, salts and dissolved gases as well as complex organic compounds such as chlorinated hydrocarbons. (Meybeck et al 1989). Measurements of some other parameters can also be carried out on effluents relatively easily, e.g. temperature, turbidity, colour and pH.Controls of discharges are relatively simple to operate when applied to these parameters. However, knowing the nature of a pollutant in an effluent is only the first of a series of requirements. Measurement of the amount of effluent entering a river provides a total loading of that material. Most effluents vary in quantity as well as quality so that load may be varying different at different times of that day, of the week or seasons of the year. The river flow will also vary throughout the year. Calculation of dilution factors is rendered more complex by such variations and often the worst situation is used to define consent limits i.e. maximum effluent concentration and maximum permitted effluent quantity under dry weather flow conditions of the river.

Variations in quantities of chemicals in effluents may create difficulties in assessing pollutant loading of rivers. This is particularly important when dealing with substances which bio accumulate in nature Many discharges to rivers are intermittent (e.g.strom overflows) and produce peaks of chemical concentration in the river down stream. The concentrations of pollutants in the river will be lower the further downstream it is sampled away from the discharge. The presence of a particular pollutant in a river indicates an input, but does not pinpoint its source.

The consent limit therefore provides the ceiling level of pollutant (concentration multiplied by quantity of effluent) allowed into a river by the regulatory authority. It does not necessarily equate with a "no observable effect concentration" in the receiving river.

2.15 ECOTOXICOLOGICAL EFFECTS

Modern technology uses tens of thousands of different compounds, most of which find their way to the local river via sewage works, industrial discharge or diffuse input (e.g. agriculture). It is not possible to have analytical suites to monitor for the presence of all of these materials, so their effect on biological system is often used. This is particularly helpful in assessing the toxicity of complex effluents where many similar organic compounds may be released in to the discharge. Simple toxicity tests involve the addition of an effluent to certain volumes of water to produce a series of dilution to which fish, invertebrates or bacteria are introduced. Until recently the end point of toxicity tests was death of the test organisms (Claims and Dickson 1973).

2.16 ECOLOGICAL IMPACTS OF POLLUTANTS

In a population subjected to a pollutant challenge, there will be intrinsic factors that determine the severity of damage to individuals with in it. A riverine community, because of the different niches occupied by component organisms, will be disproportionately damaged in some areas by extrinsic factors as well. For example, with benthic macro invertebrate communities, competition between individuals in populations may force the smaller or less fit members in to the substrate. In the event of pollution of the river, these individuals may survive to recolonize the more favorable parts of the substrate, replacing those organisms lost. Enhanced detachment and increased drift can occur as a result of pesticide application to streams, resulting in changes in insect distribution (Muirhead-Thomson 1987).The immediate environment of organisms in the water flow also influences their survival and here the influence of dead zones becomes apparent. These zones of relatively static water within rivers may have retention times many times greater than that of the main river. Their stability depends on the nature of the river bed and banks, and the speed of the flow. In low flow summer conditions retention times of water in these dead zones can be up to several weeks. Absorption of pollutants is slower, but so is release downstream. Fish and macro invertebrates may use them as refuges from chemical assaults under certain conditions of flow Impaired flows at the edges of rivers will act in similar ways and enable some organisms to escape from high concentrations of toxic materials flowing downstream.

There is a large element of chance in pollution incidents in that at any one time a different group of organisms may be affected. Low dissolved oxygen is the most common cause of fish mortality in rivers. It can result from a large number of organic materials entering rivers (e.g. pulp, sewage, silage, milk, urea, ammonia) and depressing the available oxygen. If it coincides with migratory fish presence in that section of the river, then considerable inroads can be made in to those populations.

The same occurrence days or weeks later may have little effect on those populations. At other times, coarse fish fry or eggs may be severely affected. Such intermittent pollution episodes result in biological communities of an apparently unbalanced nature being present for significant periods of time. The ecological picture presented as a result of intermittent discharges is consequently different from that presented by continuous discharges.(Muirhead-Thomson 1987).

2.17 PHYSICAL EFFECTS

The chemical composition of polluting materials has been the subject of polluting materials has been the subject of many investigations over the last 150 years. Less attention has been paid to physical pollution studies. Studies in this area have concentrated on temperature; pressure or the nature of suspended or settle able solids. Thermal discharges (e.g. power station effluents, cooling water from chemicals manufacture) have direct and indirect effects. The direct temperature effect of increased productivity as a result of raised metabolic rates. It is illustrated from the river Trent in Nottinghamshire with its numerous coal–fired power station effluents. Less well documented are temperature influences in the lower river Thames as a result of major sewage works inputs. For organisms well with in their thermal range, minor temperature changes are relatively important, but their organisms at the edge of their range this additional environmental stress may decide between species survival and extinction. The return of Salmon to the River Thames may be jeopardized by relatively small increase in Temperature. Many materials are suspended or dissolved in organic solvents. The nature of these organic solvents is normally lipophilic, i.e. cell membrane-dissolving or exoskeleton-affecting. Damage caused by such solvents, because of their detergent effect, is irreversible and often greater than the solute or suspension that they carry (Dickson et al 1987).

2.18 BIOLOGICAL POLLUTANTS

Pollution studies have been centered on chemical analysis and biological effects. The major contributor to river pollution in most developed countries is still the domestic component of sewage.

There is a scientific discipline geared to measuring BOD, Dissolved Oxygen and Ammonia in all its forms. The bacterial component of effluents like sewage and silage is considerable and normally expressed as Coli forms, Escherichia coli, or faecal Streptococcus numbers per 100 ml of receiving water. In more eutrophic waters the natural balance would favour heterotrophs; in mesotrophic and oligotrophic environments, autotrophs would predominate. The influence of this bacteria input to riverine ecology is both fundamental and massive and yet it remains one of the least investigated components of sewage pollution.

2.19 POLLUTANTS PATHWAYS

There are three major routes by which pollutants can enter living organisms- with their food, via their respiration and by contact. The major route of entry depends on the physical and chemical characteristics of the pollutant and the level of organization the assaulted animal or plant. Some materials have immediate effect on the individual while others bioaccumulate and their effects may not be realized for a considerable time. Chloride is a good example for the former: in water it can exist as free chlorine or combined with Ammonical compound as chloramines (Lievsley and Perims 1991).

2.20 EUTROPICATION

A whole series of human activities have resulted in the enrichment of rivers in many parts of the world. Sewage effluent, industrial discharges, farm slurries and agricultural run –off are all major sources of plant nutrients, notably nitrates and phosphates. In rivers in their natural state the limiting factors to plant growth vary according to topography, geology and geography (Haslam SM. 1990).By increasing light, increasing nitrate, but primarily by addition of phosphate enhanced plant growth results. This growth may be of relatively small numbers of submerged or emergent macrophytes, floating leaved plants or diatoms green algae or blue green algae. The particular species that predominate will depend on the original diversity present, but essentially the effect is one of species impoverishment with a large biomass of very few species.

Habitat provision afforded by plant communities is a major influence on the diversity of macro invertebrates, so that enriched rivers become impoverished in their macro invertebrate fauna, not only because of direct influences of water quality, but also by direct indirect influences. Such changes inevitably control the composition of the fish community. Eutrophication has been initiated by the domestic sewage and effluent into river or other water bodies. Seven and Walter (1989) have defined eutrophication is qualitatively as the state of a water body which is manifested by an intense proliferation of algae and other higher aquatic plants and their accumulation in the water body in excessive quantities resulted as bloom due to nutrient enrichment of water . .A phosphorus and nitrogen input from domestic wastes water and agricultural fertilizers accelerates the process of eutrophication of aquatic environment (Schindler, 1971).

Eutrophication is a burning problem for the aquatic environment. The pollution resulting from increased human activities is threatening the several rivers characterized by eutrophication and the occurrence of dramatically low dissolved oxygen (Jhingran, 1991).

2.20.1 Effect on Bacteriological Parameters

Sewage loaded with human excreta and direct human defecation are the two major sources of the faecal pollution in Indian rivers. Microbiological studies on water quality of major Indian rivers have shown the presence of faecal coli form and faecel *streptococci* as an indication of faecal contamination (Shukla et al., 1992; Gaur et al., 1997). The high faecal load indicates the high degree of human defecation by thick urban population on the bank of the river and directly discharge the nutshell into the sewage system ultimately which comes to the river. The most common and widespread danger associated with the drinking water is directly or indirectly contaminated by sewage, human and animal faecal matter and other wastes (Clark, et al., 1982) .

Some coli forms are faecal in nature and those reach the terrestrial and aquatic ecosystem via alimentary canal of herbivorous animals. Non faecal bacteria are the normal inhabitants of soil (Salle, 1971). Thelin and Gifford (1983) observed that the number of faecal coli form bacteria released from 30 days old faecal deposits amount to several millions per 100 ml .

The survival and multiplication of total coli form bacteria species in water depends upon several factors like temperature, light, various chemicals, which are directly proportionate to the amount of sewage and human interferences (Hiraishi et al., 1984) .

The content of E. coli in open water bodies varies with seasons and their level sharply increases after heavy rainfall (Voznaya, 1981). The *Escheria coli* and coli form group or organisms as a whole has been recommended for the detection of water quality. Concentration of coli form bacteria is usually as an index of civic pollution.

2.20.2 Effect on Self Purification

Accumulation of sewage in water bodies retards the self regulatory capabilities of aquatic organisms. Self purifying ability is lost and it becomes unfit for domestic purposes. Sewage containing oxidisable and fermentable matter causes depletion of dissolved oxygen in the receiving water bodies. Presence of solid matter flowing in suspension, colloidal and pseudo-colloidal dispersion in sewage creates severe water problems. When industrial effluents are discharged through sewage system, these adversely affect the biological purification mechanism of sewage treatment and put an adverse effect on the receiving water body.

2.20.3 Chemical indicators of pollution

The concentration of dissolved oxygen (DO) can be used as a good indicator of the polluted river water due to its chemical and biological nature. The rate of deoxygenating reflects the BOD exertion rate in the river water. The reaeration rate is directly proportional to the DO deficit from the saturation value. Regarding this, the state of pollution of a river can be assessed by observing the concentration of dissolved oxygen present in the river water. Similarly, the pollution status of a river can also be judged by using the concentration of BOD present in the river water.

2.21 ACIDIFICATION

In the context of aquatic pollution, the decrease in pH of freshwaters is encompassed by the term acidification. Simple chemistry informs us that it is a shift to the right of the following equation:

$$(H_2O) = (H^+) + (OH^-)$$

with pH being defined as $-\log 10\ (H^+)$.

The effect of acidification are the gradual removal of fish species until only the most tolerant are left, the elimination of the crustaceans and the disappearance of mollusks.

2.22 BIOLOGICAL WATER-QUALITY ASSESSMENT OF RIVERS

At present, the monitoring, assessment and regulation of aquatic ecosystems is largely based on chemical measures of water quality. Direct biological assessments of the health of biotic communities in receiving waters offer several important advantages over chemical –based approaches. Biological assessments may also be able to detect the impact of flow alterations, habitat destruction, over harvesting of biological resources, etc. (Karr 1991).

2.22.1 Benefits

1. Macro invertebrate communities are differentially sensitive to pollutants of various types and react to them quickly (Cook 1976), and are capable of a graded response (Pratt&Coler 1976).
2. Macro invertebrates are present in most aquatic habitat, especially flowing water systems (Reynoldson 1984), and are abundant and relatively easy and inexpensive to collect (Plafkin etal 1989).
3. Benthic invertebrates are relatively sedentary, and are therefore representative of local condition (Cook 1976).
4. They have lifespan long enough to provide a record of environmental quality (Pratt &Coler 1976)
5. Macro invertebrate communities are very hetrogenous,with numerous phyla and tropic level represented .The probability that at least some of these organism will react to a particular change in environmental conditions is,therefore,high (France 1990).

2.22.2 Disadvantages

1. They respond to seemingly minor changes in substrate particle size, organic content and even texture. As a result, discrimination between the effects of pollution and other environmental factors is often difficult (France 1990).
2. Their life histories are complex and the results of bioassessments can vary with season (Hellawell 1977).
3. Spatial heterogeneity is high, requiring considerable replication (Reynoldson 1984).

2.22.3 Traditional Approaches to Bioassessments

2.22.3.1 The saprobic system

The term saprobia refers to dependence of an organism on decomposing substances as a food source. According to the saprobic system, water quality is classified in to ten categories ranging from the purest ground water to anaerobic sewage and industrial wastes.

2.22.3.2 Diversity indices

Diversity indices are mathematical expressions which use three components of community structure , namely richness(number of species present), evenness(uniformity in the distribution of individuals among the species) and abundance (total number of organisms present), to describe the response of a community to the quality of its environment.Un disturbed environments are characterized by high diversity or richness, an even distribution of individuals among the species, and moderate to high counts of individuals(Mason et al 1985).By far the most widely used diversity index is the Shannon –Wiener index (H `), because it is stable in any spatial distribution and insensitive to rare species.

2.23 WATER QUALITY CONTROL

Traditionally control of chemical and biological quality of waters in rivers to protect different uses has been considered adequate to provide full environment protection. This can be achieved by control of point and diffuse discharges using a variety of measures.

However, a profound change is occurring whereby water quality control is considered as a necessary but not sufficient condition to protect the ecological quality of rivers and other water bodies (Newman et al 1992).Consideration of sediment quality and protection of riparian habitat in addition to water quality control are now seen as requirements for full environmental protection. Doubtless this wider aspect of river quality control will assume more importance in the future (Royal Commission on Environmental Pollution 1992), the control of river water quality is affected by regulation of the entry or discharge of the contaminated or polluted waters in to the river and by control of the flow regime. The effects of abstractions and other aspects of flow regime control will also important to emphasize that effective river management requires that control of abstractions and discharges are inextricably linked. In the past there were considered to be two fundamentally different approaches to pollution control: the 'quality objective approach' traditionally used, which took into account the dilution capacity of the receiving waters, and the 'uniform emission standard approach' also used, which applied the same concentration and the local conditions to discharges from the same industrial sector. Currently, these two approaches are being seen as complementary are being applied together. As indicated above, river water quality control is concerned with the control of pollution which can be defined in the widest sense with reference to European Community legislation as the discharge by man, directly or indirectly of substances or energy into the environment, the results of which are such as to cause hazards to human health, harm to living resources and to ecosystems, damage to amenities or interference with other legitimate use of water. Thus any control strategy adopted must not only control those activities likely to cause pollution in the aquatic environment, but must also protect humans from exposure to pollutants.

The selection of the most appropriate control strategy to minimize the effects of the discharge of pollutants will depend on the type of pollutant, its source and the nature and use of the receiving water. (A.J. Dobbs and T.F. Zabel).

2.23.1 Type of Pollutants

Pollutants can be classified in a variety of different ways (Holdgate .1979) lists several of these and gives advantages and disadvantages of the alternatives. An alternative approach is to divide substances into those causing direct toxic effects and those resulting in indirect effects.

1. Pollutants causing direct toxic effects: most of the substances may be classified under this heading and may include heavy metals (e.g. cadmium) organometallics (e.g.organotions), other inorganic (e.g. ammonia), persistent organic compounds (e.g. pesticides) or volatile organic compounds (industrial solvents).
2. Pollutants causing indirect adverse effects: gross pollutants causing oxygen depletion and/or Sulphide formation (e.g. farm waste, sewage effluent) or those causing eutrophication (nutrients) fall in to this category. Aesthetic parameters such as foaming (presence of detergents), colour, litter and oil, which although not toxic at the concentrations present, may also, affect the use of the water. Bacteria and viruses may also be considered as causing indirect effects by, for instance, reducing the tolerance of animals to the effect of other pollutants present. However, they can also cause direct effects (e.g. illness in bathers).The way in which contaminants cause effects and there by become pollutants varies widely. For instance, the organtins are toxic at very low concentrations to mollusc species but fish are more tolerant. In contrast, DDT's main effect occurs via food chain, because of its high bioaccumulation potential, leading to

problems in higher animals, for instance the thinning of egg shells in birds of prey.

In practice almost any chemical or contaminant can become a pollutant if it is present in high enough concentration, and the main value of pollutant classification is to focus pollution control activity on the most hazardous.(A.J.Dobbs and T.F.Zabel).

2.23.2 Sources of Pollutants

Whilst the distinction is not very precise it is often useful to distinguish between point and diffuse pollution sources because different pollution control strategies are required in each case. Point sources are best thought of as discharges from fixed sites, such as factory or sewage treatment plant, which if the process involved was stopped so would the discharge. Generally speaking a modification to the nature of the process or treatment of the discharge will change the composition of a point discharge. Diffuse inputs on the other hand result from no particular process but originate from the wide spread use of the substance. Using this approach, for example agricultural runoff would be considered a diffuse source. Phosphates used in detergents would probably also be best considered as a diffuse input, at least to the sewerage system. However, the aggregate phosphate discharged from a sewage treatment plant can be considered as a point source. It is monitored in this way and is capable of reduction by tertiary treatment.

In addition to consideration of the nature of the sources, point or diffuse, which as we have just seen depends to some extent on the point in the system where the pollutants is being considered, the temporal variability of discharges needs to be considered. In general three classes of discharge can be distinguished.

1. Continuous – a discharge whose composition and flow may fluctuate but which effectively happens all the time. A sewage treatment works effluent or a cooling water discharges from a power station are good examples
2. Intermittent- as the name implies these do not discharge all the time and they may or may not discharge regularly but their location can be identified and the discharge is to some degree predictable in terms of composition and flow. Probably the best example is a storm sewer overflow; during rain events of a given severity such over flows will produce a discharge

3. Incidents- the location, the nature and timing of these is unpredictable. Examples are transport accidents and fires.

Each of these has their own range of control measures. Most pollutants will arrive in rivers from a variety of sources, and control requires an understanding of all the routes if it is to be effective and efficient.

2.23.3 Control Options

For most substances, particularly those occur naturally, it is unrealistic to expect zero discharge to the environment. Control must be exercised and what ever control option is used, the end result must be to protect the vulnerable targets, i.e. humans and human food sources, or other living organisms at the different levels. Thus for the most substances it is generally accepted (GESAMP 1986):

- That there is a minimum acceptable concentration which does not produce unacceptable effects on the target;
- The environment therefore has a certain capacity to assimilate pollutants;
- The capacity can be quantified.

It is important that the reference values are chosen on a non-environmental risk basis, e.g. expressed as a percentage of the background concentration. However, background levels can vary widely depending on the origin of the water. For instance, for metals, streams originating from a mineral rich area will much higher background concentrations than those from mineral-poor areas.

It is important that that the reference values are based on scientific evidence and that these values are reviewed periodically in the light of new scientific evidence. Otherwise the use of the substances may be so restricted that its use is economically unattractive, leading to substitution by other substances which have different, but may be unknown, effects on the environment. A typical example is the replacement of phosphate in detergents by a alternative substances for which some of the effects are only now emerging (Dwyer et al 1990).

A number of different options are available to control pollutants entering the aquatic environment, which include the establishment of standards relating to different aspects of the overall production/use/disposal cycle (Holdgate 1979) .

- Process standards;
- Product standards;
- Exposure standards;
- Biological standards;
- Environmental quality standards;
- Emission standards.

Besides these control standards, two further control options need to be considered (Haigh 1985).

- Preventive controls e.g. total prohibition on the use of a substance;
- Standards for total emissions for a given area, e.g. whole catchments area of a river system Most of these different control options have been utilized either individually or in different combinations.

2.23.4 Process Standards

The process standard approach specifies the process to be used to ensure that the required quality is achieved. As such it is not really directly relevant to the process of the control of river water quality. However, the process control aspects of integrated pollution control and waste minimization are becoming increasingly important and these will have important implications for river water quality.

2.23.5 Product Standards

Product standards are widely used to control the release of certain substances to the aquatic environment. One of the examples was the EC Detergent Directive. This was introduced to prevent foaming in rivers caused by detergent residues which resisted biodegradation in sewage treatment works. The directive requires that the detergents satisfy certain biodegradation criteria established in the form of test protocols. Product standards are particularly useful for substances entering the aquatic environment from diffuse sources. A restriction on lead in petrol has resulted in reduced emissions of lead to the air which, via reductions in atmospheric deposition and run-off, has reduced the amounts of lead entering the aquatic environment.

2.23.6 Exposure Standards

Exposure standards may be defined as primary standards for the target, which can be either human or aquatic organisms. The standards laid down on the quality of water intended for human consumption can be considered as exposure standards. The directive provides maximum admissible concentrations for certain parameters, taking in to account exposure from other sources such as air and food. Applying exposure standards, for instance maximum admissible concentration in drinking water, could in the extreme, require that discharges to the receiving water used for the abstraction of drinking water may have to meet those exposure standards if insufficient dilution is available in the receiving water and the water treatment plant is not equipped for the removal of the particular substance. Alternatively the treatment plant would need to be improved.

In case of pesticides a uniform non-toxicologically derived exposure standard of 0.1 ugI-1 has been set in the drinking water directive yet agricultural use frequently give rise to run-off waters with pesticide concentrations considerably higher than this value. If the standards for bacteria are exceeded ,which can lead to illness in people consuming the bivalves, the bivalves must either be treated in special purification plants to reduce the levels of bacteria prior to sale, or the water quality must be improved to ensure that the standards in the bivalves are not exceeded (A.J.Dobbs and T.F.Zabel).

2.23.7 Biological Standards

No numerical values are laid down only limit values and quality objectives for mercury discharged by the electrolysis industry. A numerical standard for mercury of 0.3 mgHgkg-1 wet flesh in representative samples of fish flesh chosen as indicator. However, no numerical values are laid down for individual substances. The advantage of using biological assessments related to accumulation of the substance in tissue or blood is that it provides an indication of total exposure from all sources whether point or diffuse or from intermittent events such as storm overflows. The effect of intermittent events is particularly difficult to assess by the usually employed periodic spot-sampling methods and even diffuse inputs can vary substantially depending on the metrological conditions.

The difficulties in applying biological standards are in relating tissue or blood levels to concentrations in the water or sediment, to actual effects on the ecosystem or harm to higher organisms and in obtaining representative samples for analysis from vulnerable areas. (A.J.Dobbs and T.F.Zabel).

2.23.8 Preventive Controls

Preventive controls can include a total prohibition on the use of a particular substance or partial prohibition for a particular purpose or in a designated `protection zone`. This control can be similar to the product standard approach. Preventive controls can also relate to the location of a plant or the requirement that emergency plans are produced or particular storage facilities used to minimize any accidental that could occur.

For particular dangerous substances, total prohibition on their use may be most appropriate control strategy. However, for other less dangerous substances partial prohibition of use may be sufficient if the permitted uses do not cause unacceptable effects and particularly if no equally effective and economical alternatives are available.

The ban on the use of certain pesticides in ground water protection zones in Germany may be considered as an example of this approach. The ban relates to those pesticides which may reach concentrations in the groundwater above the maximum admissible concentration of 0.1 ugl-1 for individual pesticides in the drinking water directive. Prohibit the use of certain products such as the use of mercury containing pesticides and the use of cadmium for pigmentation in a range of products and as a stabilizer in certain plastics and surface treatments. Although preventive controls can be applied to point sources of pollution they are most appropriate for the control of substances originating from different sources (A.J.Dobbs and T.F.Zabel) .

2.23.9 Environmental Quality Standards

The environmental quality standard approach is based on the premise that a minimum acceptable concentration of a pollutant can be defined which does not interfere with the use of the water. A distinction has therefore to be made between the Environmental Quality Objective which defines the use for which the water is intended (e.g. abstraction for drinking water).

2.23.10 CPCB Classification on Designated Best use of Water

The water resources can be classified or zoned depending upon the designated best use of the water. The Central Pollution Control Board (CPCB) along with the State Pollution Control Boards has adopted a scheme of classification and zoning of water resources. Therefore, the water quality criteria for the classification of surface water are given below in the following Table: 2.2.

Table 2.2: Classification and zoning of water bodies (CPCB-1979)

Sl. No.	Designated best use	Nomenclature for the class of water
1.	Drinking water source without conventional treatment but after disinfection	Class A
2.	Out door bathing (organized)	Class B
3.	Drinking water source with conventional treatment followed by disinfection	Class C
4.	Propagation of wild life, fisheries	Class D
5.	Irrigation, industrial cooling and controlled waste disposal	Class E.

The water quality criteria for the above classification are given in the following Table 2.3 for the surface water resources.

Table 2.3: CPCB standards for classification of inland surface waters

Sl. No.	Parameters	Class of waters				
		A	B	C	D	E
1.	Dissolved oxygen (DO) mg/l (min)	6	5	4	4	-
2.	Biochemical oxygen demand (BOD), mg/l (max)	2	3	3	-	-
3.	Total coliform MPN/100 ml (max)	50	500	5000	-	-
4.	Total dissolved solids (TDS), mg/l (max.)	500	-	1500	-	2100
5.	Chloride, mg/l (max)	250	-	600	-	600
6.	Colour, hazen units (max)	10	300	300	-	-
7.	Sodium absorption ratio (max)	-	-	-	-	26
8.	Boron, mg/l (max)	-	-	-	-	2
9.	Sulphates, mg/l (max)	400	-	400	-	1000
10.	Nitrates, mg/l (max)	20	-	50	-	-
11.	Free ammonia (as NH_3), mg/l (max)	-	-	-	1.2	-
12.	Conductivity at 25^0C micro-mhos/cm (max)	-	-	-	1000	2250
13.	pH value	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5

Conti….table

14.	Arsenic (as As), mg/l (max)	0.05	0.02	0.2	-	-
15.	Iron (as Fe) mg/l (max)	0.30	-	50	-	-
16.	Fluorides (as F), mg/l (max)	1.50	1.50	1.50	-	-
17.	Lead (as Pb), mg/l (max)	0.10	-	0.10	-	-
18.	Copper (as Cu), mg/l (max)	1.50	-	1.50	-	-
19.	Zinc (as Zn), mg/l (max)	15	-	15	-	-

If the coli forms are found to be more than the prescribed tolerance limits, the criteria for coli form shall be satisfied if not more than 20% of the samples exceed the tolerance limits specified and not more than 50% samples have values more than 4 times the tolerance limits.

There should be no visible discharge of domestic and industrial wastes into "Class" "A" water. In case of "Class" "B "and "Class" C," the discharge shall be regulated / treated as to ensure the maintenance of the stream standards.

2.23.11 Indian Standards Institution (ISI) Standards (IS: 229, 1982)

The parameters for primary water quality criteria for various uses of Inland / surface water as prescribed by the Indian Standards Institution, 1982 is given in the following table: 2.4.

Table 2.4 : ISI standards for classification of inland surface waters

Sl. No.	Parameters	Class of waters				
		A	B	C	D	E
1.	Dissolved oxygen (DO), mg/l (min)	6	5	4	4	-
2.	Biochemical oxygen demand (BOD), mg/l (max)	2	3	3	-	-
3.	Total coliform, MPN/100 ml (max)	50	500	5000	-	-
4.	Total dissolved solids, mg/l (max)	500	-	1500	-	2100
5.	Chlorides, mg/l (max)	250	-	600	-	600
6.	Boron, mg/l (max)	-	-	-	-	2
7.	Sulphates, mg/l (max)	400	-	400	-	1000
8.	Nitrates, mg/l (max)	20	-	50	-	-
9.	Free ammonia (NH_3), mg/l (max)	-	-	-	1.20	-
10.	Conductivity at 25^0C micromhos/cm (max)	-	-	-	1000	2250
11	pH	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5

2.24 ENGINEERING CONTROLS OF WATER QUALITY

Catchments in old industrialized areas are polluted as a result of historic pollution and inadequate storm-water provisions; river water quality is often poor, in particular if the flow in the river is comprised mainly of sewage effluent. In such case `purification lakes` can alleviate the pollution load carried by the rivers and lead to improvements in downstream water quality.

Artificial introduction of oxygen into river waters it is also used on the River Thames in the UK to minimize the impact of oxygen depletion in the estuary resulting from storm discharges. The `Thames Bubbler ` can move up and down the estuary and inject up to 30 tonnes per day of oxygen in to the water .The water quality is a most important for a river management programmes. The water quality objectives are set with respect to the demands placed on the water resources such as irrigation, drinking, industry, power generation, recreation, fisheries, bathing and even for discharging waste waters together with the fact that all water sources are not necessarily required to meet all potential uses. This has lead to the concept of classification and zoning of water bodies which indicate to meet the requirement of water quality for one or more of the above purposes. The water quality criterion has been established for the designated best use for the particular use. (Adams 1992., Hellawell and Green 1986).

The process of setting quality objectives, determining action plans and monitoring trends to assess achieve is much like an industrial production process. If it is viewed in this way then river quality control can be considered to be a true quality control task much like any other (Stakes and Flatman 1991) .

2.25 FLOW ALLOCATION FOR RIVER

Because of its variable occurrence-spatial and temporal; water an elixir, and a sine qua non for survival of flora and fauna, is sandwiched between reduced quality and ever increasing demand coupled with emergent contemporary socio-politico-economic and environmental (legal trends)-sending an SOS to policy makers, planners, water resources experts and intelligentsia alike for integrated and comprehensive planning and management of water resources for sustainability (Sethi and Srivastava, 2006b).

Water resources planning and management is broadly concerned with accurate assessment , identification and development of water from different sources for the well being of the human being in particular; and for preservation of the biotic species and development of the nation in general (Sethi and Srivastava, 2007).

With the increasing demands upon water resources and growing concern for environmental protection over the past decade, greater attention has been given to the allocation of water for in river needs. Typically, this attention has been directed to maintaining habitat for a target species. However, the maintenance of minimum flow is only one of the range of considerations necessary for protection or rehabilitation of fluvial hydro systems (Hill et al, 1991).

The problem needs to be nipped in bud or else it will be insurmountable to curb the crisis as in the Cauvery tangle which arose after the reorganization of the States in 1956- and be cancerous if further reorganization is involved (Sethi and Srivastava, 2006a).

2.26 WASTE WATER EFFLUENT IRRIGATION AND REUSE IN FORESTRY

The conventional waste water treatment facilities are being energy intensive and expensive. The disposal of untreated and partially treated waste water in to river system or lands creates severe pollution problems and affects terrestrial ecosystems .Due to un availability of flow in River Noyyal and the absence of dilution factor it is better to formulate a separate sewage effluent irrigation scheme with the help of State PWD Irrigation Department to prevent ground water contamination (Natarajan. 2006).

The pilot study and demonstration project for the development of forestry using domestic waste water at Puri by National Environmental Engineering Research Institute (NEERI) in collaboration with public Health Engineering Department (PHED), Puri Orissa State. (NEERI 1994 and 1996). The entire waste water 10 MLD generated in Puri Town ship to avoid pollution in river Musa in Orissa State will be treated through facultative pond system followed by HRTS to irrigate an area of 59 hectares under forestry. The barren land of 59 hectares in the forest area is planted with Acacia mangium (Acacia), Dendrocalamus tinctus (Bamboo), Cassurina sp. (Cassurina), Azadirachta indica (neem), Tectona grandis (Teak) and Gravellia sp, (gravellia). There is no potential for ground water contamination (NEERI 1996).

CHAPTER – 3

ENVIRONMENTAL STATUS OF RIVER CAUVERY

3.1 WATER POLLUTION CONTROL

Water pollution is being prevented and controlled by enforcing the Water Prevention and Control of Pollution Act 1974 as amended in 1988. The TNPCB categorizes the polluting industries into three, viz., red, orange and green with reference to seriousness of water pollution. Under `red' category, there are 17 industrial concerns which are prone to adverse environmental spill over. Under these 17 concerns of highly polluting industries, there are 191 plants as on 31.3.2004 and the details are presented below. The industries which are highly polluting the atmosphere have to obtain letters of consent to establish' and `consent to operate, Till 31.12.04, the Board had issued 4,822 letters of consent to establish industries and 22,663 letters of consent to operate under the Water Act.

Table 3.1: Categories of Highly Polluting Industries

S.No	Category	No. of Industries
1.	Aluminium	1
2.	Caustic Soda	3
3.	Cement	16
4.	Copper Smelter	1
5.	Distillery	15
6.	Dyes & Dye Intermediate	1
7.	Fertilizer	7
8.	Integrated Iron & Steel	1
9.	Tanneries	62
10.	Pesticides	1
11.	Petrochemicals	5
12.	Basic Drugs & Pharmaceutical	16
13.	Pulp & Paper	5
14.	Oil Refinery	3
15.	Sugar	38
16.	Thermal Power plant	16
17.	Zinc Smelter	0
	Total	191

Source: The Tamil Nadu Pollution Control Board

3.2. WATER QUALITY MONITORING

Water quality ensures health and human effectiveness. For attaining high water quality the Board is constantly watching the inland water quality through two major programmes, namely Monitoring of Indian National Aquatic Resources System and Global Environmental Monitoring System. The water quality of rivers, namely, Cauvery, Thamiraparani, Palar, Vaigai and lakes of Udhagamandalam, Kodaikanal and Yercard comes under the first category whereas water quality in Cauvery basin at Mettur, Pallipalayam, Musiri and ground water monitoring at Musiri comes under the second programme.

3.3 COMMON EFFLUENT TREATMENT PLANTS (CETPs)

Leather industry creates emission of high incidence of pollution affecting the water quality in the neighborhood but also tells upon the ambience. In order to arrest the effluents of waste from the leather industries, the Board has been directing the leather industry to come under the fold of Common Effluent Treatment Plants. In addition to the leather industry, textiles, dying, hotels and lodges are also bound to generate adverse externality. For coping with the incidence of pollution of varying proportion, the Board has established 33 Common Effluent Plants in different places. Establishment of the Common Effluent Treatment Plant impacted on the reduction in the quantum of pollution. The Common Effluent Treatment Plant constructed in Nagalkeni near Pallavaram is showcasing the effective role of the TNPCB in abatement of water pollution.

Table 3.2: Establishment of CETPs in different sectors

S.No	Sector	No. of CETPs formed	No. of CETPs under operation
1	Tanneries	24 Schemes	14 Schemes
2	Textile Bleaching &	25 Schemes	18 Schemes
3	Hotels & Lodging Houses	1Scheme	1Scheme
	Total	50 Schemes	33 Schemes

Source: The Tamil Nadu Pollution Control Board

3.4 CLEANER TECHNOLOGY

Technologies adopted by industrial units are one of the sources from which the pollution of various types stems. In order to motivate the highly polluting industrial units to go in for cleaner technological options, the Board has taken various steps towards achieving the objectives. With active support and encouragement, industrial units in Tamil Nadu have switched over to cleaner technologies such as adoption of membrane cell instead of mercury cell in caustic soda manufacturing, adoption of dry process instead of wet process to reduce air pollution in cement factories, adoption of double conversion and double absorption technology in Sulphuric acid manufacturing, gas carburizing instead of cyanide salt in heat treatment and cyanide free electroplating. The distillery units have responded to move towards zero effluent discharge by adopting bio-composting of effluents with press mud of sugar industry. Pulp and Paper industries are encouraged to go in for elemental chlorine free bleaching to reduce the formation of organo chlorides including dioxins. Industries consuming ozone depleting substances are systematically changing to environment friendly compounds.

3.5 ENVIRONMENTAL IMPROVEMENT OF RIVER CAUVERY UNDER NATIONAL RIVER ACTION PLAN

The Department of Environment has been implementing a 100% Centrally sponsored scheme, 'Abatement of Pollution in five stretches of Cauvery River in Tamil Nadu' at an overall project cost of Rs.36.28 crores since 1996-97, the project period being ten years. A sum of Rs.16.58 crores has been spent by the executing agencies, viz., TWAD Board and the concerned local bodies, and this amount has been utilized fully. The scheme will be continued during 2007-2008.

Under the Non-Core Scheme, works in respect of construction of low cost sanitation facility, River Front Development (RFD), bathing ghats and wood based crematoria (WBC) has been completed. Under the Core scheme, interception and diversion of sewage treatment works are being implemented by the Tamil Nadu Water Supply and Drainage Board in Erode, Komorapalayam, Bhavani, and Pallipalayam. All the works in Trichy have been completed. Interception and diversion of sewage works in Komorapalayam and Erode have been completed and other works are in progress.

National River Conservation Plan - New Integrated Schemes with the assistance of National River Conservation Directorate (GOI) in five towns viz., Madurai, Kumbakonam, Thanjavur, Tirunelveli and Mayiladuthurai.

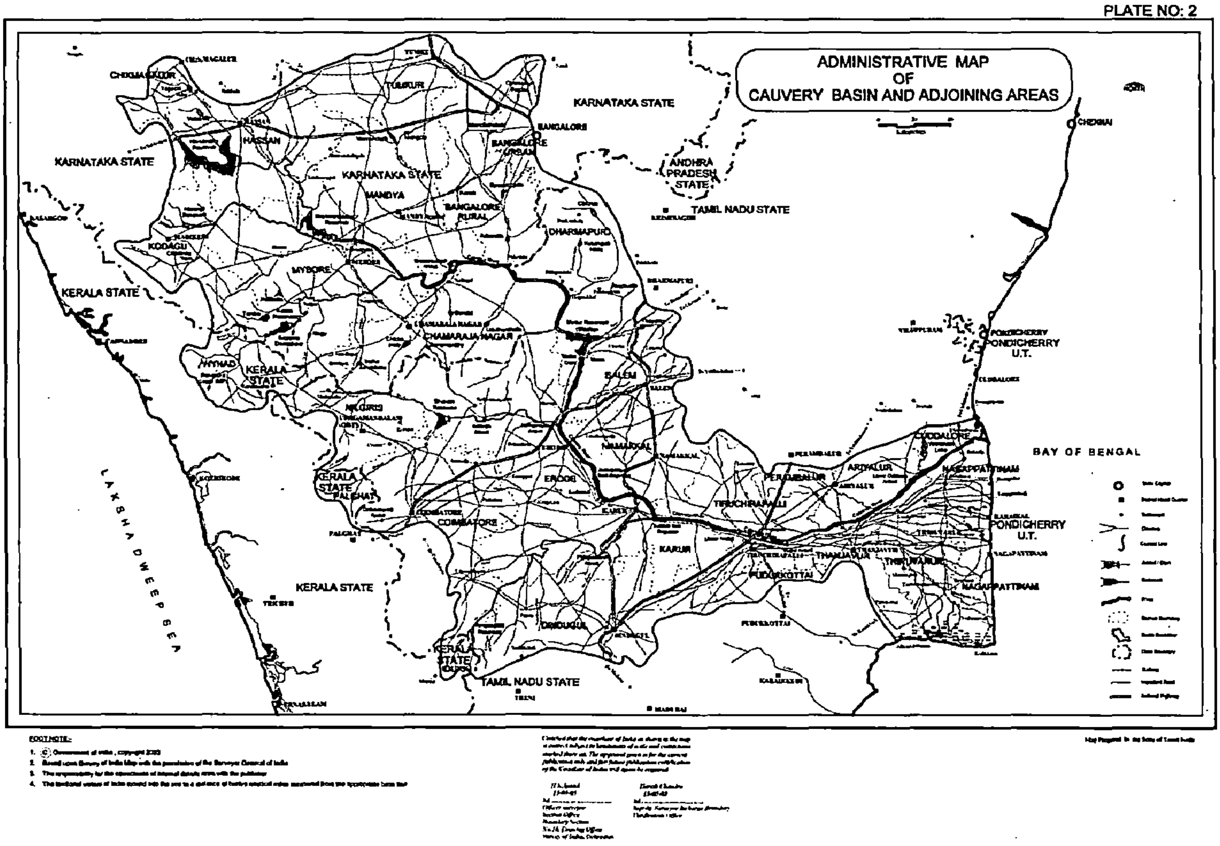


Figure 3.1: Cauvery River Basin

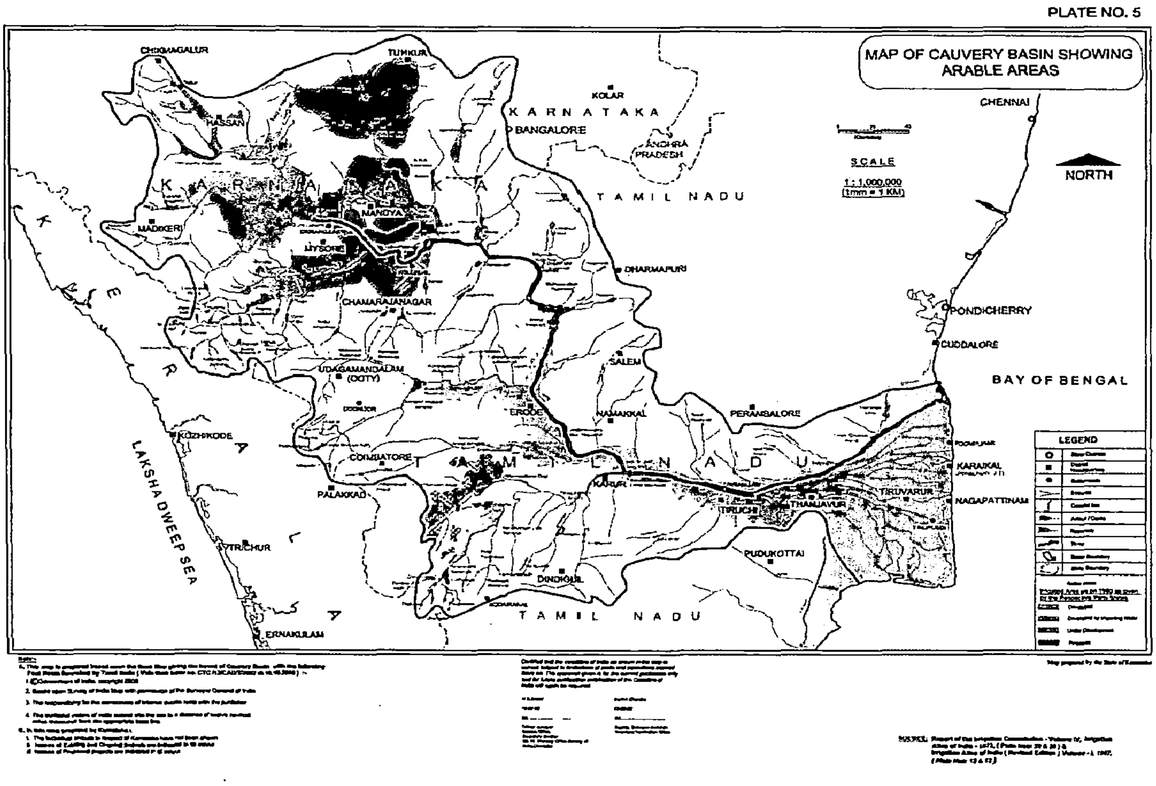


Figure 3.2: Cauvery River Basin

3.6 STATUS OF STUDY AREA METTUR DAM TO ERODE

The study area Mettur dam to Erode reach of River Cauvery is one of the polluted stretch from out of 10 problem areas and 10 polluted river stretches identified to concentrate the pollution control efforts by the CPCB in the year 1988-1989 themselves.

As per the Tamil Nadu Government State Pollution Control Board statistics, the total pollution load admitted by giving consent to industries after necessary treatment to River Cauvery is BOD loading of 1190 kg / day and 74417 kg/day of Total Dissolved Salts in 85917 KLD of treated effluent as per the Table 3.3

An increase in flow rate during irrigation water release in Cauvery River the water quality gets improved significantly. In non flow season and the minimum lean flow periods the assimilation and self purification capacity of the river water is not enough to digest the pollutant load. The discharge of Domestic and Industrial Effluents in to Cauvery River during flow days result in depletion of Oxygen in running water. The discharge of these effluents will also import colour to the water. These may destroy the flora and fauna of the receiving waters of Cauvery River. Further, the rich solids presents may settle at the bottom of the river. Continuous settling of these solids at the bottom will affect the fish spawning grounds. High toxic chemicals present in the effluent may have direct impact on the fish diversity of the river.

Table 3.3: Details of total pollution load discharged into Cauvery River from industries

S.No	Type of Industry	No .of Units	Effluent Quantity KLD	Pollution Load in K.g/Day			
				Before Treatment		After Treatment	
				BOD	TDS	BOD	TDS
1	Chemical	2	390	10.5	0	0.35	0
2	Electroplating	1	0	0	0	0	0
3	Pesticides	1	0	0	0	0	0
4	Tannery	12	682	377	3327	9.81	1788
5	Textile	156	9805.3	2132.5	30050	1105	28829
6	Thermal Power	1	75000	75	43800	75	43800
7	Sago	1	40	0	0	0	0
	Total	174	85917.3	2595	77177	1190.16	74417

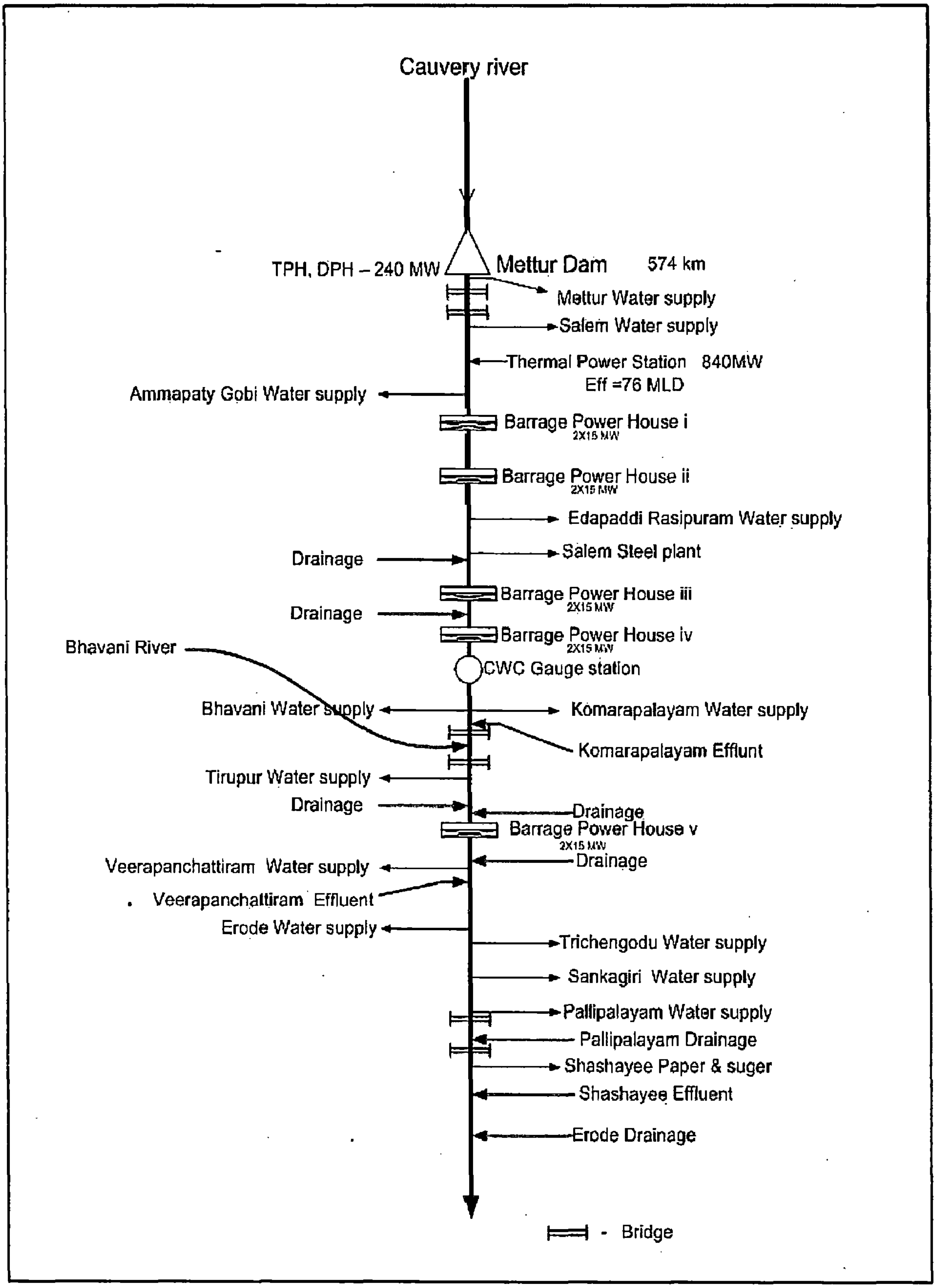


Figure 3.3 : Schematic flow Cauvery River From Mettur Dam to Erode

Table 3.4 : Details of water supply intakes in Cauvery river Mettur Dam to erode stretch

Sl.No	Location and Purpose	Chainage k.m	Population benefited	Intake Quantity in MLD	Type of Intakes
1	Mettur Municipal W.S	574	53633	7.5	Surface Water
2	Salem Corporation W.S	576	800000	100	Surface Water
3	Mettur Thermal Power Station	579	10000	130	Surface Water
4	Ammapettai-Gopi Municipal W.S	586	300000	30	Surface Water
5	Edapadi-Rasipuram	590	120000	10	Surface Water
6	Salem Steel Industry	590	10000	50	Surface Water
7	Bhavani Municipal W.S	603	38645	4	Surface Water
8	KomarapalayamMunicipal W.S	603	65868	6.5	Surface Water
9	New Thirupur W.S	610	1000000	185	Surface Water
10	Veerapan chattram Municipal W.S	623	72703	7	Surface Water
11	Erode Municipal W.S	624	151184	38	Surface Water
12	Trichengodu Municipal W.S	625	80177	8	Surface Water
13	Pallipallayam Municipal W.S	626	52000	6	Surface Water
14	Sankagiri Municipal W.S	626	30000	4	Surface Water
15	Small Villages	574-628	215790	49	Surface Water
16	Erode Railway Station	627	10000	10	Surface Water
17	Sashsayees Sugars and Paper Boards	628	5000	55	Surface Water
	Total	574-628	3015000	700	Surface Water

Table 3.5: Details of water supply intakes at Cauvery River in Tamil Nadu

Sl.No	Districts	Population benefited	Chainage k.m	Intake Quantity in MLD	Type of Intakes
1	Dharmapuri	2992754	512	100	Surface water
2	Salem	2833252	576	285	Surface water
3	Erode	2574067	630	257	Surface water
4	Nammakal	1495661	664	150	Surface water
5	Karur	933791	678	94	Gallery Well
6	Trichy	2388831	715	240	Gallery Well
7	Perambalur	486971	752	50	Gallery Well
8	Ariyalur	694058	735	70	Gallery Well
9	Tanjore	2205375	736	220	Gallery Well
10	Thiruvarur	1165213	785	116	Gallery Well
11	Nagapattinam	1487055	785	148	Gallery Well
12	Cuddalore	2280530	762	140	Surface water
13	Chennai Veeranam scheme	4216268	762	184	Surface water
14	Pudukottai	1452269	690	100	Gallery Well
15	Ramanathapuram	1183321	690	78	Gallery Well
	Total	26239416		2232	

CHIEF WATER ANALYST'S LABORATORY COIMBATORE

RESULTS OF ANALYSIS ON SAMPLE OF SEWAGE

R.No.0418/ A3/2007 (84) CWA/CBE. Dt. 28.4.2007

From	Thiru. T. Natarajan, Executive Engineer, M.Tech. II Year, A.H.E.C, Institute of Technology, Roorkee- 247607
Date of Collection	16.04.2007
Date of Receipt	16.04.2007
Collected by	Thiru. T. Natarajan, Executive Engineer.
Sample Particulars	Raw sewage collected from Erode- Cauvery Nullah Confluence Point.

RESULTS:

PHYSICAL EXAMINATION

Color	yelloish
Odor	Disagreeable color
Turbidity	Turbid

CHEMICAL EXAMINATION

Total Dissolved Solids mg/l	590
Total Suspended Solids mg/l	70
Chemical Oxygen Demand mg/l	124
Dissolved Oxygen, mg/l	0
Biochemical Oxygen Demand mg/l	70
Free Ammonia (as N) mg/l	15.12
Total Kjeldahl Nitrogen (as N) mg/l	26.88
pH Value	7.4
Phosphates (as P04) mg/l	9.0
Nitrate Nitrogen (as N) mg/l	0

BACERIOLOGICAL EXAMINATION

1) Plate Count per ml on agar at 37°C for 24 hrs.	65×10^3
2) MPN of Coliform Bacteria per 100	240×10^5

(sd------------------------------------)

CHIEF WATER ANALYST

COIMBATORE

Table 3.6: Structures and their uses Cauvery River from Mettur Dam to erode stretch

Sl.No	Structure Location and Purpose	Chainage k.m	Features	Benefits
1	Mettur Dam	574	Stone Maonary Gravity Dam	Irrigation,Water supply,Power Generation, Fish Culture,Flood Control
2	Tunnel Power House	574	M.W	Power Generation
3	Direct Power House	574	M.W	Power Generation
4	Mettur Municipal W.S	574	Intake well	Watersupply
5	Highway Bridge	576	R.C.C	Watersupply
6	Salem Corporation W.S	576	Intake well	Watersupply
7	Highway Bridge	579	R.C.C	Watersupply
8	Mettur Thermal Power Station	579	840 M.W- State Owned	Power Generation
9	Lower Mettur-Barrage- I	584	2 X 15 M.W -VERTICAL	Power Generation
10	Ammapettai-Gopi Municipal W.S	586	Intake well	Watersupply
11	Lower Mettur-Barrage - II	589	2 X 15 M.W -VERTICAL	Power Generation
12	Edapadi-Rasipuram	590	Intake well	Watersupply
13	Salem Steel Industry Intake	586	Intake well	Industrial needs
14	Lower Mettur-Barrage - III	594	2 X 15 M.W -VERTICAL	Power Generation
15	Lower Mettur-Barrage - IV	600	2 X 15 M.W -VERTICAL	Power Generation
16	Central Water Commission Gauge	601	Gauge Station	Flow Monitoring and water quality
17	Bhavani Municipal W.S	603	Intake well	Watersupply
18	Komarapalayam Munil W.S	603	Intake well	Watersupply
19	Highway Bridge	604	R.C.C	Transport
20	Highway Bridge	609	R.C.C	Transport
21	New Thirupur W.S	610	Intake well	Watersupply and Industrial needs
22	Lower Mettur-Barrage - V	619	2 X 15 M.W -VERTICAL	Power Generation
23	Veerapan chattram Municipal W.S	623	Intake well	Watersupply
24	Erode Municipal W.S	624	Intake well	Watersupply
25	Trichengodu Municipal W.S	625	Intake well	Watersupply
26	Pallipallayam Municipal W.S	626	Intake well	Watersupply
27	Sankagiri Municipal W.S	626	Intake well	Watersupply
28	Small Villages	574-628	Intake well	Watersupply
29	Highway Bridge	627	R.C.C	Transport
30	Erode Railway Authority	627	Intake well	Watersupply
31	Railway Bridge Erode- Salem	628	Steel Girder Bridge	Transport
32	Shashasayee Sugars and Paper Boards	628	Intake well	Industrial needs

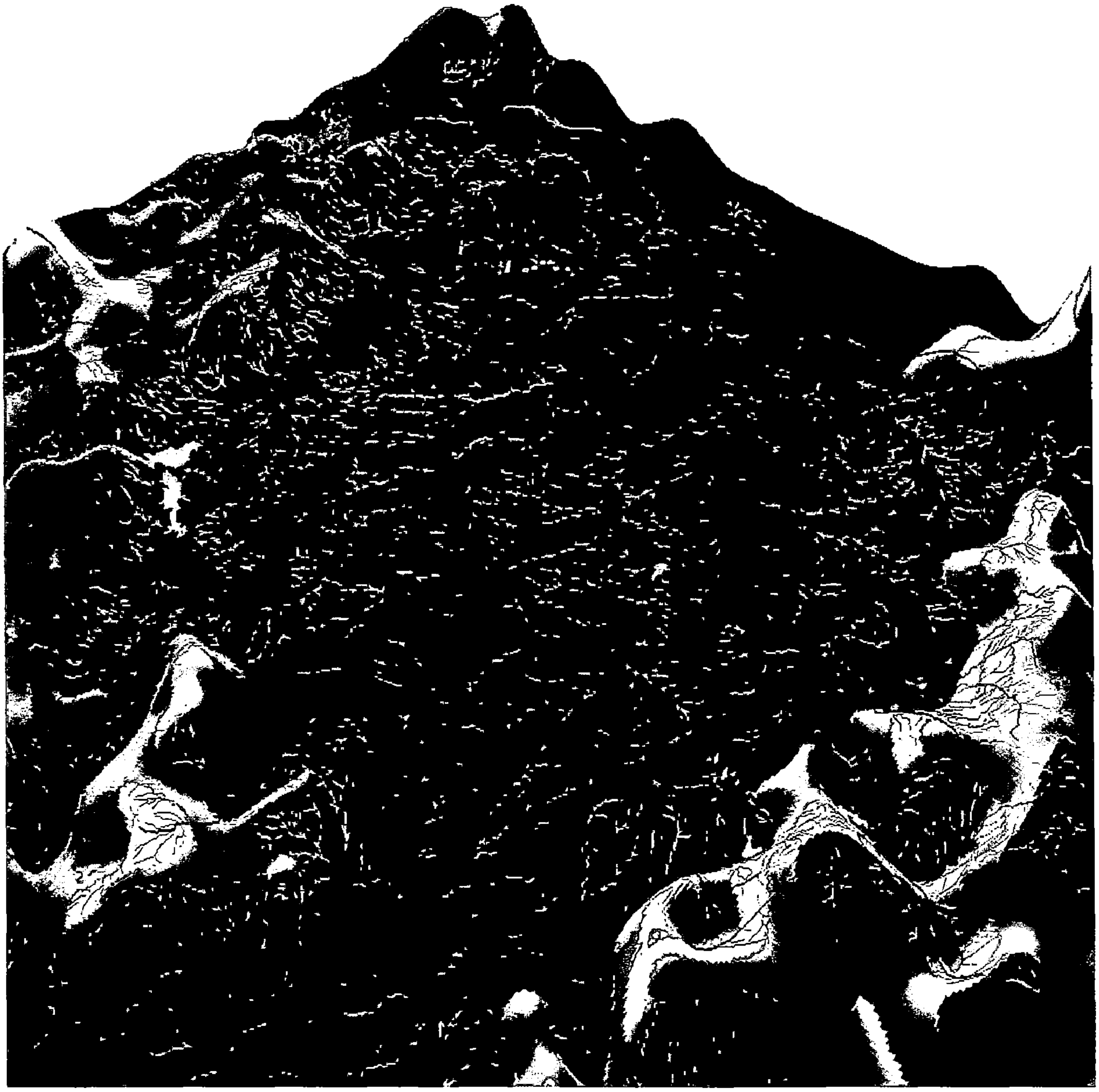


Figure 3.4 : Three Dimensional view of Cauvery River and Tributaries

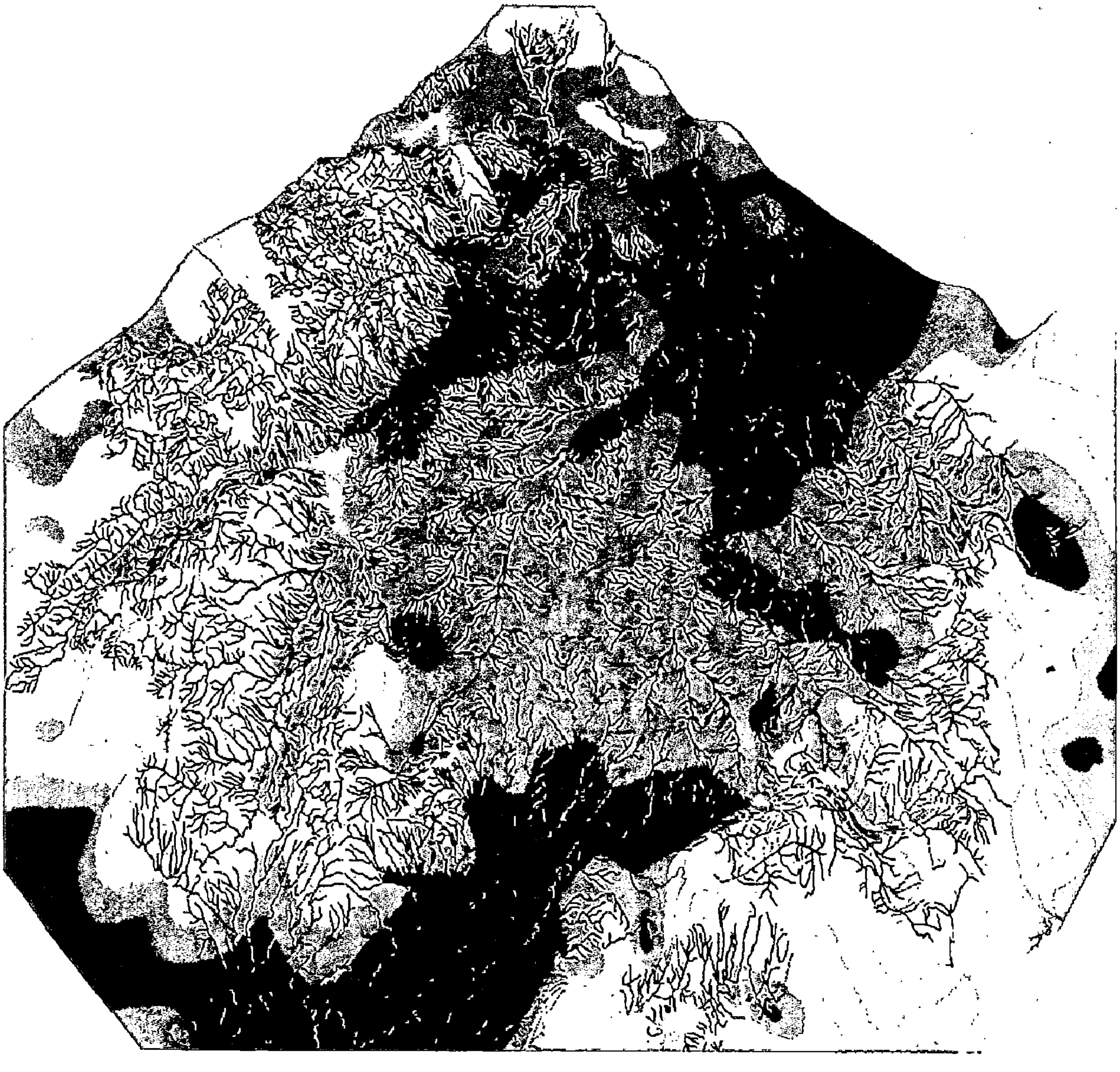


Figure 3.5 : Three Dimensional view of Cauvery River and Basin

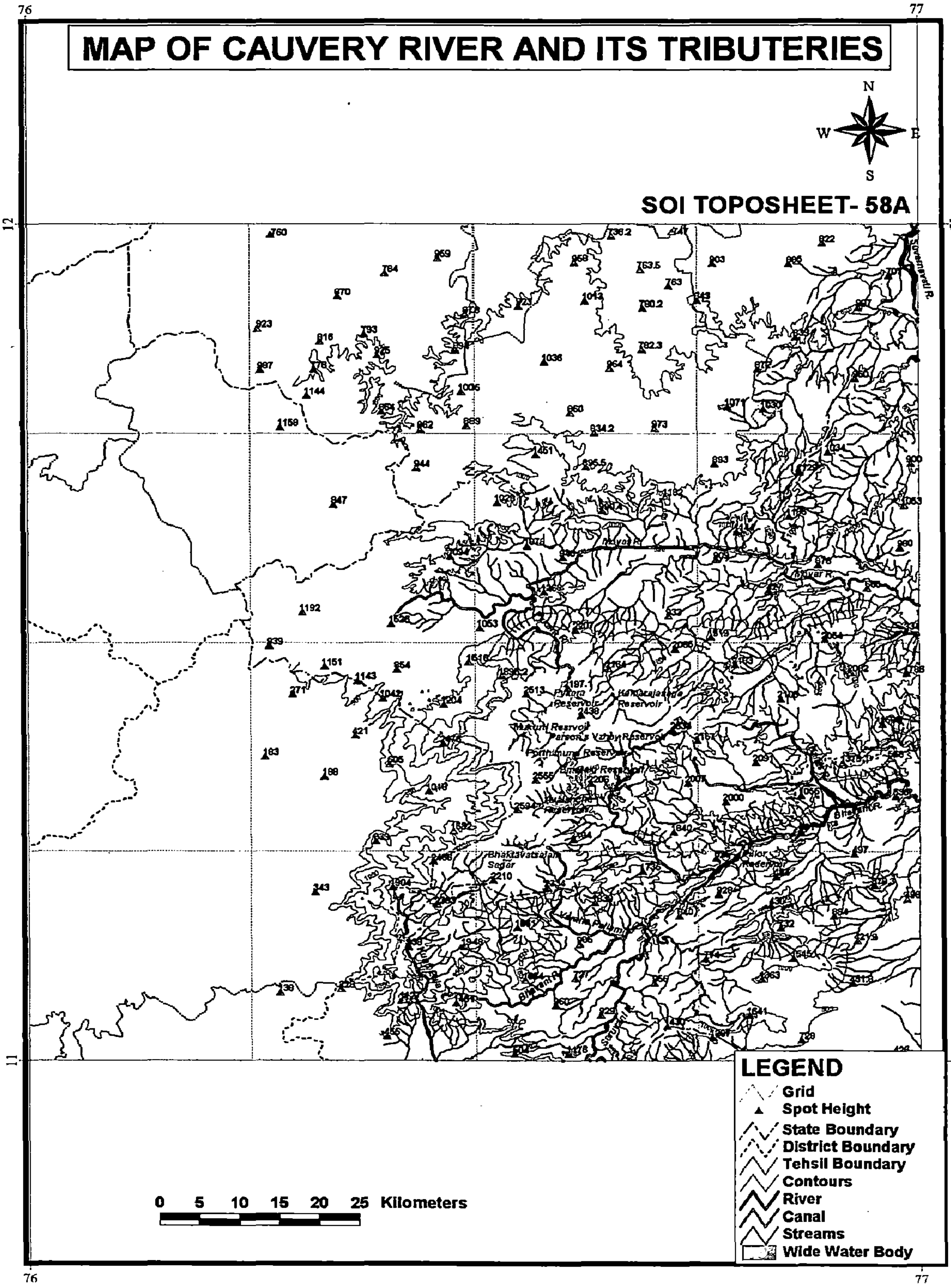


Figure 3.6: Map of Cauvery River and its Tributaries

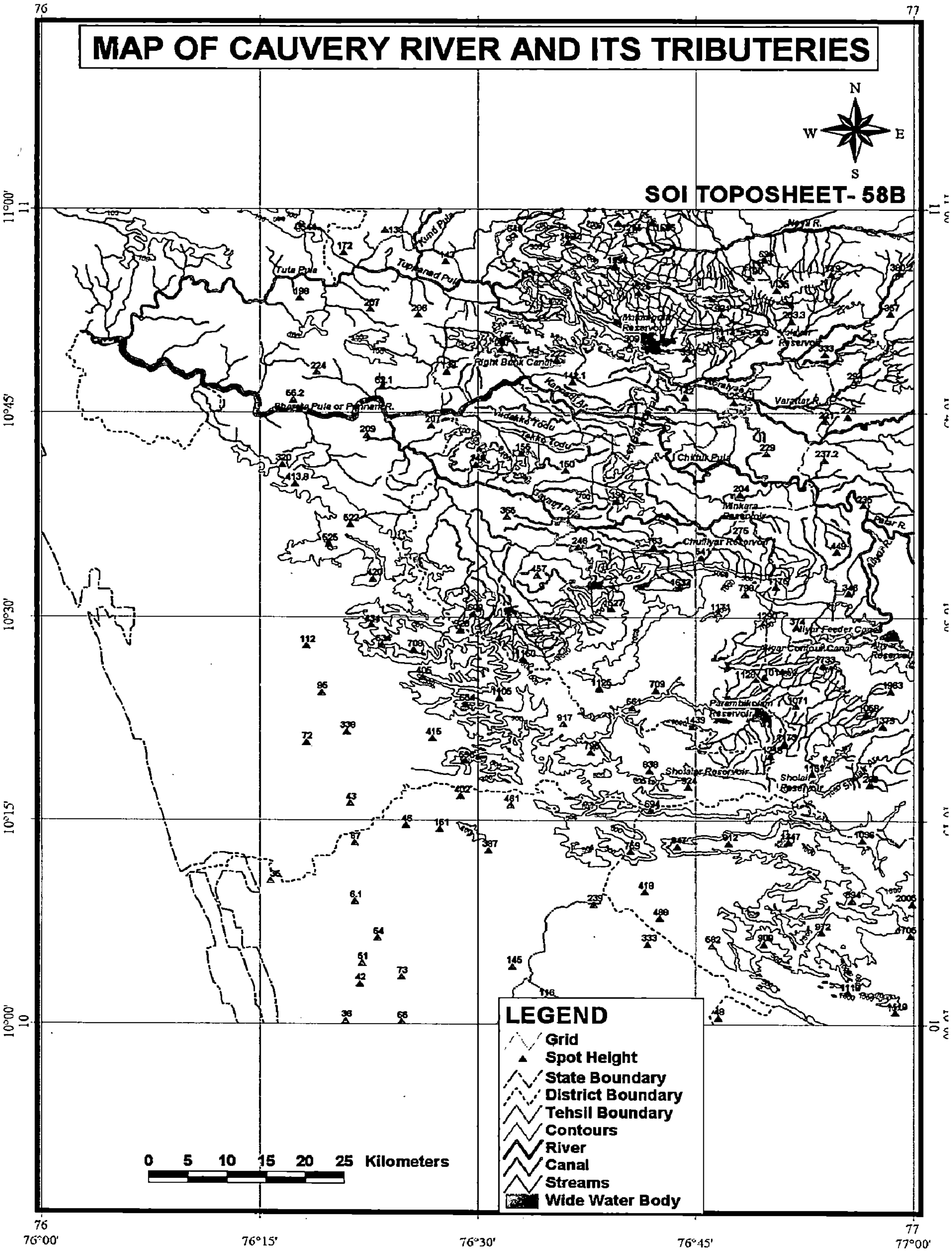


Figure 3.7: Map of Cauvery River and its Tributaries

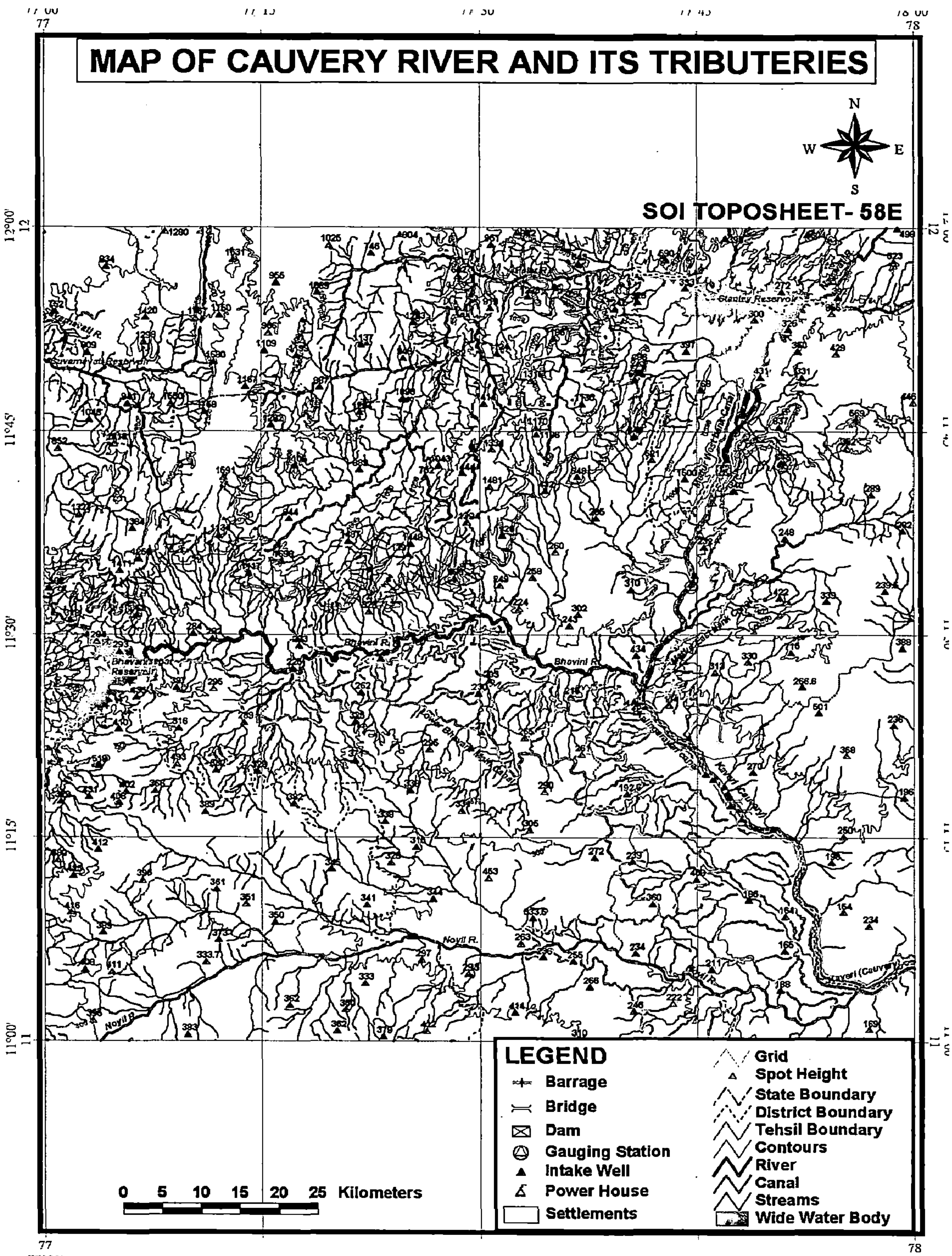


Figure 3.8: Map of Cauvery River and its Tributaries

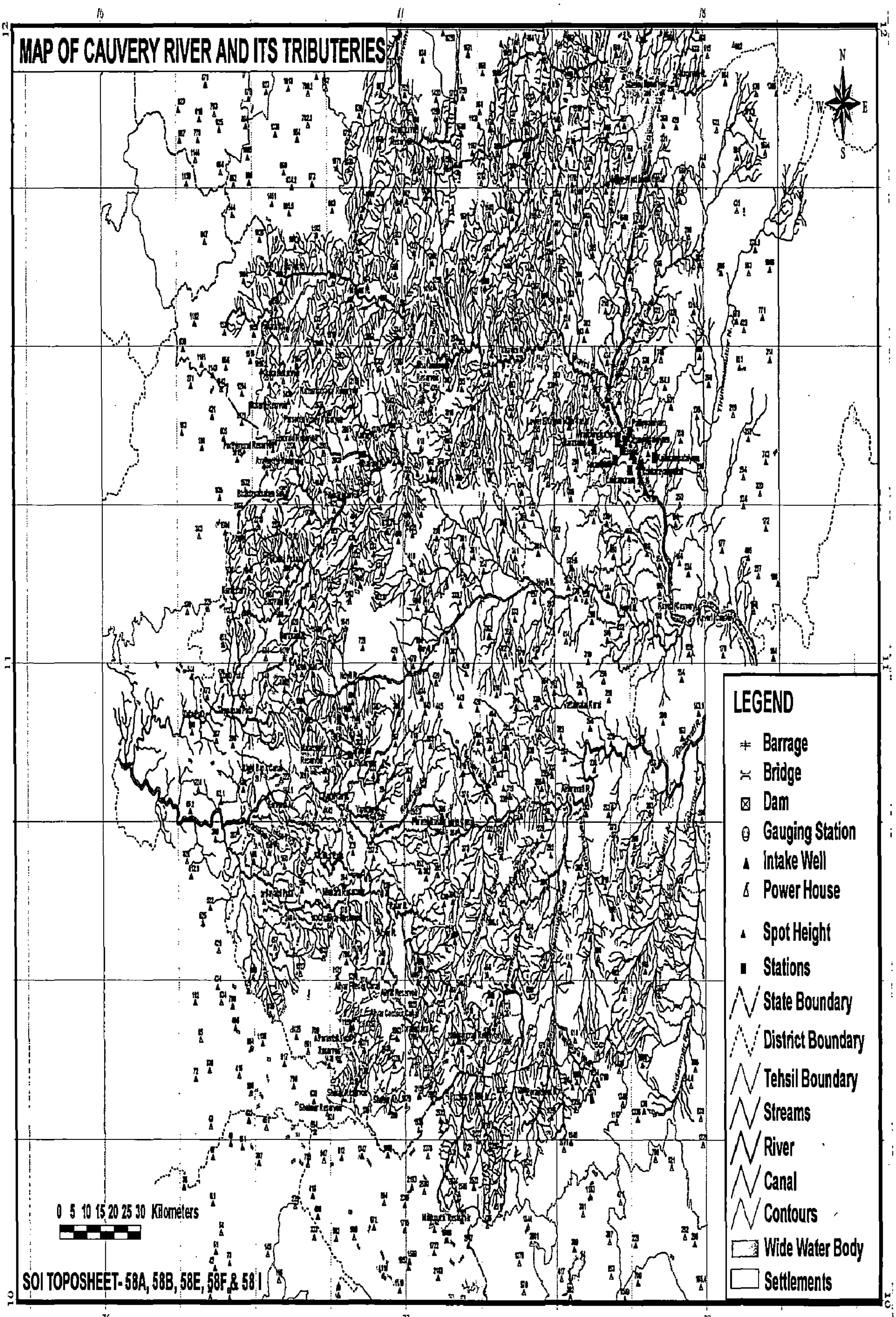


Figure 3.9: Map of Cauvery River and its Tributaries

3.6.1 Mettur

Prefatory: Mettur town is one of the taluk headquarters in Salem district, and it comprising an area of 14.55. sq.km, and situated 11°45'N and longitude 77° 45'E.The maximum and minimum temperatures are 41.70° C and16.00°C. The average annual rainfall was 746 mm and the driest month is May and the wettest month is October. The average number of rainy days is 46 days per year.

Importance: Mettur is known for its huge dam built 1934 which is still one of the best dams in the country and also a notified tourist centre. Cauvery River runs in the town. The Mettur canal, an irrigation canal forms the western boundary of the town. The town has five major industries.

Profile: The general slope in the town is from north to south. The ground level variation is about 20 m.

Population: The populations of the town with reference to previous census records are for years 1981: 45,970, for 1991:45773 and for 2001:53633 respectively. The ultimate population of Mettur for the year 2038 has been arrived as 90000. The sewage quantity at 90 lpcd comes around 8.1 MLD.

Existing water supply: The source of the existing water supply is from River Cauvery surface water drawn through intake well. Daily7.5 MLD of water has pumped to treatment plant for treatment. After necessary treatment treated water conveyed to 3 reservoirs located at 3 different locations and supplied to the consumers.

Solid Waste Management

Existing Situation: Mettur town generates around 15 tonnes of waste every day at a rate of 275 grams per capita per day and an average daily 15 M.T. of mixed waste collected and damped in the Komburankaadu, for manure preparation.

Table 3.7: Process and disposal of waste compost dumping yard details

S.No	Name	Area in Acres	Distance from Centre of the Town / Process
1	Komburankaadu	43.72 Acres	3.0 K.M.-Dumping

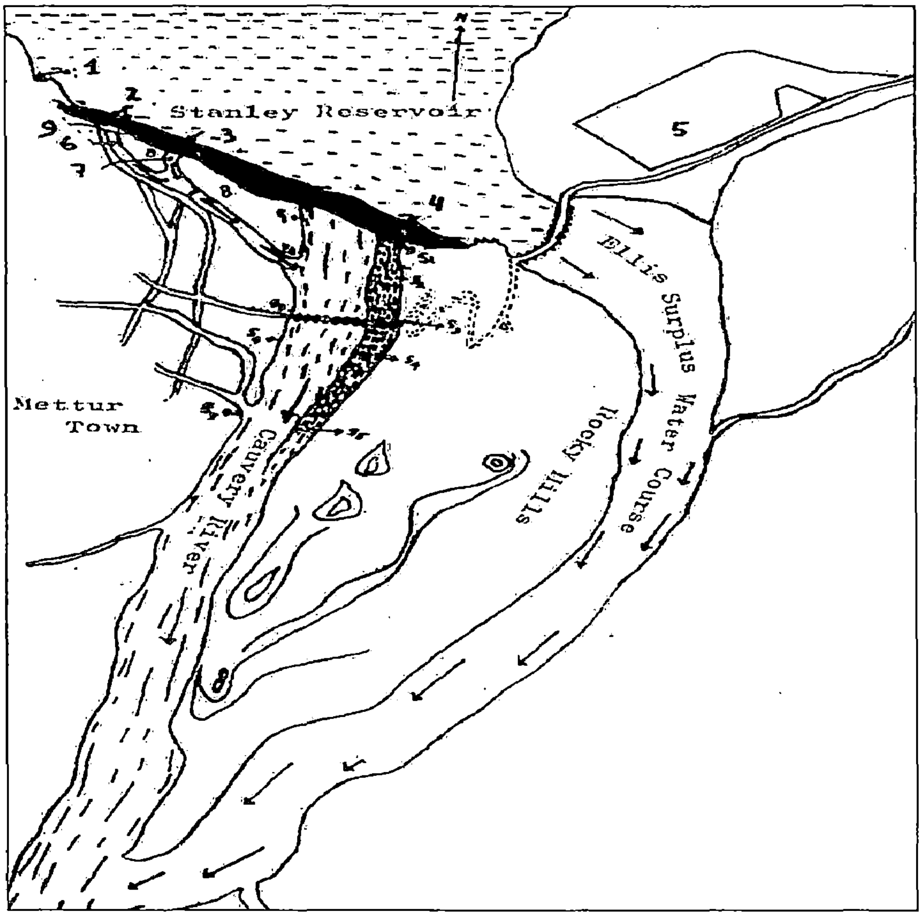


Figure 3.10 : Mettur Town, Mettur dam, Cauvery River

Waste water: The half of the area of Mettur Municipality has been covered by the net work of sewerage system, and the discharge is being drained in three sewage farms set up at places like Mettur Camp (91.94 acres), Salem Camp (16.85 acres) and Madhaiyan Kuttai (3.90 acres).

3.7 BHAVANI

Bhavani is a Compact medium sized town in Erode District of Tamil Nadu, is located at the confluence of the river Bhavani and Cauvery. It comprises an area of 8.44. sq.km, and situated 11° 25°N and longitude 77° 33°E.The maximum and minimum temperatures are 42.70° C and 28.00°C. The average annual rainfall was 895 mm and the driest month is May and the wettest month is October. The average number of rainy days is 46 days.

Importance: Cauvery River runs on the western boundary of the town and located at the confluence of the river Bhavani and Cauvery. The famous Sangameswarar Temple is located at the confluence of river Cauvery and Bhavani which draws a large number of Pilgrims throughout the years and also an organized bathing is take place for Addi

Amavasi (non moon day) and Addi pirogue festival thousands of devotees perform their holy bath and ritual rights in the bathing ghats located in Cauvery river confluence with Bhavani river named as koduthrai. Bhavani declared as a tourist center by the government of India. The town has many small scale industries such hand looms, power looms, and textile finishing units etc.

Profile: The general slope in the town is from west to east and the average elevation of the town is 218.36m above MSL.

Population: The populations of the Bhavani town with reference to previous census records are for years 1981:28898, for 1991:35198, and for 2001:38645 respectively. The ultimate population of town for the year 2038 has been arrived as 90000and the sewage Quantity at 90 lpcd comes around 8.1 M.L.D.

Existing water supply: The source of the existing water supply is surface water from River Cauvery drawn through intake well. Daily 4.3 MLD of water has pumped to treatment plant for treatment. After necessary treatment the treated water conveyed to 5 Water supply reservoirs located at 5 different locations and supplied to the consumers.

Discharge of Effluents

The effluents discharged from small scale industries, Textile Processing units, etc. are let into Cauvery River. Municipal solid waste and tourist food wastes and packaging wastes, poses severe environmental problems. Scientific disposal of Municipal waste needs to taken up to save the land.

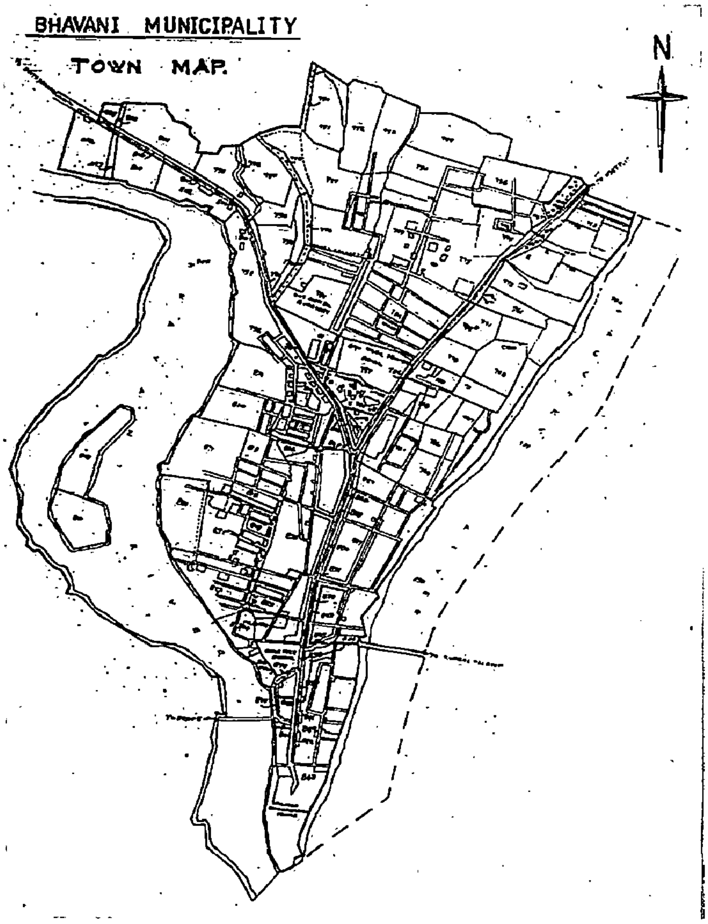


Figure 3.12 : Bhavani Municipality map

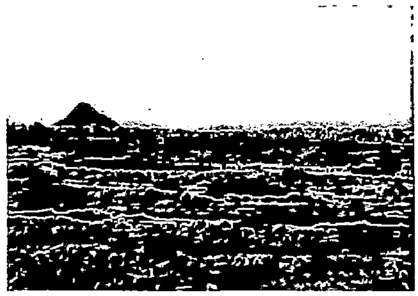


Figure 3.11 : River Cauvery @ Bhavani

Figure 3.13 : River Cauvery& Bhavani River confluence point

3.8 KUMARAPALAYAM

Prefatory: Komorapalayam town a taluk headquarters in Salem district, it comprising an area of 7.80. sq.km, and situated $11^0 20^0$N and longitude 77^0 45^0E.The maximum and minimum temperatures are42.70° C and 28.00° C. The temperature here is moderate through out the year except during summer. The prevailing south–west and north-east monsoon winds bring less rains and heavy rains during the month of July and November respectively. The average annual rainfall was 895 mm and the driest month is May and the wettest month is October. The average number of rainy days is 46 days.

Importance: Cauvery River runs close to the town. The town is situated on plain fertile lands. The town has Cauvery River as its western boundary. The town has many small scale industries such as Dyeing units Hand looms, Power looms, and Textile finishing etc and famous for its special cotton carpets.

Profile: The general slope in the town is from west to east. The ground level variation is 10 m.

Population: The population of the town with reference to 2001 census was 65868. The ultimate population of Erode town for the year 2038 has been arrived as 94000.The Sewage Quantity at 90 lpcd comes around 10 MLD including industrial effluents.

Existing water supply: The source of the existing water supply is from River Cauvery surface water drawn through intake well. Daily 6.31 MLD of water has pumped to treatment plant for treatment. After necessary treatment treated water conveyed to 9 reservoirs located at 9 different locations and supplied to the consumers

Solid waste management

There is no compost yard for this municipality. At present under N.R.C.P Grants Land purchased for compost yard Rs 6.27 Lakhs.It has to be developed as per Tamil Nadu Pollution Control Boards' norms.

Discharge of Effluents

The effluents discharged from small-scale industries such as Power looms, dyeing and Processing and Bleaching units are let their untreated effluents to municipal open drains and it finally reaches through open drains and let into Cauvery River. Municipal solid waste and food wastes and packaging wastes, poses severe environmental problems. Scientific disposal of Municipal waste needs to taken up to save the land.

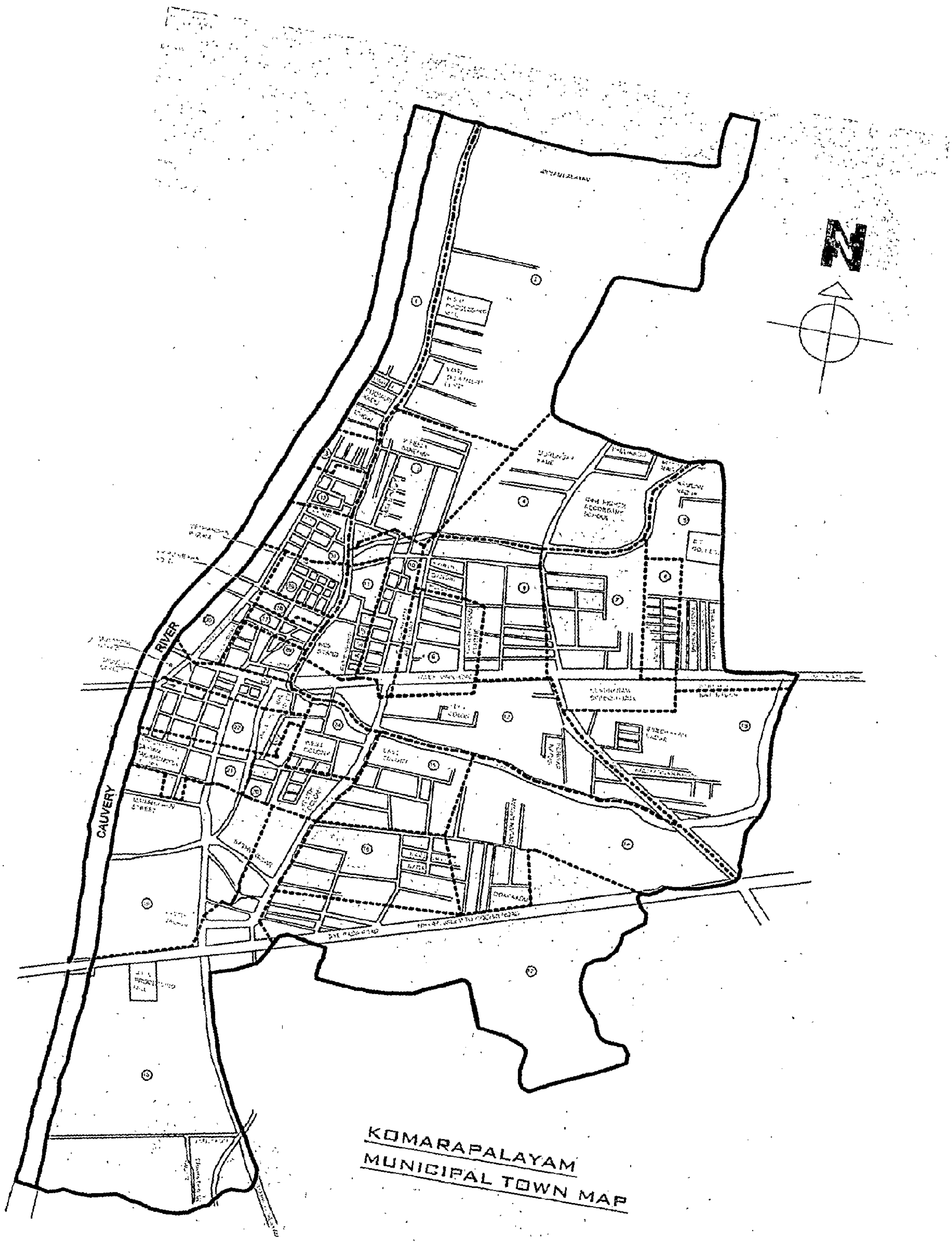


Figure 3.14: Komaraplayam Municipal Town Map

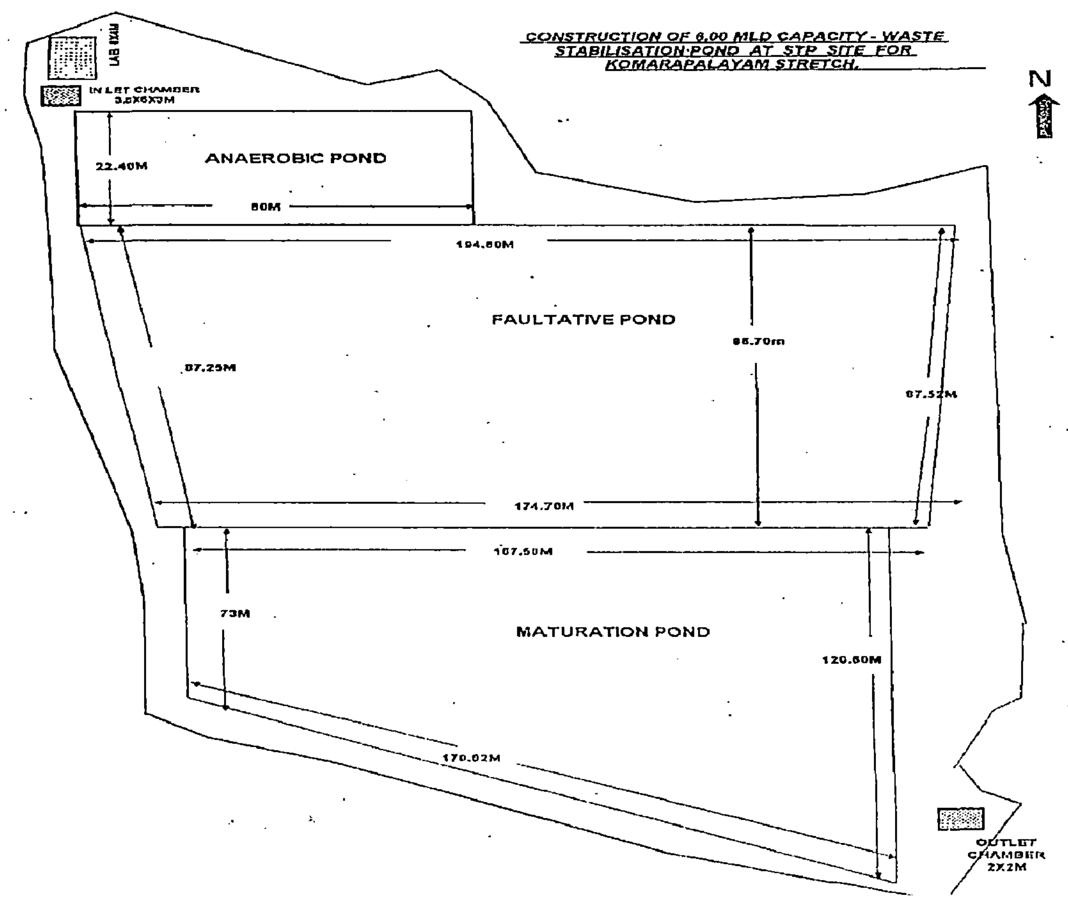


Figure 3.15: Komaraplayam STP Site Plan

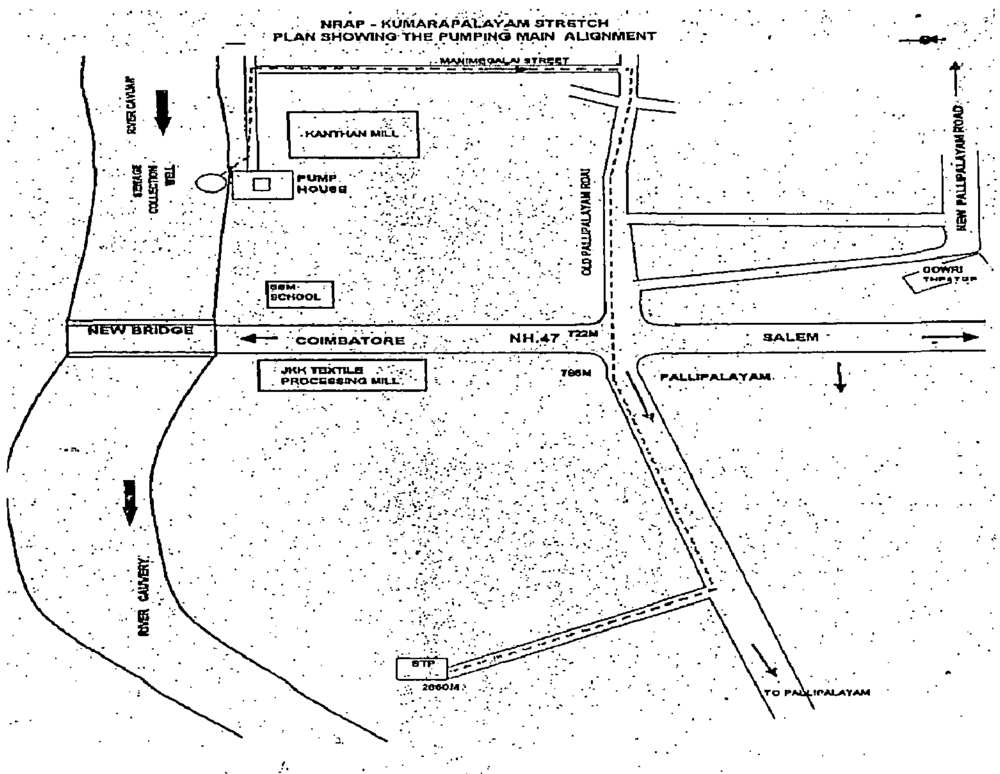


Figure 3.16: Komaraplayam STP Site Plan

3.9 ERODE

Prefatory: Erode town a District headquarters of Erode district, and comprising an area of 8.44. sq.km, and situated $11^0 30^0$N and longitude 77^0 45^0E.The maximum and minimum temperatures are 41.70^0 C and16.00^0 C. The average annual rainfall was 746 mm and the driest month is May and the wettest month is October. The average number of rainy days is 46 days.

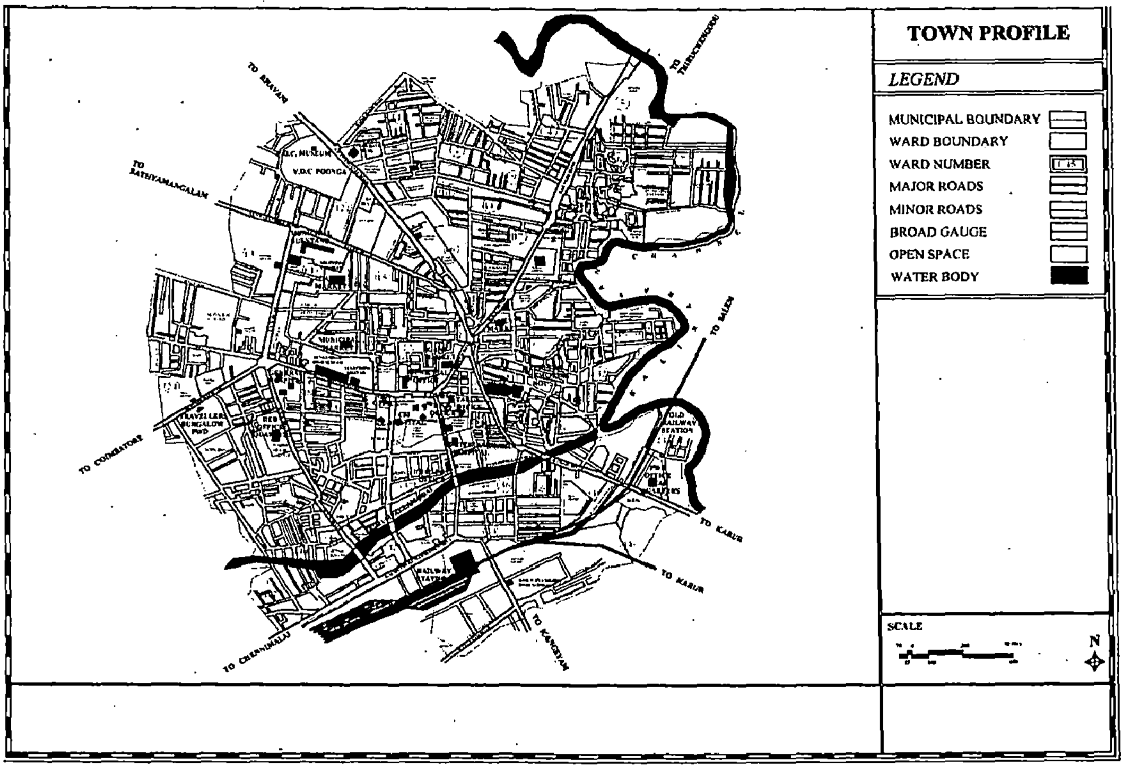


Figure 3.17: Erode Municipal Map

Importance: Cauvery River runs close to the town. The Kalingarayan Canal, an irrigation canal forms the eastern boundary of the town. The town has many small scale industries such as engineering works, automobiles ancillaries, power looms, and textile finishing units etc.

Profile: The general slope in the town is from west to east. The ground level variation is about 20 m.There are two major natural drains (I) Perumallpallam odai from west to east, through the southern part of the town and (II)Pithaikaran odai runs outside the town, through northern part of the town and finally join the River Cauvery. The mid-eastern portion of the town drains in Kalingarayan Canal.

Population: The population of the town with reference to previous census records are for years 1981: 1,42,252 , for 1991:1,59,232, and for 2001:1,51,184 respectively.

The ultimate population of Erode town for the year 2038 has been arrived 3, 45,000.The Sewage Quantity at 90 lpcd comes around 31.05 MLD.

Existing water supply: The source of the existing water supply is from River Cauvery surface water drawn through intake well. Daily 40 MLD of water has pumped to treatment plant for treatment. After necessary treatment treated water conveyed to 8 reservoirs located at 5 different locations and supplied to the consumers. Erode Town is not sewered at present. Rain water as well as Domestic sullage collected Perumpallam Odai and this sullage is pumped from karaivaikkal sewage pump house to sewage farm located at lakkapuram. (Scheme none functioning due to ground water pollution).

3.10 PALLIPALAYAM

Prefatory: Pallipalayam town a medium municipal town of Namakkal district, it comprising an area of sq.km, and situated 11^0 30^0N and longitude 77^0 45^0E.The maximum and minimum temperatures are 41.70^0 C and16.00^0 C. The average annual rainfall was 746 mm and the driest month is May and the wettest month is October. The average number of rainy days is 46 days.

Importance: Cauvery River runs along the south boundary of the town. The town has many small scale industries such as, power looms, hand looms, dyeing and textile finishing units etc.

Profile: The general slope in the town is from North to South. The ground level variation is about 10 m.

Population: The population of the town with reference to census records for the year 2001, 51,184 respectively. The ultimate population of Pallipalayam town for the year 2038 has been arrived as 80000 .The Sewage Quantity at 90 lpcd comes around 7.2MLD.

Existing water supply: The source of the existing water supply is from River Cauvery surface water drawn through intake well. Daily 6 MLD of water has pumped to treatment plant for treatment. After necessary treatment treated water conveyed over head reservoirs and supplied to the consumers.

Pallipalayam is not sewered at present. Rain water as well as Domestic sullage collected through open drained and this sullage is drained to Cauvery River near Highway Bridge.

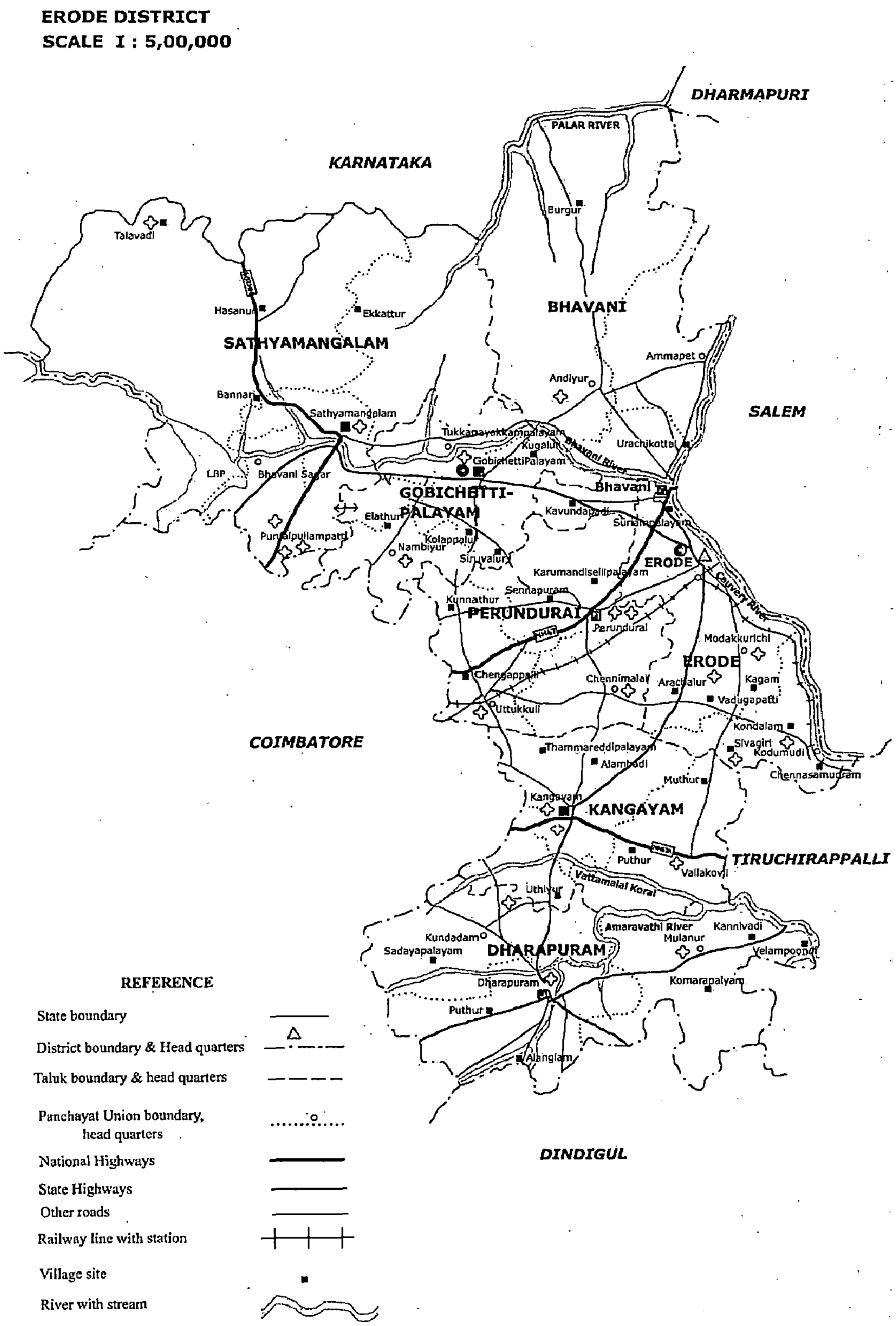


Figure 3.18 : Erode District Map

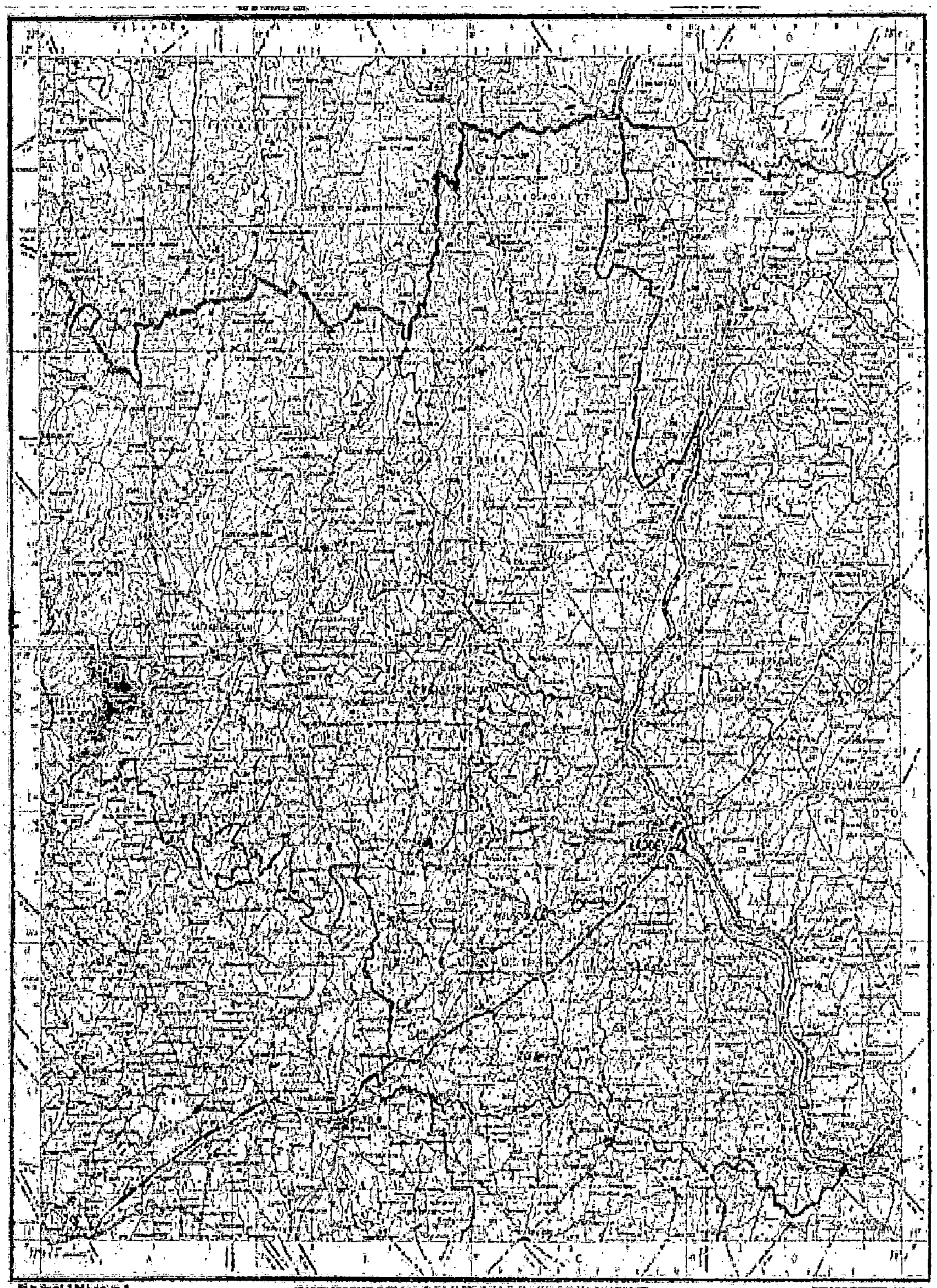


Figure 3.19 : Tope sheet: 58 E Tamil Nadu –Erode – Study Areas. Mettur Dam to Erode

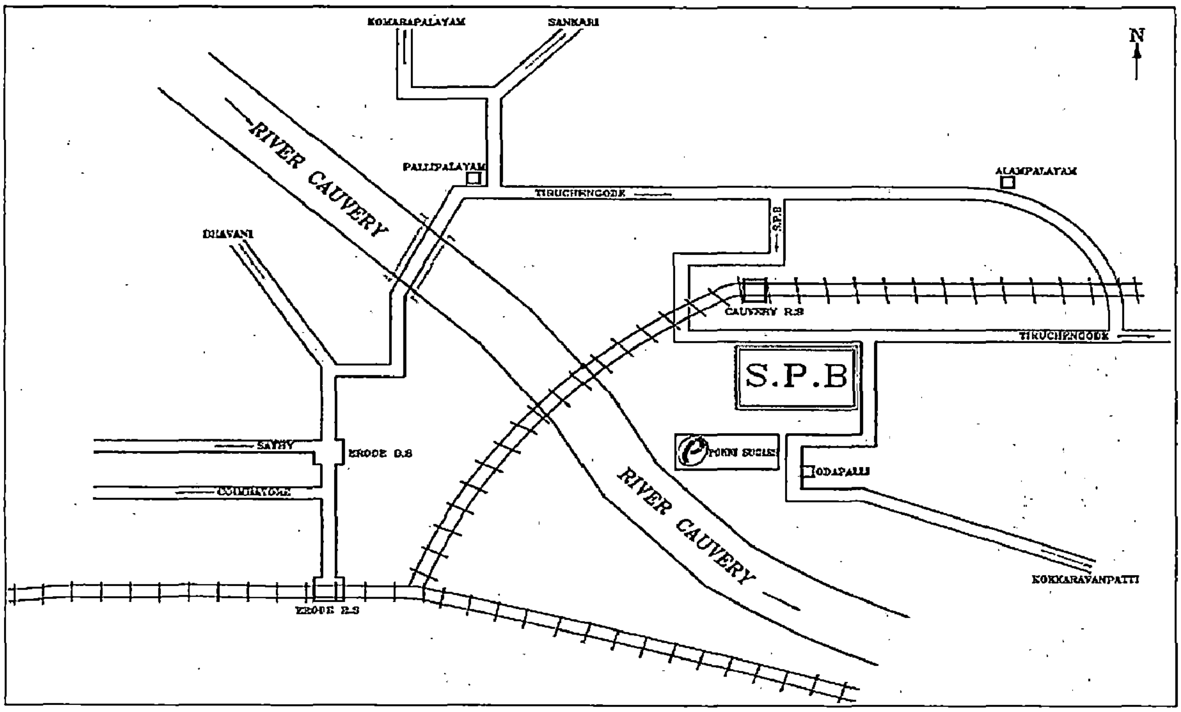


Figure 3.20 : Pallipalayam Municipality

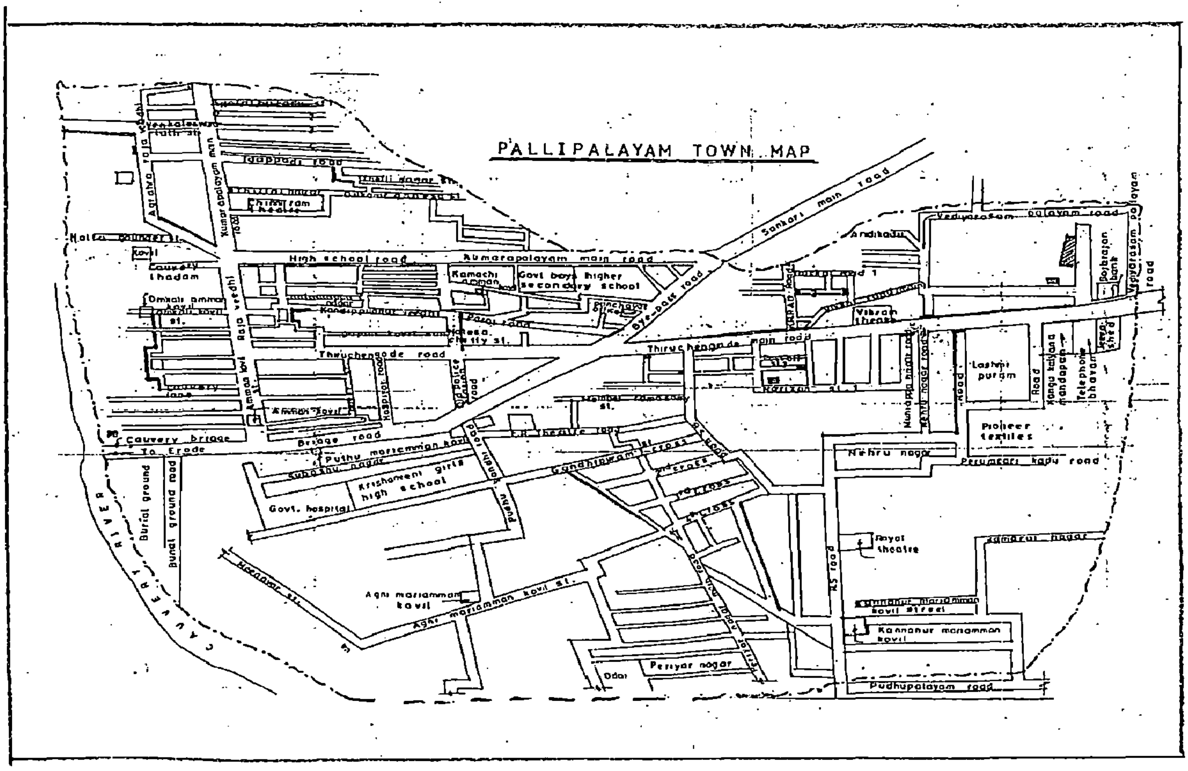


Figure 3.21 : Pallipalayam Municipality

3.11 VEEARPAN CHATTRAM

Prefatory: Veearpan chattram is a medium municipal town of Namakkal district, it comprising an area of sq.km, and situated 11^0 30^0N and longitude 77^0 45^0E.The maximum and minimum temperatures are 41.70^0 C and16.00^0 C. The average annual rainfall was 746 mm and the driest month is May and the wettest month is October. The average number of rainy days is 46 days.

Importance: Cauvery River runs along the Northern and Eastern boundary of the town. The town has many small scale industries such as, power looms, hand looms, dyeing and textile finishing units etc.

Profile: The general slope in the town is from North to South. The ground level variation is about 10 m.

Population: The population of the town with reference to 2001 census records was72703. The projected population of this town for the year 2038 has been arrived as 100,000 .The Sewage Quantity works out at 90 lpcd comes around 9 MLD.

Existing water supply: The source of the existing water supply is from River Cauvery surface water drawn through intake well. Daily 7 MLD of water has pumped to treatment plant for treatment. After necessary treatments water stored in the elevated tank and supplied to the consumers.

Waste water: Veearpan chattram is not sewered at present. Rain water as well as Domestic sullage collected at Pitchaikarananpallam Odai and this sullage is pumped from sewage pump house to Treatment plant located near Water intake Cauvery bank executed under N.R.A.P.

CHAPTER - 4

METHODOLOGY

4.1 INTRODUCTION

Indiscriminate disposal of industrial effluent and domestic sewage in rivers has led to serious river pollution in Cauvery River at Tamil Nadu. Effective monitoring of parameters is an important initial step in abatement of river pollution. The monitoring techniques can be classified as conventional, automatic recording and remote sensing techniques. The Cauvery River has been monitored. The data's available from Mettur Dam gauge station maintained by State Government P.W.D and from Central Water Commission gauge station Urachikottai data's are collected after conducting the reconnaissance survey of the river. Samples were collected and analyzed for the required parameters.

4.2 RECONNAISSANCE SURVEY

The following in formations are collected through the reconnaissance survey:

1. The Quantity industrial effluents that are confluences with the Cauvery river water.
2. The Quantity of domestic waste water is directly discharging into the river.
3. The Quantity of waste water including solid wastes discharging into the river.
4. The detailed data's for municipal drinking water and industrial water intakes from Cauvery River and their locations in the study area.
5. Impact of human activities upon the quality of water and suitability for use.
6. The sources and pathways of pollutants.
7. Influence of polluted and unpolluted water on distribution, density and community structure of the biota.
8. Mixing of pollutants thus representing water quality of river at that particular stretch.
9. Self purification capacity of the water body.
10. The quality of water in its natural state which might be available to meet the future need.

4.3 TYPES OF SAMPLES

The samples must be representative in nature. The samples are generally of three types:

1. Grab sample: It is a sample taken at a sampling point and time. The sample is collected from the main current and 20 to 30 cm below the surface to avoid collection of scum. This sample may be taken to represent the water quality of the source.
2. Composite sample: It is a combination of equal volumes of a number of grab samples collected at the same location at different times. Composite samples may be required only in special cases for calculation of mass flux in rivers when the quality of water is suspected to change over short periods of time.
3. Integrated sample: It is a mixture of grab samples collected simultaneously at different locations across the width of the river or at different depth. The need for an integrated sample may occur for very wide and deep rivers where the quality of water may vary across its width and depth.

4.4 METHOD OF WATER AND WASTE WATER SAMPLING

The method of water and wastewater sampling mainly depends on the nature of analysis to be carried out. Analysis may be broadly divided into physicochemical, bacteriological and biological categories.

1. Water samples for chemical analysis: The water samples are collected from a depth of 20-30 cm from the river by the plastic containers of minimum 5 liter of capacity, provided with double cap device. The samples are collected up to the top, without leaving any space so as to prevent the premature release of dissolved gases during the transit period.
2. Water samples of bacteriological analysis: The water samples are collected from 30 cm depth of the river in properly sterilized neutral glass bottles of 120 ml capacity.

   The water sample is not collected up to the top of the glass bottles due to the survival of bacteria. The water samples are analyzed within 24 hours of collection.
3. Water samples of biological analysis: The river water up to a depth of 10 cm are collected in wide mouth glass bottles of 1 liter capacity and preserved by using 1ml of Lugol's solution. The collection of samples was done in the

morning time. All the samples were brought to the laboratory and stored at 4°C in a refrigerator till the analysis was completed.

4. Water samples of bioassay test: The water samples of about 15 liter are collected from 20-30 cm depth of the river in a plastic container.

4.5 TIME INTERVAL BETWEEN COLLECTION AND ANALYSIS OF SAMPLES

Parameters such as pH, temperature and dissolved oxygen are analyzed on the spot as soon as the samples are collected.

The samples collected for bacteriological parameters are analyzed within 24 hours of their collection.

The samples for the identification and evaluation of algae are preserved by adding Lugol's solution or 4% formalin solution at the time of sample collection.

The water samples for the bioassay test are used within 12 hours of their collection from the river.

4.6 EXPERIMENTAL WORKS

Physicochemical and bacteriological parameters were evaluated identification and test are performed according to the methods specified in "Standard Methods for the Examination of Water and Wastewater" (APHA-AWWA-WPCF-1995) [ ]. The techniques, instruments and principles involved in arriving at different water quality parameters are tabulated in Table 4.3

Table 4.1: Summary of principles and methods

Sl. No.	Parameters	Principles	Instrument / Technique used
1	Temperature	Metric	Thermometer.
2	Turbidity	Photometric	Nephlometer or turbidity meter.
3	Dissolved solids	Gravimetric	Evaporation of filtrate (Whatman paper no. 44) at 103^0-105^0C
4	Total solids	Gravimetric	Evaporation in oven at 103^0C-105^0C hrs.
5	Total suspended solids	Gravimetric	Difference of residue of total solids and residue of dissolved solids in muffle furnace at 600°C in 20 minutes.
6	Specific conductance	Electrometric	Digital conductivity meters

7	pH	Electrometric	Digital P^H meter
8	Dissolved oxygen	Volumetric or Electrometric	Winklers method, Digital D. O. meters
9	BOD	Volumetric	Dilution technique and keeping the sample at 20°C for 5-days followed by winkers method.
10	COD	Volumetric	Dichromate digestion method
11	Ammonical nitrogen	Calorimetric	U.V. spectrophotometer, Nesselerization
12	Nitrate	Calorimetric	U.V. Spectrophotometer, Phenoldisulphonic acid method
13	Total Nitrogen	Calorimetric	Kjeldahal method, U.V. Spectrophotometer
14	Sulphates	Volumetric	Precipitate as $BaSo_4$
15	Sulphide	Volumetric	Ethylene blue method
16	Phosphate	Calorimetric	U.V. Spectrophotometer, $Sncl_2$ method
17	Oil & Grease	Gravimetric	Extraction method
18	Phenols	Calorimetric	U.V. Spectrophotometer
19	Fluoride	Electrometric	Ion selective electrode
20	Chloride	Volumetric	Titrimetric method using $AgNo_3$
21	Total coliform	MPN-index	Mc. Concey's browth at 35°C for 48 hrs
22	Faecal coliform	MPN-index	Mc. Concey's browth at 44°C for 48 hrs
23	Algae	Enumeration	Microscopic field by lackey's drop count method
24	Mortality of fish	Glass aquariums	Bioassay test


Photo 4.1: Erode Drain Interception

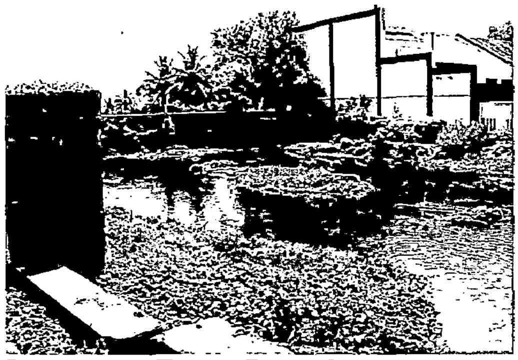


Photo 4.2: Erode Drain Interception

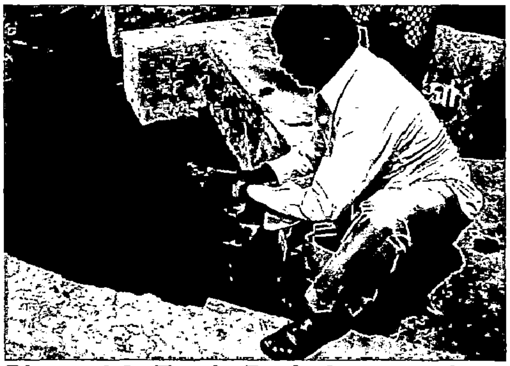


Photo 4.3: Erode Drain Interception-Waste Water Sample Collection


Photo 4.4 Erode Drain Interception Waste Water Sample Collection


Photo 4.5: Erode Drain Interception - Waste Water Sample Collection


Photo 4.6 Cauvery River -Solid Waste Leaching

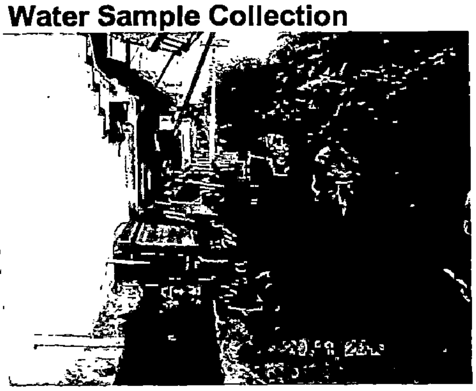


Photo 4.7: Erode Storm Water Drain -


Photo 4.8 Bhavani River- Solid Waste Leaching

4.7 SUMMARY

Effective monitoring of parameters is an important initial step in abatement of river pollution. Collections of samples are the most important function for river restoration program. The samples should be representative of the water body under examination and to avoid accidental contamination of the sample during the time of collection because the interpretation of results and recommendations for treatment are all based on the analysis report. Therefore, the selections of method or technique used are most important for detection and evaluation of pollutants which ultimately helps to initiate to abatement of river pollution.

By detailed investigation on the field and interaction with concerned officials , with available data's ,field measurements and observations, the quantity of sewage generation is worked out and correlated with the quantity of water supply provided along with their own raw water supply sources like open well and bore wells. The quality of waste water is ascertained by taking field sample as per the described methods and tested as per the Physicochemical and bacteriological parameters were evaluated identification and tests are performed according to the methods specified in "Standard Methods for the Examination of Water and Wastewater" (APHA-AWWA-WPCF-1995) [ ]. In the State Government, Chief Water Analyst Lab, Coimbatore.

The Cauvery River flow data and water quality data from June 1999 to January 2007 are collected from Executive Engineer, Mettur Dam, State P.W.D, and also from Central Water Commission Chief Engineer's office, Coimbatore. The raw data's of Cauvery River Mettur Dam gauge station obtained from State P.W.D are in F.P.S; hence these data's are converted in to S.I units. The data's are correlated with the CWC Gauge station flow data's. Field data's like Quantity of flow, Velocity, Dissolved Oxygen. pH, Temperature, are measured at various locations on 21.11.2006 with the direct reading field kits with the supervision of Dr.A.A .Kazmi Assistant . Professor Department of Civil Engineering I.I.T .Roorkee.

CHAPTER-5

ECOLOGICAL AND ENVIRONMENTAL DEGRADATION

5.1 GENERAL

Overview

The environment sustains all life plants and animals that provide us food, clothing, medicines, raw materials and all other human needs including a livable atmosphere providing the basic life support system to us. Natural resources form the basis of all our scientific advances, technological progress, genetic engineering, agriculture and industries. It is the basis of human survival itself. Natural resources, which are vital for food, livelihood and environmental security, are under intense pressure today. The challenges of their conservation and sustainable use remain enormous. The issue of environmental sustainability formally entered the international agenda after the Earth Summit held in Rio de Janeiro in 1992.

The land base per person is shrinking, posing the challenge of maintaining the soil health while obtaining more and more from less and less area and quality of land. Soil erosion accelerates greenhouse effect. The task is to reverse land degradation under the present patterns of land use, biotic pressure, state of technology and investment.

The water resources are also facing problems of pollution leading to high occurrence of water borne diseases. The major task country is to rehabilitate the degraded forests and to enhance the area under forest/tree cover to 33% of total area as envisaged in the National Forest Policy, 1988.

5.2 POLLUTED RIVER STRETCHES - IDENTIFICATION

The Central Board, in collaboration with concerned State Pollution Control Boards has initiated water quality monitoring at limited number of locations. The monitoring network was gradually augmented. At present there are 784 locations. The monitoring data are annually compiled, analyzed and compared with desired water quality in different water bodies.

Where ever gaps are observed especially with respect to pollution related indicators like Biochemical Oxygen Demand (BOD), the water body is identified as polluted.

In 1988-89, CPCB identified 10 problem areas and 10 polluted rivers stretches to concentrate the pollution control efforts and the list of polluted stretches formed the basis for formulation of River Action Plan of the National River Conservation Directorate. The list was further extended based on increasing pollution problem in our country.

The water bodies having BOD more than 6 mg/l are identified as polluted water bodies. A list of such water bodies is placed ahead. The respective Committees have been requested to formulate action plan to restore the water quality of the water bodies. In order to achieve the compliance of the water quality criteria in the Cauvery river polluted river stretches is identified, the following action is required:

- Inventory of sources which are discharging effluent in those stretches;
- Action Plan preparation to control the discharge of untreated effluent and implementation of the same; and,
- Location specific effluent standard based on water quality modelling exercise for the polluting sources.

Table 5.1: Polluted stretch Cauvery basin

River	Polluted Stretch	Source/Town	Critical Parameters (in mg/l)
Bhavani	Mettupalayam to Bhavani Town	Urban sewage and Industrial effluents	BOD- 6.4-7
Cauvery	D/s of Mettur Dam to Erode city	Municipal sewage of Erode and Industrial effluents	BOD- 6.4-7

5.3 SEWAGE POLLUTION

With the rapid increase in the population of the study area and the need to meet the increasing demands of irrigation domestic and industrial consumption of the Cauvery Basin, the available water resources are getting depleted and the water quality has become contaminated one. The pollution comes from three main sources: domestic sewage, industrial effluents and run-off from agriculture. The most significant environmental problem and threat to public health in the study area and the Cauvery basin is inadequate access to clean drinking water and sanitation facilities.

Almost all the surface water sources are contaminated to some extent by organic pollutants and bacterial contamination and make them unfit for human consumption unless disinfected. The diseases commonly caused by contaminated water are typhoid, cholera, gastroenteritis, bacterial dysentery, hepatitis, poliomycitis; amoebic dysentery etc urban environmental management is one of the most pressing issues as the urbanization trend continues globally. The under-management of domestic and industrial wastewater from Mettur Dam to Erode reach of Cauvery River presents a major challenge. The accumulation of human waste is constant and unmanaged wastewater directly contributes to the contamination of locally available freshwater supplies. Additionally, the cumulative results of unmanaged wastewater can have broad degenerative effects on both public and ecosystem health.

5.4 WASTEWATER GENERATION & TREATMENT: DOMESTIC SEWAGE VS INDUSTRIAL EFFLUENT

It is estimated that 68.4 million litres per day (MLD) of domestic wastewater is generated from urban centers against 84.80 MLD of industrial wastewater. The treatment capacity available for domestic wastewater is only for 31.17 MLD, against 60.00 MLD of industrial wastewater. Thus, there is a big gap in treatment of domestic wastewater. Govt. of India is assisting the local bodies to establish sewage treatment plants under the National River Action Plan. Since the task is massive, it may take long time to tackle the treatment of entire wastewater. It is estimated that the total cost for establishing treatment system for the entire domestic wastewater would be around Rs. 2700 Lakes.

Operation & maintenance cost would be in addition to this cost. Similarly, there is a gap in treatment of about 24.80 MLD of industrial wastewater, mainly generated from small-scale industries. Establishing effluent treatment systems in small-scale industries is a problem, since a large number of them are located in residential areas, where space is a constraint. Moreover, the small-scale industries are not having adequate resources to establish treatment systems. Such industries need to establish common effluent treatment plants (CETPs). A number of such facilities have been established across the country. It is expected that establishment of CETPs would reduce the pollution load in the aquatic resources of the country to a large extent.

5.5 SOURCE-RELATED CHARACTERISTICS OF DIFFUSE WATER POLLUTION

In the study area from Mettur Dam to Erode, part of the rural people and slum dwellers use open fields , river banks and drains, for their defecation, with a few using common toilets, own toilets, pit-latrines . Much of the bathing and washing (clothes, utensils etc.) shall be in or near the River Cauvery abstraction and transport of water but causing in-situ diffuse pollution. Generation of liquid effluents would be minimal and all wastewater generated shall soak into the nearby land. A careful materials-balance as also field experience would show significant quantities of various types of pollutants including salts, nutrients, organics and micro-organisms from such hamlets and rural areas reaching ground or surface water bodies through leach ate and as washings in the storm run-offs. It is estimated an average 15g BOD per capita per day of the rural population reaching the major river draining that particular basin. Corresponding loads of salts, nutrients, micro-organic and other pollutants would also be reaching the Cauvery River, while the amounts of pollutants percolating to ground waters may be much larger.

For considering the study area study period from June 1999 to January 2007 for critical evaluation and analyzing period of totally 2802 days flow data's and water quality of River Cauvery from first June 1999 to 31st January 2007, totally 815 days virtually there is no flow in the river, it comes around 29.08 % as non flow days.

But the Industrial and Municipal sewages treated, partially treated and un treated effluents are continuously let out into the Cauvery River in our study area Mettur dam to Erode along the natural sources of contamination like agricultural return run off, carcasses of death animals, fishes, decaying vegetations and trees, agricultural excess fertilizers. Pesticides, agricultural wastes, and other natural disturbances in the catchment area, etc has influence the sub surface flow of the river as well as stagnated low level pockets of river course and it leads heavy pollution and contamination. The accumulated sewage and Industrial effluents stagnating in the river, and it settle it's down in the river as solid matters in the river bed it self due to zero velocity. Absence of sufficient out flow from the Mettur Dam to the study area, the drinking and industrial water intakes daily 700 MLD drawn from the Cauvery River in the study area alone against 2232 MLD of total drawl of 15 Districts for their requirements including the study area from the intake wells in Cauvery River.

The quality and reliability of the drinking water resources of 30,15,000 population as per 2001 census now under severe threat due to the absence of requirements for continuous flow in the Cauvery River considering pollution load the dilution factor as well as self purification capacity of the Cauvery River ecosystem in the study area alone. The overall drinking water source for 15 districts 2,62,39,416 population as per the Table- and the total quantity of Cauvery river water daily drawl 2232 MLD for drinking purpose alone from surface water as well as from infiltration wells erected in the river itself are under severe threat. The water supply sources of Erode, Pallipalayam, Sankagiri, Veearpan chattram Tiruchengodu are surrounded by effluents and sewage due to zero velocity and absence of dilution factor. The above water supply sources now getting contaminated by the stagnated sewage and effluents both quantity and quality wise.

The filter beds of the water supply treatment plants are requiring frequent backwash, poor performance and delivers very poor bacteriological quality of water. During absence of out flow from Mettur dam the Cauvery River has only sewage and industrial effluents flow with strong different colour dyes depending up on the textile processing units and chemicals used. The chemicals dyes are daily and hourly varying with reference to day to day requirement and demands of the season and export orders. The absence of fresh water and zero velocity of the river water ,and the presence of heavy nutrients algal growth, weeds growth, foul smell, black colour, absence of light penetration and sewage with septic condition due to the heavy requirement of Biochemical Oxygen Demand.

5.6 MANGROVE VEGETATION

Mangroves are a group of salt tolerant plant species that occur in the Tropical and subtropical intertidal estuarine regions, sheltered coast lines and creeks and are dominated by partly submerged sclerophyllous plant species that are taxonomically unrelated. Mangroves constitute a dynamic ecosystem with a complex association of species, both of flora and fauna, of terrestrial and aquatic systems and the vegetation presents an evergreen type with varied life forms. Mangroves stabilize loose soil and detritus, act as a filter for land runoffs, prevent sea erosion and protect the hinterland from tidal surges, cyclonic storms and high velocity winds. Mangroves have four major functions:

- Help in soil formation by trapping debris.
- Serve as a sieve for rich organic soil washed down through river systems into sea.
- Provide appropriate ecosystem and refuge for fish, marine invertebrates, mollusc and birds.
- They contribute detritus enhancing the productivity of the ecosystem.

Mangroves have different mechanisms for salinity tolerance. Some species store the salt in older leaves and others secrete the excessive salts through excretory glands. Root system of Mangroves also shows a number of adaptations to suit the salt marsh habitat. Some mangrove genera like Rhizophora have 'aerial' or 'prop' or 'stilt roots' and genera like Avicennia possess 'pneumatophores' or 'breathing roots'. Another important adaptation is Viviparous seedlings germinating of seeds into seedlings while attached to the parental plant) and dispersal of seedling through water. In Tamil Nadu mangrove vegetation is mainly seen in Pitchavaram. Pitchavaram covers an area of about 14 sq km of dense mangrove vegetation. Apart from Pitchavaram they are seen in Gulf of Mannar. In Tamil Nadu there are 22 species of mangroves under 16 genera and 13 families.

Table 5.2: The list of mangroves seen in Cauvery River delta mouth

S.No.	Binomial	Family
1	Acanthus ilicifolius L.	Acanthaceae
2	Aegiceras corniculatum (L.) Blanco	Mrysinaceae
3	Avicennia alba Blume	Avicenniaceae
4	Avicennia marina (Forssk.) Vierh.	Avicenniaceae
5	Avicennia officinalis L.	Avicenniaceae
6	Bruguiera cylindrica (L.) Blume	Rhizophoraceae
7	Bruguiera gymnorrhiza (L.) Savigny	Rhizophoraceae
8	Cerbera odollam Gaertn.	Rhizophoraceae
9	Ceriops decandra (Griff.) Ding Hou	Rhizophoraceae
10	Ceriops tagal (Perr.) Robins	Rhizophoraceae
11	Dalbergia spinosa Roxb.	Fabaceae
12	Excoecaria agallocha L.	Euphorbiaceae

13	Heritiera littoralis Dryand	Sterculiaceae
14	Kandelia candel (L.) Druce	Rhizophoraceae
15	Lumnitzera racemosa Willd.	Combretaceae
16	Myriostachya wightiana (Nees ex Steud.)Hook.F	Poaceae
17	Rhizophora annamalayana Kathir.	Rhizophoraceae
18	Rhizophora apiculata Blume	Rhizophoraceae
19	Rhizophora mucronata Poir.	Rhizophoraceae
20	Scyphiphora hydrophyllacea Gaertn.	Rubiaceae
21	Sonneratia apetala Buch. – Ham.	Sonneratiaceae
22	Xylocarpus granatum Koen.	Meliaceae

The mangrove on the mouth of the Cauvery River basin in the East Coast is dwindling and species vanishing due to anthropogenic activities. There is over exploitation that has led to degradation and shrinkage of mangroves and vanishing of species as a result. Species like Bruguiera gymnorrhiza and Acanthus ilicifolius collected earlier in Rameswaram have not been recollected in recent years. Vegetation is undergoing severe damage because of firewood collection. Rapid industrialization all along the mainland coast and increase in the extent of Shrimp culture and non receipt of flow from the Cauvery River are the other major reasons for the disappearance of mangroves in the recent past.

5.7 ENVIRONMENTAL PROTECTION AGAINST DEGRADATION

Protection of environment and reduction of wastes at source, besides continuing enforcement and monitoring activities.

Conservation and enhancement of life support systems like land, water, forests, biodiversity, ocean and the atmosphere giving ecological security.

Properly treating or converting the pollutants into useful products and thereby reducing their negative impact.

Promotion of suitable measures and technologies for recycling or reusing.

Emphasizing the environmentally safe waste disposal options viz, composting of all organic wastes, common facilities for bio-medical wastes, etc.

Maintaining essential ecological processes to ensure genetic diversity and prevent environmental degradation.

Promoting the active participation of people at all levels from the village panchayat to the State as a whole in the preservation of the environment and promotion of sustainable development through awareness campaigns.

While water-related diseases vary substantially in their nature, transmission, effects, and management, adverse health effects related to water can be organized into three categories: water-borne diseases, including those caused by both fecal-oral organisms and those caused by toxic substances; water-based diseases; and water-related vector diseases. Diseases consist of diseases that develop where clean freshwater is scarce.

5.8 WATER-BORNE DISEASES

Water-borne diseases are "dirty-water" diseases those caused by water that has been contaminated by human, animal, or chemical wastes. Water-borne diseases include cholera, typhoid, shigella, polio, meningitis, and hepatitis A and E. Human beings and animals can act as hosts to the bacterial, viral, or protozoa organisms that cause these diseases. Millions of people have little access to sanitary waste disposal or to clean water for personal hygiene. Where proper sanitation facilities are lacking, water-borne diseases can spread rapidly. Untreated excreta carrying disease organisms wash or leach into freshwater sources, contaminating drinking water and food. The extent to which disease organisms occur in specific freshwater sources depends on the amount of human and animal excreta that they contain.Diarrhoeal disease, the major water-borne disease, is prevalent in many countries where sewage treatment is inadequate. Instead, human wastes are disposed of in open latrines, ditches, canals, and water courses or they are spread on cropland. Using contaminated sewage for fertilizer can result in epidemics of such diseases as cholera. These diseases can even become chronic where clean water supplies are lacking. Sewage water that was used to fertilize vegetable fields caused outbreaks of cholera. Slum neighborhood faced continual outbreaks of cholera, hepatitis, and meningitis because only 4% of homes had either water mains or proper toilets, while poor diets and little access to medical services aggravated the health problems in the study area. Toxic substances that find their way into freshwater are another cause of water-borne diseases. Increasingly, agricultural chemicals, fertilizers, pesticides, and industrial wastes are being found in freshwater supplies. Such chemicals, even in low concentrations, can build up over time and, eventually, can cause chronic diseases such as cancers among people who use the water.

Health problems from nitrates in water sources are becoming a serious problem. Nitrates from fertilizers have seeped into water wells, fouling the drinking water. Excessive concentrations of nitrates cause blood disorders. Also, high levels of nitrates and phosphates in water encourage growth of blue-green algae, leading to deoxygenation (eutrophication). Oxygen is required for metabolism by the organisms that serve as purifiers, breaking down organic matter, such as human wastes, that pollute the water. Therefore the amount of oxygen contained in water is a key indicator of water quality.

Pesticides such as DDT and heptachlor, which are used in agriculture, often wash off in irrigation water. Their presence in water and food products has alarming implications for human health because they are known to cause cancer and also may cause low sperm counts and neurological disease. Irrigation return water entered to River Cauvery during the rainy season found that the water was contaminated with a number of pesticides. Examination of pregnant women in the area found that they all had breast milk containing DDT residues—toxins that can be passed to an infant. The seepage of toxic pollutants into ground and surface water reservoirs used for drinking and household use causes health problems. In the study area peoples and live stocks drinks water contaminated with heavy metals, a practice that helps to explain high infant mortality rates and endemic diarrhoeal and intestinal diseases reported there.

In particular, constructing sanitary latrines and treating wastewater to allow for biodegradation of human wastes will help curb diseases caused by pollution. At the least, solids should be settled out of wastewater so that it is less contaminated. It is important that a clean water supply and the construction of proper sanitary facilities be provided together because they reinforce each other to limit the spread of infection.

5.9 WATER-BASED DISEASES

Aquatic organisms that spend part of their life cycle in the water and another part as parasites of animals cause water-based diseases. These organisms can thrive in either polluted or unpolluted water. As parasites, they usually take the form of worms, using intermediate animal vectors such as snails to thrive, and then directly infecting humans either by boring through the skin or by being swallowed.

Water-based diseases include guinea worm (dracunculiasis), paragonimiasis, clonorchiasis, and schistosomiasis (bilharzia). These diseases are caused by a variety of flukes, tapeworms, roundworms and tissue nematodes, often collectively referred to as helminths that infect humans. Although these diseases usually are not fatal, they can be extremely painful, preventing people from working and sometimes even making movement impossible. The prevalence of water-based diseases often increases when dams are constructed, because the stagnant water behind dams is ideal for snails, the intermediary host for many types of worms.

Individuals can prevent infection from water-based diseases by washing vegetables in clean water and thoroughly cooking food. They can refrain from entering infected rivers, because many parasites bore through the feet and legs. In areas where guinea worm is endemic, people can use a piece of cloth or nylon gauze to filter out guinea worm larvae, if clean water is unavailable. As with water-washed diseases, providing hygienic disposal of human wastes helps control water-based diseases. Also, for irrigation channels and other constructed waterways, building fast-flowing streams makes it more difficult for snails to survive, thus eliminating the intermediary host.

5.10 WATER-RELATED VECTOR DISEASES

Millions of people suffer from infections that are transmitted by vectors insects or other animals capable of transmitting an infection, such as mosquitoes and tsetse flies that breed and live in or near both polluted and unpolluted water. Such vectors infect humans with malaria, yellow fever, dengue fever, sleeping sickness, and filariasis. The incidence of water-related vector diseases appears to be increasing. There are many reasons: people are developing resistance to antimalarial drugs; mosquitoes are developing resistance to DDT, the major insecticide used; environmental changes are creating new breeding sites; migration, climate change, and creation of new habitats mean that fewer people build up natural immunity to the disease; and many malaria control programs have slowed or been abandoned.

Lack of appropriate water management, along with failure to take preventive measures, contributes to the rising incidence of malaria, filariasis, and onchocerciasis. Construction projects often increase the mosquito population, as pools of stagnant water, even if they exist only briefly, become breeding grounds. The solution to water-related vector diseases would appear to be clear eliminating the insects that transmit the diseases. This is easier said than done, however, as pesticides themselves may be harmful to health if they get into drinking water or irrigation water. Also, many insects develop resistance to pesticides, and diseases can emerge again in new forms.

Alternative techniques to control these diseases include the use of bed nets and introducing natural predators and sterile insects.

An inexpensive approach to controlling insect vectors involves the use of polystyrene spheres floating on the top of bodies of static water. Because the spheres cover the surface of the water, the mosquito larvae die from lack of air.

Table 5.3: Water related diseases and Causative factors

Name of the disease	**Causative organism**
1 Water-borne diseases Bacterial Typhoid Cholera Paratyphoid Gastroenteritis Bacterial dysentery Viral Infectious hepatitis Poliomycetis Diarrhoeal diseases Other symptoms of enteric diseases Protozoan Amoebic dysentery	 Salmonella typhi Vibrio cholerae Slmonella parayphi Enterotoxigenic Escherichia coli Variety of Escherichia coli Hepatitis-A virus Polio-virus Rota-virus, Norwalk agent, other virus Echono-virus, Coxsackie-virus Entamoeba hystolitica
2 Water-washed diseases Scabies Trachoma Bacillary dysentery	 Various skin fungus species Trachoma infecting eyes E. coli
3 Water-based diseases Schistosomiasis Guinea worm	 Schistosoma sp. Guinea worm
4 Infection through water related insect vectors Sleeping sickness Malaria	 Trapanosoma through tsetse fly Plasmodium through Anaphelis
5 Infections primarily due to defective sanitation Hookworm	 Hook worm, Ascaris

Another way to control the vectors is species sanitation—using biological methods and habitat management to reduce or eliminate the natural breeding grounds of the disease vectors. Such methods can include: filling and draining unneeded bodies of stagnant water; covering water storage containers; eliminating mosquito breeding sites by periodically clearing canals, reservoirs, and fish ponds of weeds; installing sprinkler and trickle irrigation instead of canals; and lining canals to prevent silt deposits from forming and impeding the flow of water. Also, integrating education about disease prevention into health services and encouraging community discussion of prevention would help people to control vectors and to identify and eliminate inconspicuous breeding sites.

5.11 WATER-SCARCE DISEASES

Many other diseases including trachoma, leprosy, tuberculosis, whooping cough, tetanus, and diphtheria are considered water-scarce (also known as water-washed) in that they thrive in conditions where freshwater is scarce and sanitation is poor. Infections are transmitted when too little fresh water is available for washing hands. These diseases, which are rampant throughout most of the world, can be effectively controlled with better hygiene, for which adequate freshwater is necessary. Some parasitic diseases not usually considered water-related and previously limited in their reach have been rapidly expanding as populations grow and water supplies become more polluted.

5.12 WATER QUALITY OF RIVERS IN CAUVERY BASIN CAUVERY RIVER SYSTEM

The Cauvery Basin extends over an area of 87,900 sq km in the States of Kerala, Karnataka and Tamil Nadu. The total length of the river from the head to its out fall into the sea is 812 km of which about 320 km are in Karnataka 416 km in Tamil Nadu and the remaining length of 64 km forms the common boundary between the States of

Karnataka and Tamil Nadu. The important tributaries, which join the Cauvery within the Karnataka State, are the Harangi, the Hemavathi, the Shimsha and the Arkavati on the north (left bank) and the Lakshmantirtha, the Kabani or Kapila and the Suvarnavathi on the south (right bank). In the south (right bank), they are the Bhavani, the Noyyal and the Amaravati. The delta of Cauvery is so matured that the main river Cauvery has virtually lost its link with the sea, while Coleroon, the main distributaries, bears the brunt of the burden of flow. Like other rivers of South India, the Cauvery too has a rather limited water wealth because of moderate to low rainfall in the basin. The basin area of Cauvery is covering the States of Karnataka and Tamil Nadu; The important urban centers in these states are Tumkur, Mandya, Mangalore, Mysore, Hassan, Bangalore, Channapatna, Dod, Ballapur, Ramanagaram, in Karnataka;Karaikal in Pondichery; Valparai, Tamilnadu, Pollachi, Coimbatore, Erode, Thanjavur, Karur, Tiruchirappalli, Salem, Kumbakonam, Bhavani, Chidambaram, Coonoor, Devershola, Mannargudi, Mayiladuthurai, Mettuppalaiyam Nagappattinam, Pattukkottai, Pudukkottai, Tiruchengodu, Udhagamandalam, Udumalaippettai, Villupum, in Tamil Nadu. Industrial activity is also high in this basin, particularly in the Bangalore area (Karnataka) and the towns Mettur and Coimbatore in the Tamil Nadu State, followed by the districts of Mysore and Mandya in Karnataka and Erode and Salem in Tamil Nadu.

All the Urban centers and the industries in the basin area are discharging their treated, partially treated, or un treated sewage and effluents into River Cauvery or to their Tributaries, or Lakes, which ultimately reach the Cauvery River . The non point sources like agricultural run-off , return water during rainy season and inundated drain water, rain and wind washed out pesticides, chemicals, detergents, food wastes, agricultural wastes, ash, fertilizers,dyes,construction debris,silt,weathering of rocks, lubricants ,oils, decayed vegetations, decayed fruits, human and animal, live stock daily wastes, carcasses of dead animals, fallen trees, and plants mass bathing, idols immersion, dropping of plastics and other degradable wastes in to the river system, washing soaps, detergents, chemicals, greases .Point sources like leaching from compost yards, and municipal drains, slaughterhouses, clinical and hospital wastes,themal power plant coal wastes fly ash and cooling water tower effluents from Chemical,Sugar,Paper , Mining, Mineral extraction , Sand quarrying in the river bed,

Aluminium extraction industries, and press mud red earth effluents from industries located along the river will leads ecological degradation of the riverine eco system of River Cauvery.

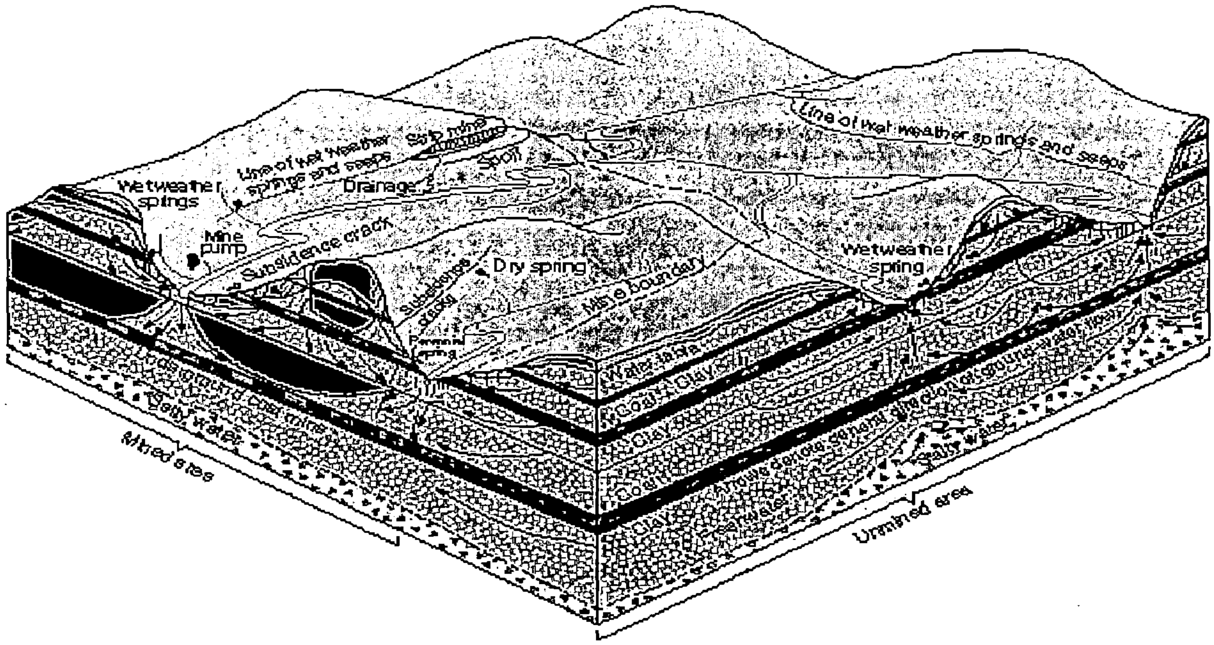


Figure 5.1 : Typical hydrology in mined and unmined area

5.13 RAINFALL PATTERN

Global warming directly altering the precipitations and evaporation pattern coupled with frequent inundations and drought. Increasing temperature regimes and sea-level rises that are regarded as consequences of global warming would alter the nature of vegetations and agriculture .The natural expansion of sea water as it becomes warmer. Consequently, areas adjoining the coast and wetlands could be frequently flooded and the distribution pattern of monsoon rains gets altered with more intense downpours, storms and hurricanes. From the meteorological data of Cauvery river delta region of Tamilnadu state, India shows that the average annual rainfall during the period of 1991 to 2000 has increased by 129 mm compared to that during 1981 to 1990. The record also reveals that the annual evaporation has reduced by 255 mm from the period between 1981 to 1990 & 1991 to 2000. Further, wet years (years with excess average annual rainfall by more than ten per cent) are also more frequent in 1991 to 2000 than 1980 to 1990.

More number of wet years annual rainfall excess by ten percent or more resulting in frequent inundation or flooding between 1991 to 2000 compared to the preceding ten years resulted in invasion of rice fields of Cauvery delta by alien invasive weeds Leptochloa chinensis Nees and Marsilea quadrifolia by virtue of their amphibious adaptation to alternating flooded and dry situations.

Table 5.4 Rainfall and evaporation pattern in the Cauvery river Delta region of India

S.No	Year	Average annual rainfall (mm)	Annual evaporation (mm)	Rainfall deficit / excess percentage
1	1981	1192.0	2701.0	-14.86
2	1982	926.8	2482.0	-33.8
3	1983	1148.6	2336.0	-18.0
4	1984	1479.6	1861.5	5.69
5	1985	1985.2	1971.0	41.8
6	1986	1257.5	1971.0	-10.18
7	1987	1438.7	2080.5	2.76
8	1988	1132.6	2007.5	-19.10
9	1989	1448.3	2153.5	3.45
10	1990	1543.0	1971.0	10.21
11	Average	1483.9	1898.0	
12	1991	1196.4	1934.5	-14.54
13	1992	1257.3	2007.5	-10.19
14	1993	2024.1	1934.5	44.58
15	1994	1349.8	1971.0	-3.59
16	1995	1124.8		16.85
17	1996	1701.5	1825.0	21.54
18	1997	1636.0		16.85
19	1998	1701.5	1861.5	11.44
20	1999	1434.0	1861.5	2.43
21	2000	1555.0	1861.5	11.07
22	Average	1483.9	1898.0	
23	1996	1343.2	1788.5	-4.06
24	1997	1281.0	2007.5	-8.50
25	1998	938.7	1825.0	-32.95
26	1999	1699.5	1745.1	21.26
27	2000	1745.1	1733.3	24.51
28	Average	1401.5	1819.88	

Both increased and decreased runoff will alter wet water regimes and the floristic composition could be invaded by floating weeds. Managing of alien invaders include several key components. But simple but vital clue is to continue traditional farming leads and the techniques plantation of avenue trees such as Tamarind largely keeps the river margins free from parthenium infestation.

5.14 STATUS OF WASTE WATER POLLUTION TO RIVER CAUVERY

Excessive water consumption, contamination of surface and ground water, inundation and semi or complete dry situations of water shed of Cauvery ,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 Cauvery River basin. In the study area from Mettur dam to Erode stretch 25 Million cubic metres of waste water have been generated per annum respectively from Six urban areas.[Table---]The facilities for waste water collection is totally Nil. The existing treatment facilities treat only 35.11MLD or 12.815 Million cubic metres of generated wastewater only 51.26% of the waste water and also mostly up to primary level and to some extent to secondary level before discharging to River Cauvery.

Table 5.5 : Cauvery River flow d/s Mettur Dam CWC Gauge Urachikottai

Month	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	Average
June	115.2	652.09	709.42	0.00	3.25	4.32	65.45	221.39
July	886.49	1284.44	1173.99	62.27	13.91	208.40	175.95	543.64
August	1566.34	884.53	945.33	166.94	46.26	725.13	1191.7	789.46
September	1106.95	1006.27	665.52	835.99	39.93	783.54	1732.92	881.59
October	150.63	2664.37	618.61	382.85	617.62	632.28	2628.84	1099.31
November	778.56	790.44	473.25	441.39	412.69	180.76	1668.58	677.95
December	632.29	959.33	701.44	525.88	296.25	726.00	776.38	659.65
January	525.06	640.00	849.65	256.35	122.96	707.19	451.53	507.54
February	171.82	183.88	84.22	85.54	0.00	0.00	58.24	83.39
March	126.8	0.00	194.38	41.77	0.00	40.55	101.45	72.14
April	130.29	13.88	196.51	15.60	0.00	38.83	136.96	76.01
May	112.8	135.53	90.36	0.00	23.13	8.14	145.15	73.59
Total M. cum	6303.23	9214.76	6702.68	2814.60	1576.01	4055.14	9133.15	5685.65

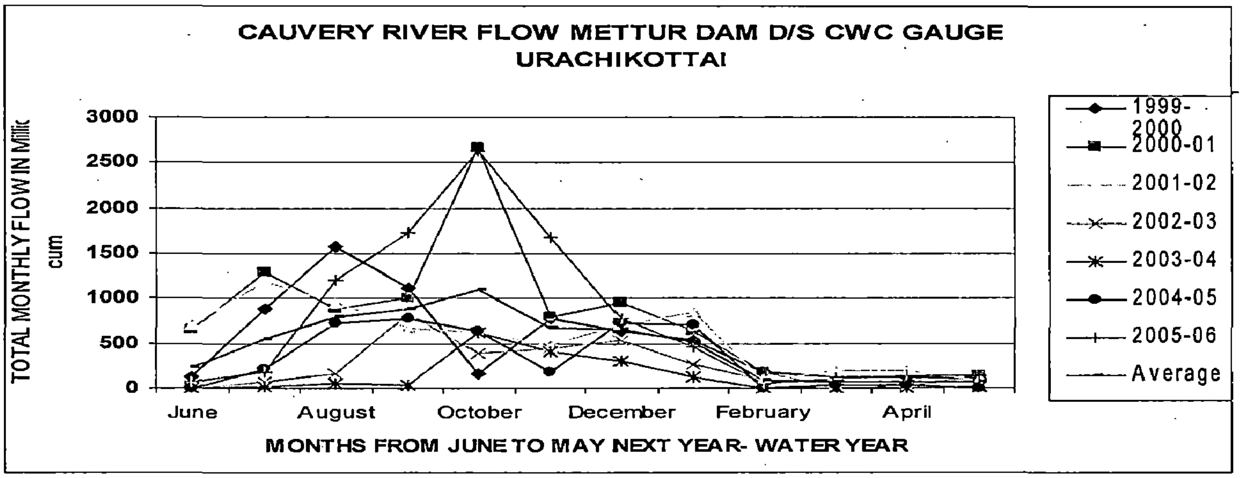


Chart 5.1

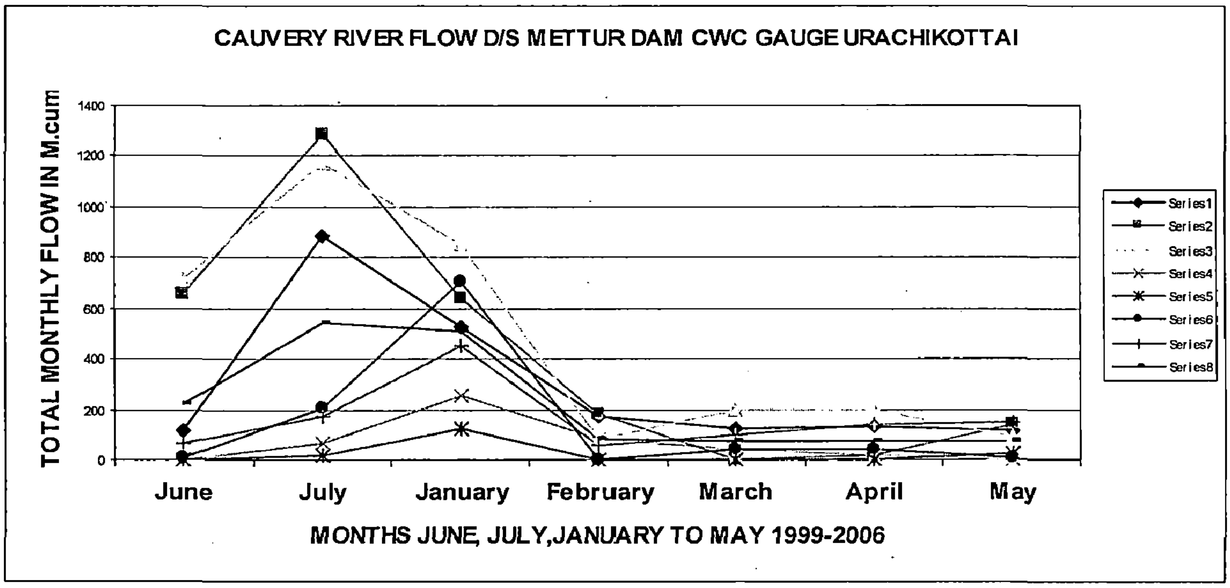


Chart 5.2

"Man has been playing a key role in shaping the environment with most of his activities directed towards its overall degradation. The aquatic ecosystems, which remained balanced and unaffected till the early days of civilization, get rapidly deteriorated due to population explosion, and disposal of sewage and mushroom growth of industries. Billions of gallons of waste water from cities, housing settlements, industries and agricultural fields are thrown into watercourses everyday. A large part of the population has to depend upon untreated or inadequately treated water supplies. In the sector of industrial pollution, while the medium and large industries can be induced to enforce pollution control, the problem becomes almost intractable for the vast numbers of small industries that have proliferated unplanned in many parts of the country.

5.15 AQUATIC LIVES

During the low water period the majority of fish tend to remain relatively static. Riverine migrant species which ascend the main course of the river and its tributaries during low water are an exception to the more general behavior pattern and form the basis of such fisheries Barrages are common throughout river systems, sometimes taking complex labyrinth-like forms, but more often simply dividing the main river channel or the smaller drainage canals into sections which limit fish movement and facilitate their capture by other means. Because the river is only one component of a larger system, the basin, fish communities in rivers are affected not only by events occurring within the channel and its associated waters but are also subject to a range of external influences. Precipitation falling within the basin eventually finds its way into the river by surface and sub-surface flow carrying with it a variety of materials including the topsoil and any contaminants it might contain. Changing conditions in the basin can produce differences in water quality and quantity, as well as in loading with silt and other material which can directly affect channel form. Many such effects are the result of natural variability, particularly climatic shifts but more frequently such changes are the result of some human intervention. In river reaches with floodplains the situation is more complex as the floodplain has a dry season phase during which time terrestrial use is made of space which is covered with water during the flood.

Because of the fertility of their soils, and their proximity to water courses for irrigation and transport, floodplains are much in demand for a wide range of activities. They are also regarded as having high development potential and efforts to 'reclaim' them by flood control are widespread. This chapter examines some of these effects and also describes the observed impacts on river fish communities of uses of the river and its basin other than fisheries. Otters from the sub family Lutrinae with in the mammalian family mustelidae and are adapted to semi aquatic mode of life. Major threat to Otter survival in Cauvery River are the loss of wetland habitats reduction in prey biomass and pollution .Development of barrages and aquaculture activities have taken their toll as wetlands and consequently to Otters.

5.16 CHANGES IN FLOW

Rivers respond to changes in mean annual flow by a period of adjustment to the new regime after which they stabilize in a form adapted to the altered conditions. Clearly reductions in flow will result in the progressive restriction of the stream to a smaller bed within the original channel with a concomitant loss of habitats for fish and other aquatic organisms. Conversely, overall increases in flow will lead to the enlargement of the river channel by erosion of former banks and other features; these, in time, should lead to an increase in habitat diversity through extension of the aquatic system. Biotic sensitivity to changes in water regimes are not limited to alterations in absolute quantity but also to the distribution of flow in time as food peaks can be moved to different times of the year or even suppressed altogether.

The living aquatic organisms in rivers are usually adapted to the particular patterns of flow found there; consequently changes in flow will produce changes in the biotic components of the ecosystem quite apart from those arising from the contraction or extension of the aquatic habitat. Fish communities tend to be either limnophilic or rheophilic, depending on the type of water regime prevalent in the river reach in which they live. Changes in flow will, therefore, tend to favour one or other of these communities, increasing flows leading to a larger presence of rheophilic species, decreasing flows encouraging colonization by limnophilic species. Adequate flows are also essential for the breeding and migration of many fishes.

Physiologically fish respond to flood conditions by becoming sexually ripe and by movement to breeding grounds. Conversely, should the appropriate flow regime not occur, eggs may be resorted. Certain critical levels of flow are also needed to maintain certain types of breeding substrate in a suitable condition for spawning. For this reason, there has been much concern over the determination of minimum flow requirements for fish, particularly in rhithronic areas where high value angling resources coincide with high demands for water. Three main approaches to the general problem of evaluating in stream flow requirements:

Table 5.6: In stream Flow Regimes for Fish and Related Environmental Resources

Description	Base flow regimes (% of original average flow in periods)	
	October-March	April-September
Flushing or maximum	200	200
Optimum range	60–100	60–100
Outstanding	40	60
Excellent	30	50
Good	20	40
Fair or degrading	10	30
Poor or minimum	10	10
Severe degradation	10–0	10–0

The above figures have been found to describe the effects of flow reductions on a wide range of tropics to base such indices. . Thus, if at any time the floodplain fails to be inundated recruitment fails in that year for all those species which spawn on the plain. Furthermore, the fertility of the plain during its dry phase is conditional on its being flooded for at least part of the year. Even if average flows within the system remain unaltered changes in the timing or form of the flood may have grave consequences. In many fish species breeding success depends on a coincidence of characters of which flow is but one. Consequently races or strains of species have adapted to a particular timing in their breeding and displacement of the floods to a different time of year may not permit them to reproduce. Changes in the timing of floods and in temperature of the water led to shifts in the spawning time and to an increase in the duration of the reproductive period species. Equally, abrupt changes in flow characteristics can influence breeding success adversely. Overly rapid rises and falls in water level can leave nests or spawning grounds dry at critical periods or can result in eggs or fry being washed away.

The precipitous decline of the flood can result in fish being trapped in temporary water bodies for lack of time to find passage to the main channel of the river.

5.17 CHANGES IN SILT LOAD

Increases in silt load resulting from changes in land or water use accelerate the natural evolutionary processes of the river system, but in doing so cause a number of problems. The deposition of fine particles of silt on what is normally a coarse substrate suffocates the rheophilic organisms that normally inhabit such reaches, cutting down on the availability of food. Such choking of the substrate may also render it unsuitable for spawning by those species requiring swift, well aerated flows and clear pebble or gravel bottoms. The silt provides an anchorage for vegetation, blocking low order streams and even diverting them into new courses. Further downstream deposition of silt on levees and on the river bottom may lead to progressive elevation of the whole channel until it stands above the level of the surrounding plain. An extreme flood in a channel so encumbered may cause the river to jump its bed changing its course by some kilometers. Excessive silting of floodplains chokes the standing waters, which disappear faster than new ones can be generated by erosion. Similarly, channels and dead arms are filled and new channels are cut to such an extent that the whole delta of a river may shift along the coastline. At the same time coastal deltaic floodplains grow rapidly, especially at their seaward end, where new land continuously appears. Heavy silt loads also directly affect living organisms. The poor light penetration into silt laden waters reduces the depth to which phytoplankton can develop and shade out submersed vegetation. Choking of bottom substrates has also been implicated in the disappearance of benthic organisms in the potamon as well as being identified as the cause of mortalities of fish scattering eggs in such areas.

5.18 CHANGES IN WATER QUALITY

The succession of physical and chemical conditions in rivers from the headwaters to the mouth may be regarded as a natural eutrophication process. Most downstream reaches are normally enriched, and further loading with nitrogen, phosphorus and organic compounds from agricultural, industrial and urban sources appears acceptable up to a point, and may even be beneficial in initially impoverished systems.

If the capacity of the ecosystem to satisfy the BOD is exceeded, however, conditions can deteriorate rapidly. Fish communities inhabiting potamon reaches of rivers are usually adapted to eutrophicated conditions and can support a measure of deoxygenation, although some of the more active species can disappear. General pollution with toxic substances has not so far been widely reported from tropical systems, although the situation in Cauvery river suffering from severe contamination with industrial effluents which have adversely affected their fish stocks. Severe local pollution can occur, however, and is commonly associated with mining where seepage and direct discharge of toxic wastes can create fishless zones in the rivers affected. The situation has been more serious and the widespread degradation of the quality of water because of damming of Mettur dam for prolonged storage of water for next irrigation year. If sufficient flow is released in the Cauvery River bad conditions caused by domestic and industrial pollution, but the self-purifying capacity of this large and swift flowing river has been sufficient to keep the main stream at an acceptable quality. The effects of pollution on the aquatic life of the system may be summarized as:

(i) Lethal toxicity which kills fish at some stage of its life history. In the case of floodplain rivers this may be indirectly in that the reduction of dissolved oxygen in standing waters of the floodplain and river channel may make them unsuitable for fish that normally live there;

(ii) Sub-lethal affects which are usually difficult to detect or prove but which alter the fish's behavior in such a manner as to prevent it completing its normal life cycle, or simply to reduce its growth or increase its susceptibility to disease;

(iii) Cumulative effects which can render fish either unsafe or unpalatable for consumption. Most pollution effects tend to be very broad affecting many different species. Whatever their immediate effects, the response at the community level is a reduction in diversity and a shift in species composition towards relatively smaller, shorter-lived forms. In other words they tend to mimic the changes expected from heavy fishing and are therefore apt to reduce the amount of fish available to the fishery. Moderate enrichment with organic substances, on the other hand, can increase the amount of fish supported by the system.

5.19 WILDLIFE

Many species of game animals move on to the floodplain during the dry season in search of the rich grazing to be found there. Certain species are more specialized to this habit than are others, and some are virtually limited to the floodplains for their distribution. Such species are migrating from the centre of the plain toward its periphery as the flood rises, and return in the wake of the falling water. Their distribution is, therefore, a mirror image of that of the fish and their dynamics are somewhat similar with a maximum in lambing as the water leaves the plain exposing new pasture. Floodplain wildlife is apt to be affected adversely by alterations to their environment in the same way as the fish. Since the closure of the Mettur Dam a lesser area of the plain has been flooded and the remaining portion is under severe pressure of utilization by the larger species of mammals which has produced changes in the vegetation. The impact of overpopulation is reinforced by changes in the type of grasses favoured by the new flood regime, which are tougher. It has been suggested that the tendency for wildlife to disappear in favour of cattle early in the development of the plains, lowers this productivity as the cattle deposits less of their wastes directly into the aquatic system.

5.20 CATTLE

Most unmodified floodplains are used as ranges for cattle during the dry season. In certain areas seasonal migrations of the cattle herding peoples dominate the demography. As they progress they burn the dead and drying aquatic vegetation to obtain the fresh shoots upon which the cattle. The dung dropped by the cattle, estimated at about 500 kg/ha/yr (Shepherd, 1976) converts much of the dry season primary production into readily dissolved organic and mineral nutrients which have an important impact on the chemistry of the flood waters. Several workers have noted the enrichment of some standing waters of the floodplain by cattle that use the lakes for drinking.

5.21 FORESTRY

Because forests tend to conserve water, topsoil and nutrients, they exert a conservative effect on the aquatic systems draining forested landscapes. The removal of the trees has several readily observable effects, notably on the water yields in streams, the timing and nature of runoff and the production of silt.

Other effects are less immediately discernable but may nevertheless be important and include increased concentrations of nutrients, changes in pH and water temperature and more recently introduction of pollutants into the system.

Deforestation of the catchment area of rivers leads to changes in the flood characteristics whereby flood peaks tend to become higher and shorter as run-off is decanted straight into the channels. In forested slopes much water is retained by the vegetation and also in the top soil. As the top soil disappears there is nothing to delay the water in its move down slope. The faster rise and fall, the more unpredictable spiky flood regimes and the lower dry season flows are detrimental to many species of fish which require a smoother transition from one water phase to another. The lack of top soil and the exposure of the bedrock also tend to lower the amount of nutrients entering solution. The conductivity of the water drops leading eventually to impoverished conditions in the river.

The management of the natural system should not be restricted to the floodplain, but should be extended upstream and downstream as part of the manipulation of the whole basin. As we have seen, activities in the headwaters of the basin can alter the siltation, runoff and flow patterns of the potamon reach, often with far reaching consequences to the fishery. Equally, pollution or damming downstream can prevent species from moving up to the floodplains to feed or breed.

5.22 IN STREAM IMPROVEMENT STRUCTURES

A variety of structures can be used to restore more natural patterns where they have been destroyed or to stabilize river channels whilst maintaining the diversity of habitats therein. Although such structures tend to diminish the effectiveness of channels modified for drainage, irrigation, flood control, etc. they can be used in a controlled fashion to improve the biological productivity of the systems concerned.

They also create slacks in the flow shadow immediately downstream and by scouring and deposition help reestablish pool riffle sequences along the channel. As a pool riffle sequence characteristically recurs at intervals of five to seven channel widths such devices should be installed with this spacing between them. Low dams and nets are even more effective in the restructuring of the bed of the river to create pool-riffle sequences. Both these types of device should be accompanied by bank stabilization to prevent selective erosion by the deflected current. Elevation structures, which are below the water surface for much of the time and which prevent island formation that can support

At the most primitive, such structures consist of fixed or floating objects which provide shade in simulation of missing vegetation cover in larger river channels. Submerged objects may also serve a similar purpose. Thus logs, boulders, branches etc, may be placed adjacent to the bank, a principle elaborated by many tropical fisheries into brush parks or artificially created or anchored masses of vegetation.

5.23 SPAWNING AREA IMPROVEMENTS

Several systems have been attempted for the improvement of bottom texture for fish which spawn over gravel, particularly where siltation has resulted in the loss of the normal substrate. These methods often consist in mechanical or hydraulic disturbance of the gravel causing deposited sediments to be washed out, although the more costly and arduous physical replacement of the substrate has also been tried.

5.24 MANAGEMENT OF THE FISH STOCK

In principle a fishery exploits a community which in its unexploited state exists in some kind of equilibrium with itself and with the environment. Under normal circumstances such a community may be assumed to tend to maximize its biological productivity and to continue to do so when subjected to a reasonable level of exploitation. In such a situation manipulation of the community in all probability adds little or nothing to the yield of the fishery. There are two circumstances, however, under which such interventions may be desirable. First, where the fish community is lacking some element to exploit a food resource or habitat it may be considered advisable to introduce one or more new species into the waterway. Second, where the fish community as a whole, or some preferred element of it, is over fished a policy of stocking may be adopted. As fishing of the floodplain and river channel in the dry season becomes more intensive there is a risk of local over-exploitation of the stock. For this reason, traditional fisheries have long been based on the designation of certain floodplain depression reaches of the river as reserves which remained unfished. In larger systems, there are usually inaccessible areas which form reserves as they are infrequently exploited.

5.25 WATER QUALITY INDEX

Water Quality Index: In an effort to develop a system to compare water quality in various parts of the country, over 100 water quality experts were called upon to help create a standard Water Quality Index (WQI). The index is basically a mathematical means of calculating a single value from multiple test results. The index result represents the level of water quality in a given water basin, such as a lake, river, or stream.

The WQI, which was developed in the early 1970s, can be used to monitor water quality changes in a particular water supply over time, or it can be used to compare a water supply's quality with other water supplies in the region or from around the world. The results can also be used to determine if a particular stretch of water is considered to be "healthy."

To determine the WQI, the following nine water quality parameters are measured:

- **Biochemical Oxygen Demand**

  The Biochemical Oxygen Demand (or BOD) is a measure of the amount of food for bacteria that is found in water. Bacteria utilize organic matter in their respiration and remove oxygen from the water. The BOD test provides a rough idea of how much biodegradable waste is present in the water. (Biodegradable waste is usually composed of organic wastes, including leaves, grass clippings, and manure).

- **Dissolved Oxygen**

  The dissolved oxygen test measures the amount of life-sustaining oxygen dissolved in the water. This is the oxygen that is available to fish, invertebrates, and all other animals living in the water. Most aquatic plants and animals need oxygen to survive; in fact, fish will drown in water when the dissolved oxygen levels get too low. Low levels of dissolved oxygen in water are a sign of possible pollution.

- **Fecal Coliform**

  Fecal coliform is a form of bacteria found in human and animal waste.

- **Nitrates**

  Nitrates are a measure of the oxidized form of nitrogen and are an essential macronutrient in aquatic environments. Nitrates can be harmful to humans, because our intestines can break nitrates down into nitrites, which affect the ability of red blood cells to carry oxygen. Nitrites can also cause serious illnesses in fish.

- **pH**

  The pH level is a measure of the acid content of the water. Most forms of aquatic life tend to be very sensitive to pH. Water containing a great deal of organic pollution will normally tend to be somewhat acidic. Water with a pH of 7 is considered neutral. If the pH is below 7, it is classified as acidic, while water with a pH greater than 7 is said to be alkaline. The pH of tap water in the U.S. is usually between 6.5 and 8.5.

- **Temperature Change**

  The water temperature of a river is very important, as many of the physical, biological, and chemical characteristics of a river are directly affected by temperature.

Most waterborne animal and plant life survives within a certain range of water temperatures, and few of them can tolerate extreme changes in this parameter. Using the same thermometer, the water temperature should be checked at the test site and at a similar site one mile upstream. Care should be taken when taking the temperature upstream to ensure that the amount of sunlight and the depth of the river are similar to the original test site.

- **Total Dissolved Solids**

This is a measure of the solid materials dissolved in the river water. This includes salts, some organic materials, and a wide range of other things from nutrients to toxic materials. A constant level of minerals in the water is necessary for aquatic life. Concentrations of total dissolved solids that are too high or too low may limit growth and lead to the death of many aquatic life forms.

- **Total Phosphate**

Phosphates are chemical compounds made from the elements phosphorous and oxygen; they are necessary for plant and animal growth. Phosphates can be present in water in many forms, so total phosphate gives an estimate of the total amount of phosphate potentially available in a given water supply.

- **Turbidity**

Turbidity is a measure of the dispersion of light in a column of water due to suspended matter. The higher the turbidity, the cloudier the water appears. If water becomes too turbid, it loses the ability to support a wide variety of plants and other aquatic organisms.

After the nine water quality tests are completed and the results recorded, a "Q" value is calculated for each parameter, and the overall WQI for the sampling site is then calculated. It is important to monitor water quality over a period of time in order to detect changes in the water's ecosystem. The Water Quality Index can give an indication of the health of the watershed at various points and can be used to keep track of and analyze changes over time.

5.26 WATER QUALITY INDEX

The Water Quality Index uses a scale from 0 to 100 to rate the quality of the water, with 100 being the highest possible score. Once the overall WQI score is known, it can be compared against the following scale to determine how healthy the water is on a given day.

Table 5.7: WQI Quality Scale	
91-100:	Excellent water quality
71-90:	Good water quality
51-70:	Medium or average water quality
26-50:	Fair water quality
0-25:	Poor water quality

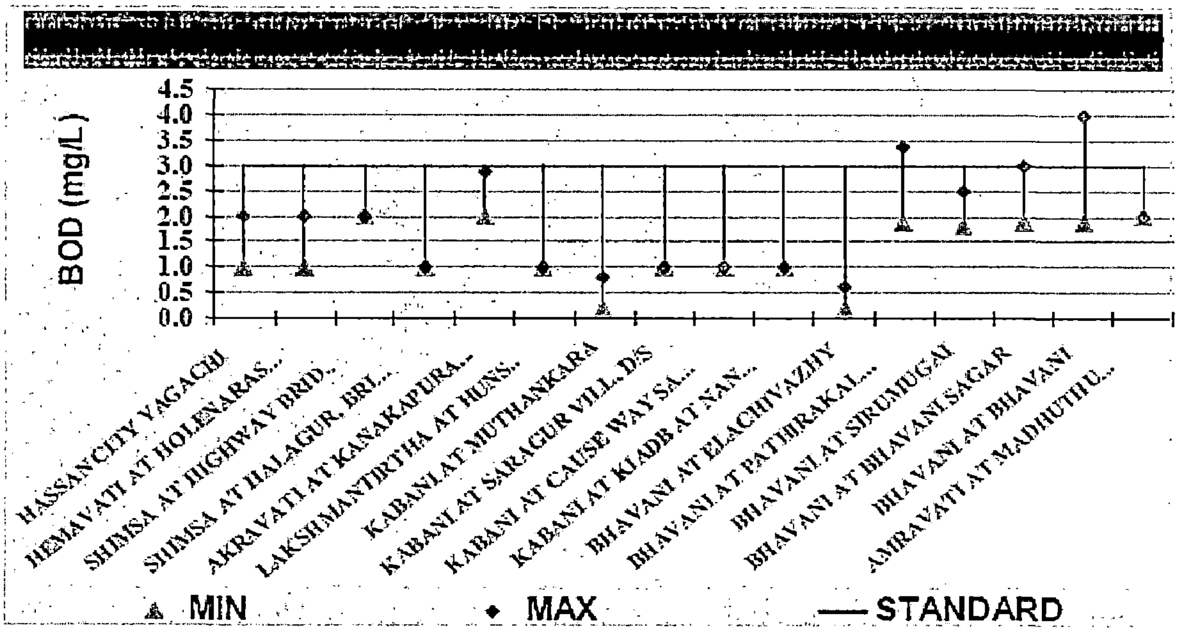
Water supplies with ratings falling in the good or excellent range would able to support a high diversity of aquatic life. In addition, the water would also be suitable for all forms of recreation, including those involving direct contact with the water. Water supplies achieving only an average rating generally have less diversity of aquatic organisms and frequently have increased algae growth. Water supplies falling into the fair range are only able to support a low diversity of aquatic life and are probably experiencing problems with pollution. Water supplies that fall into the poor category may only be able to support a limited number of aquatic life forms, and it is expected that these waters have abundant quality problems. A water supply with a poor quality rating would not normally be considered acceptable for activities involving direct contact with the water, such as swimming.

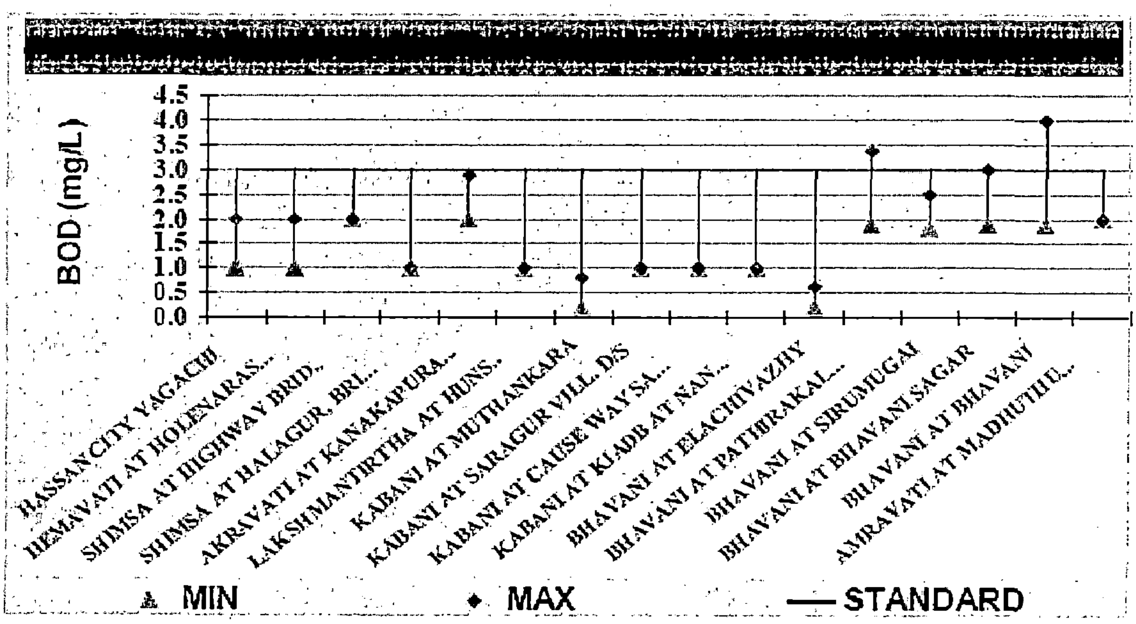
5.27 WATER QUALITY MONITORING IN CAUVERY BASIN

The water quality monitoring of the river Cauvery is being done in the basin by the State Pollution Control Board Karnataka, Tamil Nadu and Kerala at 36locations. The monitoring locations are on mainstream of river Cauvery (20) and on tributaries are- Arkavati (1), Amaravati (1), Bhavani (5), Kabini (4), Lakshmantirtha (1), Shimsha (2), Hemavathi (1) and Yagichi (1). The ranges of water quality observed in Cauvery basin with respect to pH, Conductivity, DO, BOD, COD, Total Coliform (TC) and Faecal Coliform (FC) are presented as minimum, maximum and mean value to assess the extent of water quality variation throughout the year.

5.28 WATER QUALITY STATUS OF RIVER CAUVERY

The Water Quality of Cauvery river at twenty locations indicates that DO is in the range of 0.3-9.8 mg/l. The minimum value of 0.3 mg/l of DO is observed at Erode near Chirapalayam in Tamil Nadu. The Total Coliform bacteria are in the range of 9500 MPN/100 ml whereas the Faecal Coliforms bacteria vary from 3,000MPN/100 ml. High values of Total Coliforms and Faecal Coliforms are observed at Pallipalayam and Erode near Chirapalayam in Tamil Nadu respectively is given in Figure.8.1





The Water Quality of River Cauvery is not meeting the desired water quality a criterion at Erode, The water quality of Bhavani a tributary streams indicates that DO and BOD is not meeting the water quality criteria. In the entire stretch of the study area, the levels of D.O, BOD & Total Coliforms were much higher than the desired levels.

5.29 ABATEMENT OF POLLUTION IN FIVE POLLUTED STRETCHES OF RIVER CAUVERY

Environmental Improvement of River Cauvery under National River Action Plan: This is a centrally sponsored scheme under National River Conservation Programme. The Department of Environment has been implementing a 100% Centrally sponsored scheme, 'Abatement of Pollution in five stretches of Cauvery River in Tamil Nadu' at an overall project cost of Rs.36.28 crores since 1996-97, the project period being ten years. Under Core-activities, interception and diversion as well as sewage treatment plants are being implemented through the Tamil Nadu Water Supply and Drainage Board in Erode, Bhavani, Komorapalayam, Pallipalayam and Trichy towns. All the works in Trichy, Komorapalayam and Erode have been completed. The works in Bhavani is under progress. A revised detailed Project Report for Pallipalayam is being prepared by the TWAD Board. Finalization of Pallipalayam is delayed for want of segregation of dyeing effluents. Under Non-core activities, construction of low cost sanitation facility, crematoria and river front development have been completed by the local bodies.

A sum of Rs.16.58 crores has been spent by the executing agencies, viz., TWAD Board and the concerned Local Bodies, and this amount has been utilized fully. Under the Non-Core Scheme, works in respect of construction of Low Cost Sanitation facility, River Front Development (RFD), bathing ghats and wood based crematoria (WBC) has been completed. As on 31.3.2007, Fund released by NRCD is 21.86 crores and Expenditure is around 21.10 crores

Table 5.8: Sewage Treatment Details

Town	Name of the River	MLD of Sewage to be treated	Estimate Cost (Rs in lakhs)
Bhavani	Cauvery	03.94	350
Erode	Cauvery	25.17	1489
Komorapalayam	Cauvery	6.00	594
Trichy	Cauvery	39.00	655
Pallipalayam	Cauvery	6.80	540
	Total	**80.91**	**3628**

The project comprises of core schemes and non core-schemes. Under core - schemes, the sewage flowing through open drains/ channels are intercepted near the bank of the river and diverted to Sewage Treatment plant for treatment and disposal. The technology adopted is Waste Stabilization pond / Up flow Anaerobic Sludge Blanket process "UASB".

Table 5.9: Present Stage of Cauvery Pollution Abatement in the Study Area Mettur Dam to Erode Stretch

S.No	Town	MLD of Sewage to be treated	Estimated cost Rs in lakhs	Present status
1	Bhavani	3.94	350	Non functioning
2	Komorapalayam	25.17	1489	Functioning
3	Erode	6.00	594	Non functioning
4	Pallipalayam	6.80	540	DPR stage
	Total	41.91	2973	

Due to problem of ground water pollution, the treatment plant of Erode Waste stabilization pond was none functioning for past one and half years, For Bhavani Town treatment plant was none functioning due to public agitation related to ground water contamination. For Pallipalayam for want of segregation of dyeing effluents the D.P.R has to be finalized. Regarding Komorapalayam the treatment plant was functioning and trial run by Tamil Nadu Water Supply &Drainage Board.

Due to Public agitation and ground water contamination from the treatment site in Erode, and Bhavani Town, the above two treatment plants are kept idle for more than one and half years.

The Tamil Nadu Government now sanctioned Sewerage schemes including collection system and treatment plant for the following municipalities Mettur, Bhavani Town, Erode and Komorapalayam as per the table.

Table 5.10 :Test Result of under Ground Water 1 km Radius from Erode Lakkapuram Treatment Plant

S. No	Location	Source	Turbidity	EC	TDS	NO_3	COD	BOD
1.	Balusamy Nagar	BW	5	1288	901	13	8	1.80
2.	Solar Pudur	BW	7	2010	1407	98	8	2.6
3.	C.S.I Colony	BW	4	1491	1043	54	12	2.8
4.	C.S.I Colony	BW	6	1728	1209	50	4	1.8
5.	Solar Pudur	BW	6	1303	912	72	4	1.1
6.	Transport Nagar	OW	4	1588	1111	54	8	2.6
7.	R.P.P Thottam	OW	5	2220	1554	136	8	1.8
8.	Angamuthu Mudaliar Thottam	OW	7	1160	812	60	4	2
9.	Near Facultative Pond	OW	3	1070	749	40	8	1.6

Photo 5.1: Erode-waste Leaching

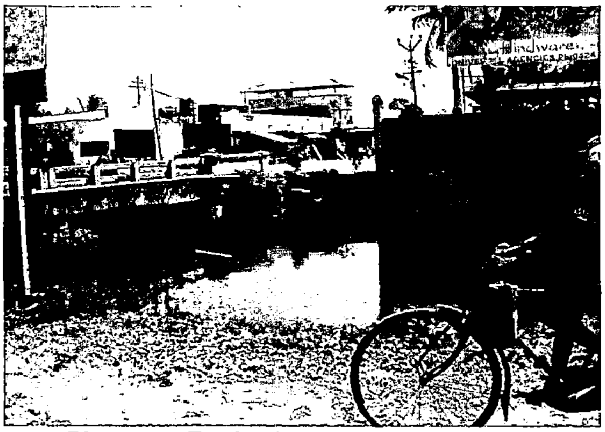


Photo 5.2: Erode-chicken Waste Leaching

Photo 5.3: Erode- chemical waste Leaching

Photo 5.4: Pallipalayam Chemical Dyes Waste Water

Photo 5.5: Pallipalayam Chemical Dyes Waste Water

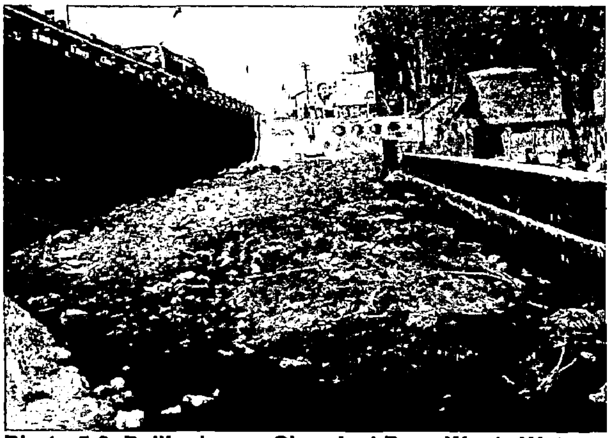


Photo 5.6: Pallipalayam Chemical Dyes Waste Water

Photo 5.7: Pallipalayam Textile processing in Cauvery River

Photo 5.8: Pallipalayam Drain with Dyes Waste Water

Photo 5.9: Barrage Five under Construction

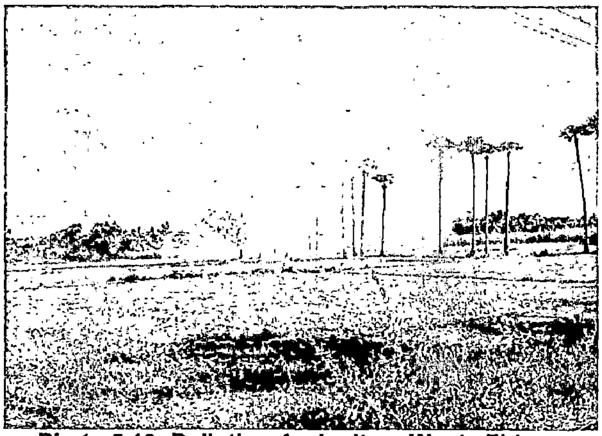


Photo 5.10: Pollution Agriculture Waste Firing

Photo 5.11: Komarpalayam Drain Dyes Waste Water

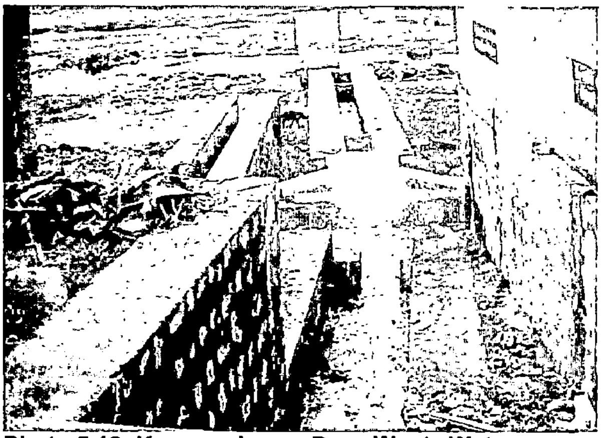


Photo 5.12: Komarpalayam Dyes Waste Water

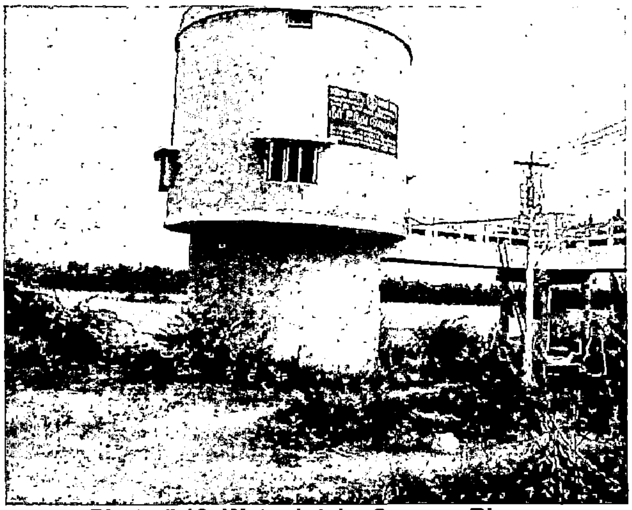


Photo 5.13: Water Intake Cauvery River

Photo 5.14: Bhavani River Action Plan

CHAPTER-6

ENVIRONMENTAL FLOW

6.1

ENVIRONMENTAL FLOW CONCEPT IN INDIA

Rivers have always held a special place in the socio-cultural ethos in India, and most of them are also treated with reverence. However, the ever –growing human population and the consequent demand for water to increase agricultural production, urban supplies and industrial development have lead to extensive regulation and diversion of river flows by constructing embankments and dams or barrages, especially during the past century. The drastic reduction of flow in the rivers, and in some cases, its total elimination except for the monsoon season, has caused rapid degradation of riverine ecosystems together with a steep decline in biodiversity, especially the fisheries. Many reaches of rivers have lost their waste assimilation capacity to the extent that they have turned into sewer drains. These changes have in turn seriously affected the livelihood of millions people who depend upon the rivers and their resources, and caused underestimated economic losses by the value of riverine resources, health impacts of polluted surface and ground water, and increased costs of wastewater treatment. Assuming that benefits have accrued elsewhere in the form of increased agricultural production and energy for industrial production, they only reduced the social and economical equity. The total benefits have never been evaluated against the total losses.

India is facing a challenge of managing its limited water resources with high spatial and temporal variability. Yet, India has been conscious of the problem of water quality in the rivers since the early 1960s when legislation was enacted to prevent and control water pollution.

Later, the Ganga Action Plan was launched to improve water quality in the river Ganga.Now; the National River Conservation Plan extends the efforts to reduce pollution in all rivers. However, despite considerable effort and costs, the water quality continuous to decline. While the growing human population, and consequently the increased population load, as well as problems related to the operation and maintenance of the sewage treatment plants are held responsible. There has been practically no attention paid, until recently, to the loss of the assimilation capacity of the rivers due to the absence of flow. Practically all Indian studies on river focus on water quality or various organisms without reference to flow regimes.

The issue of flow was highlighted in a judgment of the supreme court of India which in May 1999 directed the government to ensure a minimum flow of 10 m^3/s in the Yamuna River in its course through Delhi –to improve the rivers water quality. Since then, the requirement of a minimum flows in rivers has been discussed at several forums in the context of water quality. **In May 2001, the Government of India constituted the Water Quality Assessment Authority (WQAA) which in turn constituted, in May 2003, a working group to advise the WQAA on "minimum flows in rivers to conserve the ecosystem".**

A distinction may be made between the amount of water needed to maintain an ecosystem in close to pristine condition, and what which might eventually be allocated to it, following a process of environmental, social and economical assessment. The latter is referred to as the "environmental flow", and it will be a flow that maintains the eco system in a less then pristine condition.Intuitively,it might seem that all of the natural flows, in its natural pattern of high and low flows, would be needed to maintain a near-pristine ecosystem. Many ecologists believe, however, that some small portion of flow could be removed without measurable degradation of the ecosystem. How much could be removed in this way is more difficult to assess, with estimates ranging between about 65% and 95% of natural flow having to remain, with the natural patter of flow also retained. Once flow manipulations move past this, then river ecologists can advise on patterns and volumes of flow that will result in a range of different conditions. This information can then be used to choose a condition that allows an acceptable balance between a desired ecosystem condition and other social and economic needs for water. The flows allocated to achieve the chosen condition are the environmental flow.

Water resources need to be managed to provide environmental flows. Flows can be regulated by infrastructure, such as dams, or by diverting water from the system. There are different ways in which environmental flows can be provided, such as modification of infrastructure or changes in water allocation policies and entitlements.

6.2 THE BENEFITS

Aquatic ecosystems, such as rivers, wet lands, estuaries and near –coast ecosystems, provide a great variety of benefits to people. These include "goods" such as clean drinking water, fish, and fiber, and "services" such as water purification, flood mitigation and recreational opportunities. Healthy rivers and associated eco system also have an intrinsic value to people that may be expressed in terms of cultural significance. "The absence of environmental flows puts at risk the very existence of ecosystems, people and economies". Rivers and other aquatic ecosystems need water and other inputs like debris and sediment to stay healthy and provide benefits to people. Environmental flows are a critical contributor to the health of these ecosystems. Depriving a river or a groundwater system of these flows not only damages the entire aquatic ecosystem, it also threatens the people and communities who depend on it. At its most extreme, the long –term absence of environmental flows puts at risk the very existence of dependent ecosystems, and therefore the lives, livelihood and security of downstream communities and industries.

The impacts of long term regulation on aquatic ecosystems are becoming increasingly evident. There is growing concern over these impacts, with corresponding increases in both political awareness and action. The report of the world commission on Dams identified sustaining rivers and livelihoods and recognizing entitlements and sharing benefits as priorities. This requires dams to provide for release for environmental flows and to be designed, modified and operated accordingly.

Environmental flows are a relevant consideration at every stage in the history of a river or drainage basin

6.3 THE REALITY

The goal of environmental flows is to provide a flow regime that is adequate in terms of quantity and timing for sustaining the health of the rivers and other aquatic ecosystems. The degree of "good health" at which the river will be sustained is, however, a societal judgment that will vary from country to country and region to region. What the appropriate environmental flows is for a particular river will thus depend on the values for which the river system is to be managed. Those values will determine the decisions about how to balance environmental, economic and social aspiration and the use of the rivers waters.

This means that ecological gains will not necessarily be the only or even the primary outcome of an environmental flow programme. Such a programme will need to strike a balance between water allocations to satisfy the ecological water requirement and other water use needs like those of hydropower generation, irrigation, drinking water or recreation. A number of consideration need to be taken into account when starting with environmental flows. First of all, river and drainage systems need to be considered in their context. In a physical sense, this means considering the system from its headwaters to the estuarine and coastal environments and including its wetlands, floodplains and associated ground water systems.

In a river system where water has been over allocated to consumptive use, environmental flows might be provided simply to have ecosystem that function sufficiently to provide a sustainable base for present and future consumptive and in stream uses. Where a system is seriously over committed and values do not allow a sufficient reallocation of resources to restore "the entire system", a certain river stretches or wet land sites may be targeted for protection and specific water allocations. For rivers with high biodiversity values an environmental flow might be provided to preserve the natural state of the river system. In such case, consumptive water use may be limited to a minimum amount, which might imply that water diversions may occur only during times of very high flow and reservoir is banned. Depending up on the climate, average river discharge may be one of the least essential elements of natural flows. Variability in flow quantity, quality, timing and duration are often to maintain river ecosystems. Flows for flooding to maintain fish spawning areas, specific flows for fish migration, or flushing to wash down debris, sediment or salt are examples of the need for variability. The regulated flow is manipulated to provide environmental flows; there will be inevitably be costs to other users or uses. Competing interests will emerge between various consumptive users, and between up-stream and down-stream environmental and user benefits. Competition will also arise between parts of the river environment that require different natural flow regime. For example, while a floodplain may require irregular inundation, estuaries may rely on frequent high flows to have fresh water inputs.

Adequate environmental flows are not only characteristic of a healthy river system. There are other requirements for river health such as reduction of pollution and control of in-stream activities like fishing and recreation. Focusing on environmental flows out of context is unlikely to yield a good result and may even alienate communities. Environmental flows should be considered as an integral part of the modern management of a river basin.

6.4 DEFINING WATER REQUIREMENT

Here is no simple figure that can be given for the environmental flow requirements of rivers. All elements of a flow regime will influence the ecology of a river in some way, so that if a totally natural ecosystem is desired, the flow regime will need to be natural.

In some cases, water is returned to the river after use, i.e. in the case of hydropower generation or cooling of an industrial plant. However, the timing of the river flow downstream of the point where water is returned is likely to be altered. In the bypassed river section, the flows will be lower than natural. In other cases, i.e. when obstructing water for irrigation, the water may be returned in such small quantities or so far away from the obstruction point that, effectively, it is consumed. It is also important to recognize that flow is not the only factor affecting river health. Water quality, over-fishing and physical barriers to migration of species all influence aquatic ecosystems.

6.5 APPLYING THE METHODS AND MONITORING IMPACTS

Environmental flow assessment involves defining an appropriate flow to meet a specific environmental objective or to achieve a balance between environmental, social and economical conditions. Deciding on the actual environmental flow that will be implemented may be a political judgment that involves compromises with other imperatives.

In applying environmental flow methods it is useful to distinguish between active flow management and restrictive flow management. Active flow management occurs in the case where an action must be taken, such as opening a sluice gate, to implement an environment flow downstream. In this situation, the dam operator may have complete control over the flow downstream, although, in times of flood, water may pass the dam via a spill-way. It is then possible to design and generate an entire flow regime, including low flows and floods.

If the environmental flow is prescribed in terms of some proportion of the natural flows that would have been in the river below the dam site, then some method of determining this natural flow is required. This is often achieved by monitoring the inflows to the reservoir or nearby similar catchments that has a natural or semi natural flow regime. It many cases water released from a reservoir will be of a different quality than would normally be in the river. It may be lower in oxygen or colder and, in the case of stratified reservoirs, may be chemically altered. In these situations, water may need to be released through different gates depending on the level of water in the reservoir. On occasions, the point at which a particular environmental flow is required may be at some distance from the dam itself, such as floodplain or estuary. Flow releases may have to be altered according to lateral and tributary inflows below the dam.

Restrictive flow management occurs where abstractions or diversions are controlled in order to achieve an environmental flow. Such abstractions may be from the river itself or from ground water with an aquifer supplying the river. The impact of the abstraction may vary depending on the river flow. While the impact may be very significant at low flows, it may be negligible at high flows. In such cases, scenarios are often dictated by potential abstraction profiles, i.e. the timing and amount of water taken.

Implementation of the environmental flows, under these conditions, may be achieved by reducing the amount of water that can be abstracted as flow declines. There may be a threshold flow below which no abstraction is permitted. In such cases monitoring the river flow is a key to implementing the management policy. Methods of environmental flow assessment are the best indicative of the flow required to meet the environmental need.

The river flow: to ensure that the implementation procedures are achieving the defined environmental flow. Flow should be assessed in relation tó base line conditions, both in short term to assess whether day-to- day or seasonal variations in flow are achieved and in the long term to determine the year –to- year variability of flows.

The response of the ecosystem: to assess whether the ecological objectives are being achieved. This could requires long term monitoring since the ecosystem may adapt slowly to change in flow.Althouh monitoring is often focused on key indicator species, it should cover as many elements of the ecosystems as possible to capture any unforeseen changes. Most commonly, flows are required to flush superficial accumulations of fines and to clear the surface of the river bed. Flushing flows with normal peak flow periods should prove beneficial.

The social response to ecosystem change: to identify where and what degree communities rely for their livelihoods on fish or other river related resources.

6.6 DILUTION OF EFFLUENTS IN RIVERS AND SELF PURIFICATION

When sewage is discharged into a natural body of water, the receiving water gets polluted due to waste products, present in sewage efiluents. But the conditions do not remain so for ever, because the natural forces of purification, such as dilution, sedimentation, oxidation-reduction in sun-light, etc., go on acting upon the pollution elements, and bring back the water into its original condition. This automatic purification of polluted water, in due course, is called the," self-purification Phenomenon. In Cauvery River in the study area, the self-purification is not achieved successfully either due to too much of pollution discharged into it or due to other causes, the river water itself will get polluted, which, in turn, may also pollute the sea where the river outfalls.

The various natural forces of purification which help in effecting self-purification process are summarized below:

6.6.1 Dilution and Dispersion: When the putrescible organic matter is discharged into a large volume of water contained in the river-stream, it gets rapidly dispersed and diluted. The action, thus, results in diminishing the concentration of organic matter, and thus reduces the potential nuisance of sewage.

When sewage of concentration Cs flows at a rate Qs in to a river stream with concentration C R flowing at a rate QR, the concentration C of the resulting mixture is given by

$$CsQs + CRQR = C\,(Qs + QR)$$

$$C = \frac{CsQs + CRQR}{Qs + QR}$$

This equation is applicable separately to concentrations of different impurities, such as, oxygen content, BOD, suspended sediments, and other characteristic contents of sewage.

6.6.2 Sedimentation: The settleable solids, if present in sewage effluents, .will settle down into the bed of the river, near the outfall of sewage, thus, helping in the self purification process.

6.6.3 Sun-light: (acts through bio-chemical reactions). The sun light has a bleaching and stabilizing effect of bacteria. It also helps certain micro-organisms to derive energy from it, and convert themselves into food for other forms of life, thus absorbing carbon dioxide and releasing oxygen by a process known as photo synthesis. The evolution of oxygen in river water due to sunlight will help in achieving self-purification through oxidation, as given below:

6.6.4 Oxidation: The oxidation of the organic matter present in sewage effluents will start as soon as the sewage outfall into the river water containing dissolved oxygen. The deficiency of oxygen so created, will be filled up by the atmospheric oxygen. The process of oxidation will continue till the organic matter has been completely oxidized. This is the most important action responsible for effecting self purification of rivers.

6.6.5 Reduction: Reduction occurs due to hydrolysis of organic matter settled at the bottom either chemically or biologically. Anaerobic bacteria will help in splitting the complex organic constituents of sewage into liquids and gases, and thus paving the way for their ultimate stabilization by oxidation.

The various factors on which these natural forces of purification depend are: (a) temperature; (b) turbulence; (c) hydrography such as the velocity and surface expanse of the river-stream; (d) available dissolved oxygen, and the amount and type of organic matter present. (e) Rate of reaeration, etc.

Besides affecting the dilution and sedimentation rates, the temperature also affects the rate of biological and chemical activities, which are enhanced at higher temperatures and depressed at lower temperatures. The dissolved oxygen content of water, which is very essential for maintaining aquatic life and aerobic conditions (so as to avoid the anaerobic decomposition and subsequent nuisance), is also influenced by temperature. At higher temperatures, the capacity to maintain the D.O. concentration is low; while the rate of biological and chemical activities are high, causing thereby rapid depletion of D. O. This is likely to lead to anaerobic conditions, when the pollution due to putrescible organic matter is heavy.

The turbulence in the body of water helps in breaking the surface of the stream or lake, and helps in rapid re-aeration from the atmosphere. Thus, it helps in maintaining aerobic conditions in the river stream, and in keeping it clear. Too much of turbulence, however, is not desirable, because it scours the bottom sediment, increases the turbidity, and retards algae growth, which is useful in reaeration process. Wind and undercurrents in lakes and oceans cause turbulences which affect their self-purification. The Hydrography affects the velocity and surface expanse of the river stream. High velocities cause turbulence and rapid reaeration, while large surface expanses (for the same cubic contents) will also have the same effects.

The larger the amounts of dissolved oxygen present in water, the better and earlier the self-purification will occur. The amount and the type of organic matter and biological growth present in water will also affect the rate of self-purification. Algae which absorbs carbon dioxide and gives out oxygen, is thus, very helpful in the self-purification process.

The rate of reaeration i.e. the rate at which the D.O. deficiency is replenished, will considerably govern the self' purification process. The greater is this rate, the quicker will be the self-purification, and there will be no chances of development of anaerobic conditions.

6.7 THE NATURAL SELF PURIFICATION PROCESS

A polluted stream undergoing four process of self-purification:

Zone of Degradation or Zone of Pollution

This zone is found for a certain length just below the point where sewage is discharged into the river-stream. This zone is characterized by water becoming dark and turbid with formation of sludge deposits at the bottom. D.O. is reduced to about 40% of the saturation value. There is an increase in carbon dioxide content; reoxygenation (i.e. re-aeration) occurs but is slower than de-oxygenation. These conditions are unfavorable to the development of aquatic life; and as such, an alga dies out, but fish life may be present feeding on fresh organic matter. Moreover, certain typical bottom worms such as Limondrilus and Tubifex appear with sewage, such as sphaerotilusnatans.

Zone of Active Decomposition

This zone is marked by heavy pollution. It is characterized by water becoming greyish and darker than in the previous zone. D.O.concentration automatically falls down to zero ,and anaerobic conditions may set in with the evolution of gases like methane, carbon dioxide, Hydrogen Sulphide, etc., bubbling to the surface, with masses of sludge forming an ugly scum layer at the surface. As the organic decomposition slackens due to stabilization of organic matter, the re-aeration sets in and D.O. again rises to the original level (i.e. about 40%).

In this zone, bacteria flora will flourish. At the upper end, anaerobic bacteria will replace aerobic bacteria, while at its lower end, the position will be reversed. Protozoa and fungi will first disappear and then reappear. Fish life will be absent. Algae and Tubifex will also mostly be absent. Maggots and Psychoda (sewage fly) larvae will, however, be present in all but the most septic sewage.

Zone of Recovery

In this zone, the river stream tries to recover from its degraded condition to its former appearance. The water becomes clearer, and so the alga reappears while fungi decrease. RO.D. falls down and D.O. content rises above 40% of the saturation value; Protozoa, Rotifers, Crustaceans and large plants like Sponges, Bryozons, etc. also reappear. Bottom organisms will include: Tubifex, Mussels, Snails, etc. The organic material will be mineralized to form nitrates, Sulphates, phosphates, carbonates, etc.

Zone of Clearer Water

In this zone, the river attains its original conditions .with D.O. rising up to the saturation value. Water becomes attractive in appearance and Game fish (which requires at least 4 to 5 mg/l of D.O.) and usual aquatic life prevails. Same pathogenic organisms may still, however, survive and remain present, which confirms the fact that "when once river water has been polluted, it will not be safe to drink it, unless it is properly treated.

6.8 DISPOSAL OF EFFLUENTS IN WATER COURSES STANDARDS OF DILUTION BASED ON ROYAL COMMISSION REPORT

Dilution Factor	Standards of purification required
Above 500	No treatment is required. Raw sewage can be directly discharged into the volume of dilution water.
Between 300 to 500	Primary treatment such as plain sedimentation should be given to sewage, and the effluent should not contain suspended solids more than 150 ppm.
Between 150 to 300	Treatment such as sedimentation, screening and essentially chemical precipitation are required. The sewage effluents should not contain suspended solids more than 60 ppm
Less then 150	Complete through treatment should be given to sewage. The sewage effluent should not contain suspended solids more than 30 ppm, and its 5 days B.O.D at should not exceed 20 ppm.

Table 6.1: Details of Total Pollution Load Discharged into Cauvery River from Industries

S.No	Type of Industry	No .of Units	Effluent Quantity KLD	Pollution Load in K.g/Day			
				Before Treatment		After Treatment	
				BOD	TDS	BOD	TDS
1	Chemical	2	390	10.5	0	0.35	0
2	Electroplating	1	0	0	0	0	0
3	Pesticides	1	0	0	0	0	0
4	Tannery	12	682	366	3326	9.81	1688
5	Textile	156	9805.3	2132.5	30050	1105	28829
6	Thermal Power	1	65000	65	43800	65	43800
6	Sago	1	40	0	0	0	0
	Total	164	85916.3	2595	66166	1190.16	64416

Total Quantity of Pollution Load after Treatment
Let out by Industries into Cauvery River] = 85916.3 KLD

Total Quantity of B.O.D Load after Treatment] = 1190.16 K.g
Let out by Industries into Cauvery River

Average B.O.D Load after Treatment] = $\frac{1190.16 \text{ K.g X } 10^{6} \text{mg/day}}{85916.3 \text{ X} 10^{3} \text{ lit/ day}}$

Average B.O.D Load after Treatment] =20.36 mg/day

6.9 ENVIRONMENTAL FLOW ESTIMATION

Cauvery River flow pattern is controlled by Mettur Dam Water releasement regulations, Necessary inflow, and evaporation and quality of river water are monitored by State Government P.W.D Cauvery Division Mettur.The Central Water Commission Gauge Station at Urachikottai D/S of Mettur Dam also monitors the flow measurements and quality of Cauvery River water.

Table 6.2 : Cauvery River non Flow Days- C.W.C Gauge Station-Urachikottai									
Years									
Month	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-06	Average
June	0	19	0	30	29	30	0	0	14
July	0	0	0	18	26	16	0	0	8
August	0	0	0	0	23	10	0	0	4
September	0	0	0	0	24	2	0	0	3
October	20	0	0	4	5	6	0	0	5
November	3	8	0	6	6	21	0	0	6
December	5	4	0	5	16	0	0	0	4
January	4	3	0	22	26	3	2	2	8
February	2	28	0	24	23	28	4		16
March	0	31	0	16	31	18	3		14
April	0	28	0	25	30	16	0		14
May	5	12	0	31	26	28	0		15
Total	39	133	0	183	269	180	9		116
Average	3	11	0	15	22	15	1		

Table 6.3 :Cauvery River Minimum flow D/S Mettur Dam CWC Gauge Urachikottai

	Water Year							
Month	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007
June	30.81	0.00	72.80	0.00	0.00	0.00	24.66	56.43
July	30.81	343.60	198.10	0.00	0.00	0.00	25.32	290.27
August	450.72	164.90	9.38	50.79	0.00	0.00	155.65	519.13
September	247.63	0.00	139.50	74.77	0.00	0.00	115.81	225.91
October	0.00	176.50	10.87	0.00	0.00	0.00	84.92	2.84
November	0.00	0.00	1.09	0.00	0.00	0.00	123.29	2.83
December	0.00	0.00	3.03	0.00	0.00	162.50	151.21	28.31
January	0.00	0.00	214.50	0.00	0.00	0.00	0.00	0.00
February	0.00	0.00	7.99	0.00	0.00	0.00	0.00	0.00
March	0.00	0.00	7.99	0.00	0.00	0.00	0.00	
April	0.00	0.00	8.61	0.00	0.00	0.00	28.32	
May	0.00	0.00	9.91	0.00	0.00	0.00	42.42	

Table 6.4 : Monthly Maximum and Minimum Flows in Cumecs

Month	Type	Year							
		1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007
Jun	Max	59.24	622.50	475.50	0.00	37.56	36.98	26.42	425.34
	Min	30.81	0.00	72.80	0.00	0.00	0.00	24.66	56.43
Jul	Max	525.84	692.10	573.30	67.51	32.54	494.20	339.69	624.53
	Min	30.81	343.60	198.10	0.00	0.00	0.00	25.32	290.27
Aug	Max	781.85	484.20	493.60	77.88	86.38	580.60	750.25	1568.15
	Min	450.72	164.90	9.38	50.79	0.00	0.00	155.65	519.13
Sept	Max	480.50	605.60	395.00	501.20	91.55	475.20	2258.56	623.10
	Min	247.63	0.00	139.50	74.77	0.00	0.00	115.81	225.91
Poct	Max	381.09	3720.00	504.30	274.60	580.90	486.10	6011.13	566.08
	Min	0.00	176.50	10.87	0.00	0.00	0.00	84.92	2.84
Nov	Max	863.03	596.80	455.90	321.90	429.30	303.10	2278.52	169.25
	Min	0.00	0.00	1.09	0.00	0.00	0.00	123.29	2.83
Dec	Max	445.00	894.10	501.30	491.10	352.10	361.70	524.54	424.38
	Min	0.00	0.00	3.03	0.00	0.00	162.50	151.21	28.31
Jan	Max	425.32	359.90	380.00	427.30	296.60	401.40	340.22	340.22
	Min	0.00	0.00	214.50	0.00	0.00	0.00	0.00	0.00
Feb	Max	226.22	0.00	359.60	264.00	251.00	0.00	28.23	56.68
	Min	0.00	0.00	7.99	0.00	0.00	0.00	0.00	0.00
Mar	Max	0.00	0.00	119.70	47.20	0.00	47.38	56.69	
	Min	0.00	0.00	7.99	0.00	0.00	0.00	0.00	
Apr	Max	0.00	64.08	101.60	38.49	0.00	33.56	56.69	
	Min	0.00	0.00	8.61	0.00	0.00	0.00	28.32	
May	Max	0.00	206.20	96.89	0.00	75.59	36.98	56.80	
	Min	0.00	0.00	9.91	0.00	0.00	0.00	42.42	

Table 6.5: Yearly Maximum and Minimum Flows Cauvery Cumecs-Urachikottai C.W.C Gauge station

Year	Type	Cumecs
1999-2000	Max	863.03
	Min	0
2000-2001	Max	3720
	Min	0
2001-2002	Max	573.3
	Min	1.09
2002-2003	Max	501.2
	Min	0
2003-2004	Max	580.9
	Min	0
2004-2005	Max	580.6
	Min	0
2005-2006	Max	6011.03
	Min	0
2006-2007	Max	1568.15
	Min	0

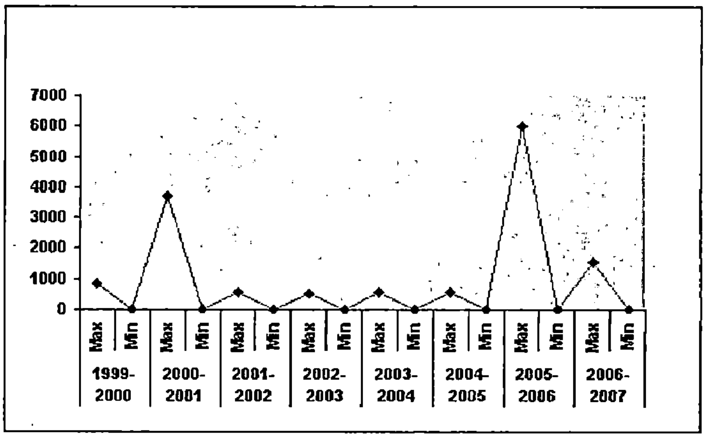


Table 6.6: Weekly Maximum and Minimum Flows-Cumecs - Cauvery C.W.C-Urachikottai & P.W.D-W.R.O.Mettur.
Flow in Cumecs

Year	1999-2000		2000-2001	2001-2002	2002-2003		2003-2004	2004-2005		2005-2006				
Week	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
1	59.24	55.25	68.41	0.00	90.42	72.80	0.00	0.00	0.00	0.00	0.00	0.00	25.29	
2	58.45	56.04	622.50	0.00	272.30	82.67	0.00	0.00	0.00	0.00	0.00	0.00	26.22	24
3	58.25	31.40	523.20	449.10	475.50	365.50	0.00	0.00	0.00	0.00	0.00	0.00	26.66	24
4	31.46	31.12	327.50	289.70	464.50	361.90	0.00	0.00	37.56	0.00	0.00	0.00	25.48	25
5	259.75	30.81	424.40	323.20	430.80	361.30	0.00	0.00	30.49	0.00	60.41	0.00	25.54	25
6	425.91	300.21	473.20	390.00	470.60	428.60	20.87	0.00	32.54	0.00	0.00	0.00	25.60	25
7	340.17	290.22	517.40	406.50	531.30	437.10	59.97	0.00	0.00	0.00	0.00	0.00	25.51	25
8	424.38	306.30	532.70	483.40	573.30	473.60	59.54	0.00	0.00	0.00	494.20	0.00	25.37	25
9	597.14	422.79	692.10	373.90	409.70	9.38	67.51	53.79	69.22	0.00	271.30	28.97	339.74	37
10	700.95	610.45	330.50	238.80	392.90	11.65	70.27	50.79	86.38	0.00	0.00	0.00	510.61	155
11	781.85	639.61	396.60	260.20	437.10	387.50	57.68	53.39	0.00	0.00	348.10	0.00	509.78	424
12	700.67	453.10	422.60	376.10	448.20	352.80	67.76	53.83	0.00	0.00	580.60	331.30	511.26	424
13	480.28	453.10	382.00	164.90	493.60	376.60	77.88	71.28	0.00	0.00	547.80	340.90	509.84	424
14	450.72	426.56	591.10	479.80	395.00	322.10	77.23	74.78	41.89	0.00	475.20	374.70	1065.44	606
15	426.42	423.11	605.60	465.90	389.10	193.70	501.20	413.10	0.00	0.00	368.10	307.90	895.68	508
16	478.07	423.11	585.70	284.30	259.90	171.90	497.80	386.30	0.00	0.00	354.70	106.50	920.36	509
17	480.50	415.66	370.40	113.10	258.50	156.30	371.60	229.50	91.55	0.00	375.20	256.10	651.39	564
18	404.27	0.00	480.10	0.00	504.30	139.50	229.10	291.30	85.31	0.00	193.40	0.00	651.62	424
19	0.00	0.00	3720.00	296.90	426.60	147.30	256.40	0.00	559.30	0.00	449.20	139.20	509.56	339
20	381.26	0.00	1720.00	474.50	366.40	142.40	183.20	0.00	580.90	274.60	486.10	320.20	340.69	20
21	206.57	0.00	2573.00	286.10	379.10	202.60	170.10	33.70	452.10	40.78	319.30	0.00	6011.12	626
22	0.00	0.00	1373.00	234.50	359.60	10.87	223.40	38.49	306.50	37.56	74.77	0.00	3599.27	423
23	404.67	0.00	596.80	444.50	455.90	288.70	47.66	0.00	429.30	275.70	0.00	0.00	2278.52	633
24	486.42	228.85	519.20	395.10	285.70	1.09	293.80	0.00	317.40	43.44	0.00	0.00	507.54	341
25	565.48	0.00	180.30	0.00	297.90	8.67	304.50	252.10	93.49	85.58	195.80	0.00	417.56	123

26	863.03	0.00	0.00	0.00	287.20	5.67	321.90	57.58	88.78	0.00	303.10	456.10	692.17	374.37
27	379.02	198.70	693.60	205.60	341.60	297.90	297.80	216.50	0.00	0.00	275.40	229.90	524.54	283.34
28	445.00	18.83	367.70	163.50	419.70	347.70	117.70	0.00	0.00	0.00	361.70	246.50	404.64	255.05
29	358.12	0.00	625.80	361.40	501.30	277.50	94.82	73.11	176.70	0.00	359.10	230.30	409.01	240.83
30	367.09	0.00	894.10	234.50	275.40	5.23	491.10	322.40	382.10	144.90	298.20	251.90	250.91	151.21
31	397.99	278.84	200.20	0.00	273.20	3.03	38.62	0.00	350.60	248.30	259.00	162.50	340.73	200.62
32	280.37	0.00	359.90	206.10	309.50	237.10	427.30	0.00	298.00	0.00	391.60	259.00	283.40	169.76
33	192.89	54.49	357.00	206.30	380.00	270.00	0.00	0.00	0.00	0.00	353.30	255.70	170.07	169.73
34	383.94	211.35	278.10	260.00	360.80	327.10	0.00	0.00	0.00	0.00	401.40	255.90	169.98	141.41
35	425.32	195.87	274.20	0.00	355.90	311.40	263.50	0.00	0.00	0.00	287.90	0.00	126.32	0.00
36	226.22	27.10	0.00	0.00	359.60	8.61	220.90	0.00	0.00	0.00	0.00	0.00	28.29	0.00
37	28.57	27.72	0.00	0.00	79.46	7.99	0.00	0.00	0.00	0.00	0.00	0.00	28.37	28.23
38	56.69	28.15	0.00	0.00	117.80	85.36	2.64	0.00	251.00	0.00	0.00	0.00	28.37	28.23
39	60.00	0.00	0.00	0.00	118.30	110.40	0.00	0.00	229.90	0.00	0.00	0.00	28.34	0.00
40	61.84	32.54	0.00	0.00	119.70	98.87	35.14	0.00	0.00	0.00	47.38	0.00	28.37	0.00
41	45.42	42.28	0.00	0.00	117.70	9.91	31.91	0.00	0.00	0.00	0.00	0.00	28.32	28.15
42	57.37	36.78	0.00	0.00	119.90	9.91	0.00	0.00	0.00	0.00	0.00	0.00	56.60	28.12
43	50.97	33.95	0.00	0.00	107.60	77.76	39.44	0.00	0.00	0.00	35.91	0.00	56.69	56.60
44	51.17	36.67	0.00	0.00	101.60	7.99	39.18	0.00	0.00	0.00	34.49	31.54	56.69	56.55
45	36.90	28.37	0.00	0.00	100.20	76.48	38.49	0.00	0.00	0.00	33.75	0.00	56.69	56.55
46	55.19	35.00	64.08	0.00	94.92	77.65	0.00	0.00	0.00	0.00	0.00	0.00	56.66	56.55
47	70.88	56.55	53.75	0.00	92.97	77.01	0.00	0.00	0.00	0.00	33.07	0.00	56.58	28.32
48	71.24	43.15	0.00	0.00	98.87	11.30	0.00	0.00	0.00	0.00	36.98	0.00	56.75	56.55
49	43.66	0.00	61.72	0.00	96.89	11.30	0.00	0.00	75.59	0.00	32.80	0.00	56.75	56.58
50	51.34	28.37	206.20	0.00	90.25	9.91	0.00	0.00	0.00	0.00	0.00	0.00	56.75	50.97
51	71.05	28.37	84.06	0.00	11.30	9.25	0.00	0.00	0.00	0.00	0.00	0.00	56.72	42.42
52	72.38	56.43	88.03	60.87	12.03	9.91	0.00	0.00	0.00	0.00	24.40	0.00	56.80	55.53

Total Water intake for Drinking water purpose and Industries

from river Cauvery in the study area Mettur Dam to Erode] = 600 MLD

Total Pollution Load from Study Area as per Table -] = 68.4 MLD

Industrial Effluents in the Study Area as per Table-] = 84.80 MLD

Total B.O.D requirement for Self Purification for

Cauvery River in Study Area Mettur to Erode] = 2605.02 K.g

As per Table -

Average B.O.D of Cauvery River water released

From Mettur Dam] =2.8 mg/lit.

B.O.D required for Best Designated Use of River

Cauvery as per C.P.C.B for Class "C" Classification] =Less then 3 mg/lit

Minimum Flow Required considering Dilution and

Dispersion to Satisfy the B.O.D Requirement of the river] = Q_R

Dilution and Dispersion: When the putrescible organic matter is discharged into a large volume of water contained in the river-stream, it gets rapidly dispersed and diluted. The action, thus, results in diminishing the concentration of organic matter, and thus reduces the potential nuisance of sewage.

When sewage of concentration Cs flows at a rate Qs in to a river stream with concentration C R flowing at a rate QR, the concentration C of the resulting mixture is given by the Equation:

$$CsQs + C_RQ_R = C\,(Qs + Q_R)$$

or

$$C = \frac{CsQs + C_RQ_R}{Qs + Q_R}$$

This equation is applicable separately to concentrations of different impurities, such as, oxygen content, BOD, suspended sediments, and other characteristic contents of sewage.

B.O.D of the Diluted Mixture $C = \frac{CsQs + C_RQ_R}{Qs + Q_R}$

$$3\text{mg/lit} = \frac{2605.02\ \text{K.g} \times 10^{6} + 2.8 \times Q_R}{153.20 \times 10^{6} + Q_R}$$

$Q_R = 1.06261 \times 10^{10}$ lit/day

$Q_R = 1.06261 \times 10^{10}$ lit/day

The Flow Required in Cauvery River Considering B.O.D Dilution and Dispersion $Q_R = 124.16$ Cumecs or 4385 cubic feet / second

Cauvery Tribunal Final Award Environmental Allocation for Cauvery River =2.5 T.M.C / Month from Feb to May.

= 60.69 M.cum / Month

= 26.3 Cumecs or 964 cubic feet / second.

On critical analyzing the Quantity of flow of water in Cauvery River as per the Central Water Commission Gauge Station Urachikottai -down stream of Mettur Dam data's from June 1999 to January 2006 it is observed that the River Cauvery has virtually there is no flow for 39 days in the water year 1999-2000,133 days for the water year 2000-2001,183 days for the water year2002-2003,269 days for the water year 2003-2004,180 days for the water year2004-2005,9 days for the water year2005-2006 ,2 days for 2006- up to January 2006 and continuous flow occurred only in the water year 2001-2002. Analyzing period totally 2802 days from first June 1999 to 31st January 2006, totally 815 days virtually there is no flow was observed in the river, comes around 29.08 %. But the Industrial and Municipal sewages treated, partially treated and un treated effluents are continuously let out into the Cauvery River in our study area Mettur dam to Erode along the natural sources of contamination like agricultural return run off, carcasses of death animals, fishes, decaying vegetations and trees, agricultural excess fertilizers. Pesticides, agricultural wastes, and other natural disturbances in the catchment area, etc has influence the sub surface flow of the river as well as stagnated low level pockets of river course and it leads heavy pollution and contamination. The accumulated sewage and Industrial effluents stagnating in the river, and it settle its solid matters in the river bed it self. Absence of sufficient flow and up stream flow in the study area the, drinking water intakes as per the Table – daily 600 MLD drawn from the Cauvery River in the study area alone. The quality and reliability of the drinking water resources of 30,15,000 population from the study area from Mettur Dam to Erode now under severe threat due to the absence of requirements for continuous flow in the Cauvery River considering the requirement of dilution factor as well as self purification capacity of the Cauvery River ecosystem. The overall drinking water source for 15 districts 2,62,39,416 population as per the Table- and the total quantity of Cauvery river water daily drawl 2232 MLD for drinking purpose alone from surface water as well as from infiltration wells erected in the river itself are under severe threat. The water supply sources of Erode, Pallipalayam, Sankagiri, Veearpan chattram Tiruchengodu are surrounded by effluents and sewage due to zero velocity and absence of dilution factor. The above water supply sources now getting contaminated by the stagnated sewage and effluents, and dyes and chemicals present in the stagnated water of River Cauvery.

6.10 CPCB ANNUAL REPORTS FOR RIVER CAUVERY

River Cauvery: On an average DO & BOD values have been found meeting the desired class. But DO values were not within the desired level at Erode in the months of January (3.8 mg/l) & October (3.5 mg/l), It is observed that BOD values was exceeding the desired limit at Erode. Total Coliforms values were also exceed.

Eutrophication symptoms were observed in the down stream of Mettur Dam. It seems that due to eutrophication, the oxygen concentration has risen up to 20 mg/lit, as the observations were taken during day time, when photosynthetic effects were prominent.

In general, there are three ways to improve the water quality of the Cauvery River

1) Reduction of pollution load
2) Increase of flow rate
3) Enhancement of the self-purification function of the River

Regarding the pollution load (BOD, in particular), the following are involved in BOD overload: the confluence of Bhavani River water , Drainage Channels water of Mettur,Komarapalayam,Bhavani,Erode, Veearpan chattram, and Pallipalayam Municipalities and drainage from wastewater treatment plants from Komorapalayam Wastewater Treatment Plant.

Eutrophication symptoms were also observed from Bhavani Town. It seems that due to eutrophication, the oxygen concentration has risen up to 20 mg/lit, the observations were taken during day time, when photosynthetic effects were prominent.

In general, there are three ways to improve the water quality of the Cauvery River

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Regarding the pollution load (BOD, in particular), the following are involved in BOD overload: the confluence of Bhavani River water , Drainage Channels water of Mettur,Komarapalayam,Bhavani,Erode, Veearpan chattram, and Pallipalayam Municipalities and drainage from wastewater treatment plants from Komorapalayam Wastewater Treatment Plant.

The reduction of the pollution load is of primary importance for the improvement of river water quality. Therefore, it is necessary to promote the expansion of sewerage systems and the introduction of advanced water treatment technology in treatment plants.

An increase in flow rate during irrigation water release in Cauvery River the water quality gets improved significantly. In non flow season and the minimum lean flow periods the assimilation and self purification capacity of the river water is not enough to digest the pollutant load. The Self-purification Rivers is based on the self-purification function it varies depending on the biota that inhabits the rivers. Generally, rivers themselves are turbulent enough to allow for rapid mixing and dilution of the effluent. Mixing of the effluent occurs in rivers at various degrees. In rivers, complete mixing is likely to occur upon entry, provided that the stream volume and flow are greater than the volume of effluent being discharged. In larger streams, the effluent may form a plume, and complete mixing may be reached only over a long distance.

Total Sewage and Industrial effluents let out into River Cauvery = 153.2 MLD
In the Study area Mettur to Erode stretch

Considering "25 "as "Dilution factor" Minimum Flow Requirement = 44.33 Cumecs

Considering "50 "as "Dilution factor" Minimum Flow Requirement = 88.66 Cumecs

Considering "65 "as "Dilution factor" Minimum Flow Requirement = 133.00 Cumecs

Considering"100 "as "Dilution factor" Minimum Flow Requirement = 166.32Cumecs

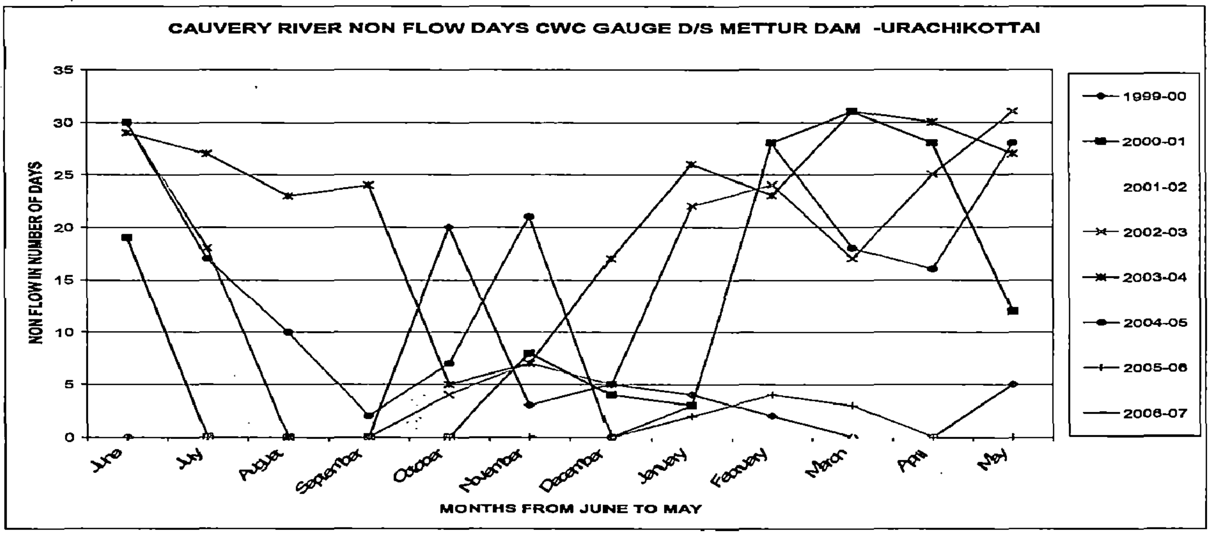


Chart 6.1

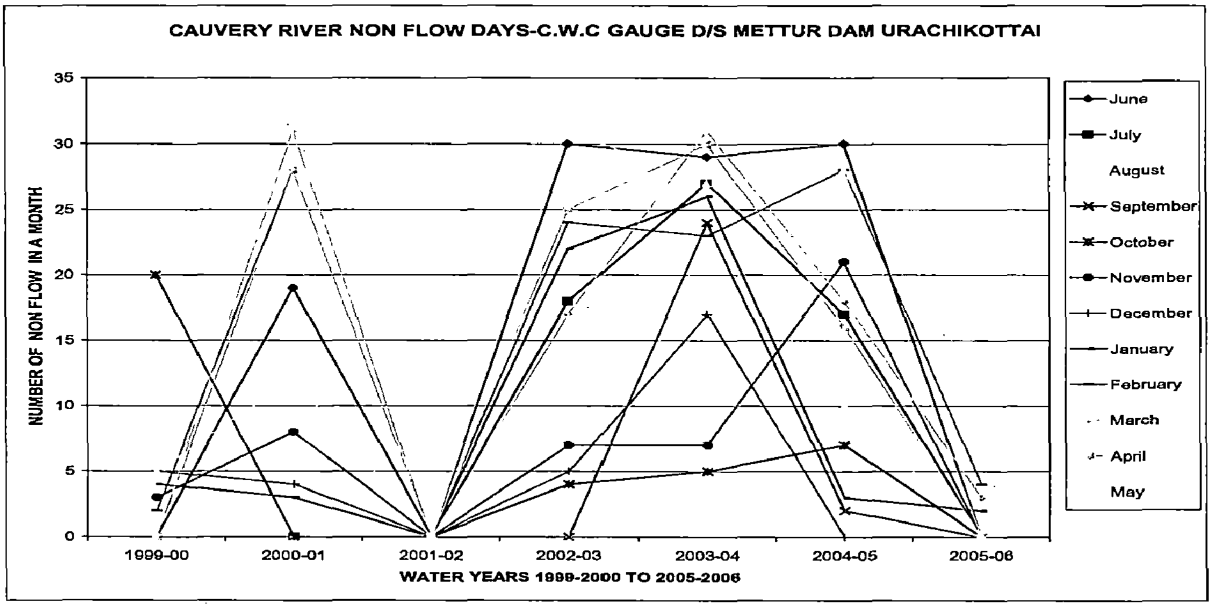


Chart 6.2

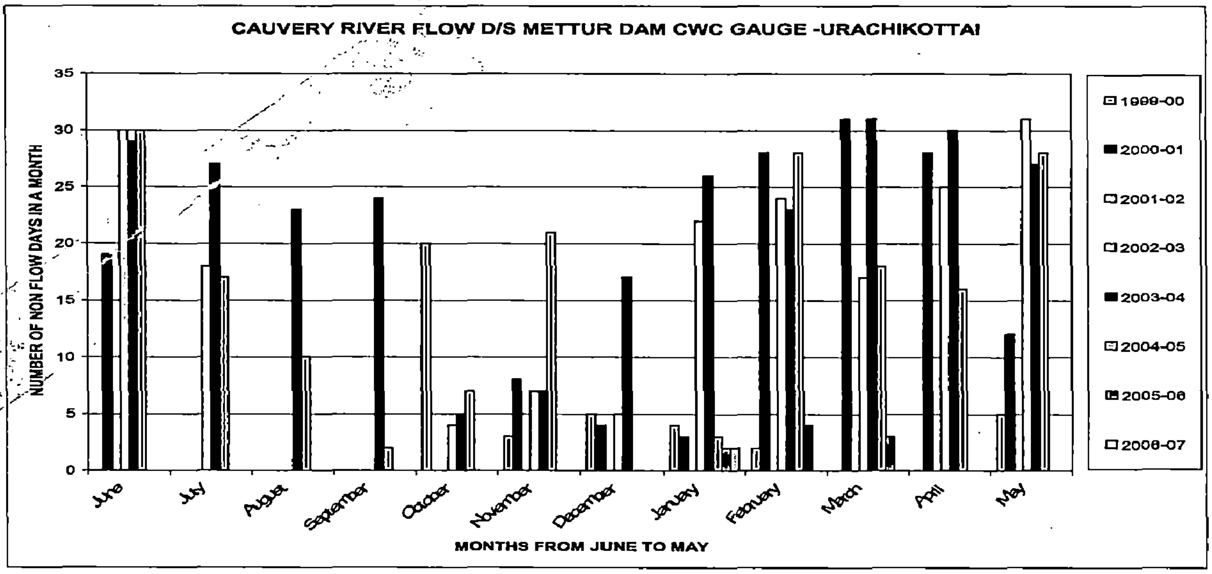


Chart 6.3

The discharge of Domestic and Industrial Effluents in to Cauvery River during flow days result in depletion of Oxygen in running water. The discharge of these effluents will also import colour to the water. These may destroy the flora and fauna of the receiving waters of Cauvery River. Further, the rich solids presents may settle at the bottom of the river. Continuous settling of these solids at the bottom will affect the fish spawning grounds. High toxic chemicals present in the effluent may have direct impact on the fish diversity of the river.

During non flow and minimum flow days in the Cauvery River the discharged treated, partially treated or un treated industrial effluents and treated, partially treated or un treated municipal sewage are stagnated as patches in the form of number of small ponds and also the sites nearer to water intakes. The non point sources like agriculture run off, and the small scale dyeing and textile and textile processing units industries, effluents having high level of suspended and total dissolved solids, usually exceeding pollution standards, with low dissolved oxygen level, and with high B.O.D and C.O.D. requirements are stagnated as patches like small ponds. Various, acetic acid and dye substances that are used Chemicals like soda ash, caustic soda, hydrochloric acid, Sulphuric acid, sodium peroxide, acetic acid and dye substances that are used in the process also find their way in to the effluent.

Discharge of these effluents lends to percolate physically to the underground water, polluting the ground water. Large scale pollution of under ground water in Tirupur has been reported at Noyyal River Basin (Prabakaran and Lakshmanan, 2002). Apart from affecting the water quality, the soil also gets affected by the application of polluted waters in to the River system.

Due to the high concentration of salts with elevated pH and electrical conductivity, the natures of aquifers are much affected and the contents are being slowly accumulated in ground water. Direct release of effluents to Cauvery River through streams and drains also adversely affect the water quality rendering the water unfit for domestic usage, irrigation and fishing. The ground water quality can also be affected by the release of the effluents from textile and dyeing industry. The salts and other chemicals contaminate the ground water by way of infiltrations into the soil resulting in increased electrical conductivity and sodium absorption ratio of underground water.

6.11 EFFECT ON CROPS

The crops irrigated from the well water near by Cauvery River are affected due to the predominance of salinity and Sodicity. Textile industry effluent inhibits the germination and growth of paddy, pearl millet and pearl. Dyeing units' effluents at higher concentrations was reported to reduce the germination of seeds and vigour index of paddy, finger millet, cowpea, soybean and maize seedlings. However, diluted dyeing units effluent was reported to improve the groundnut germination and increased the chlorophyll, carbohydrates and protein content of the seedlings (Ajmal and Khan, 1985).

Actually out of analysis period of 2802 days from 1st June 1999 to 31 st January 2007 virtually there is no flow for 815 days (details in annexure) .First the Government to maintain Environmental flow otherwise the thinking of restoration project is a wasteful exercise. With out release of freshwater from up stream of the study area i.e. From Mettur Dam how the river get freshwater to maintaining its riverine eco system. (Action Government)

6.12 ACTION REQUIRED

If the River Cauvery has considered for restoration programme, first the river Cauvery requires certain environmental flow for carrying away the pollutants and maintain life of the riverine eco system.[Action: Government]

The State Government first should release at least 27.3 cumecs as minimum environmental flow for Cauvery River from Mettur Dam during non releasement of irrigation water to delta region as described by the Hon'ble Cauvery Water Dispute Tribunal.

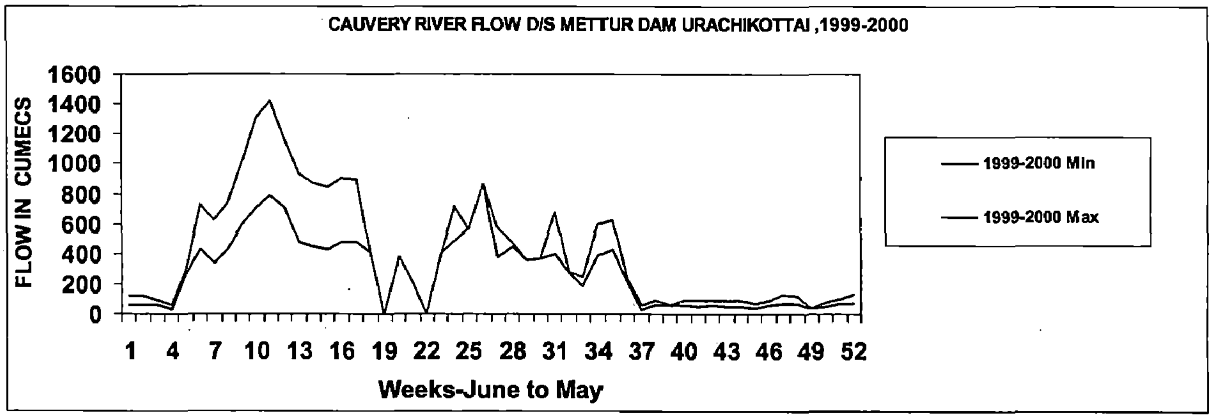


Chart 6.4

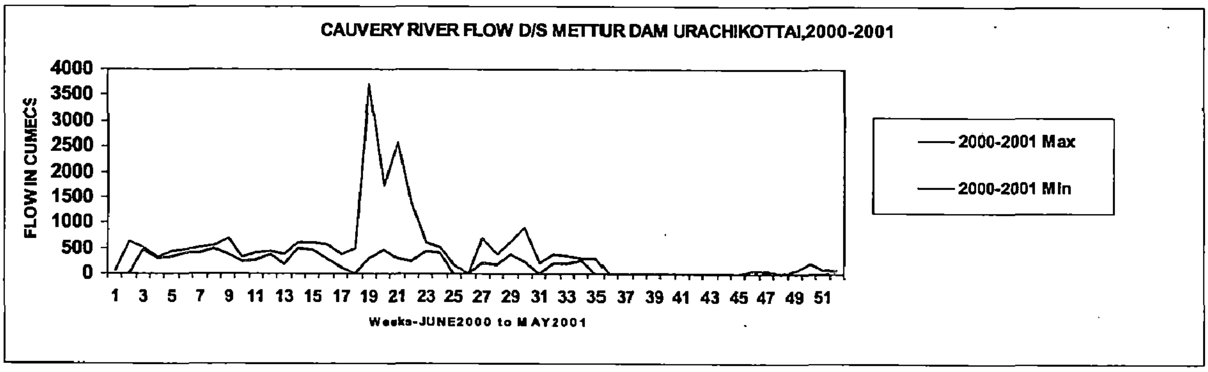


Chart 6.5

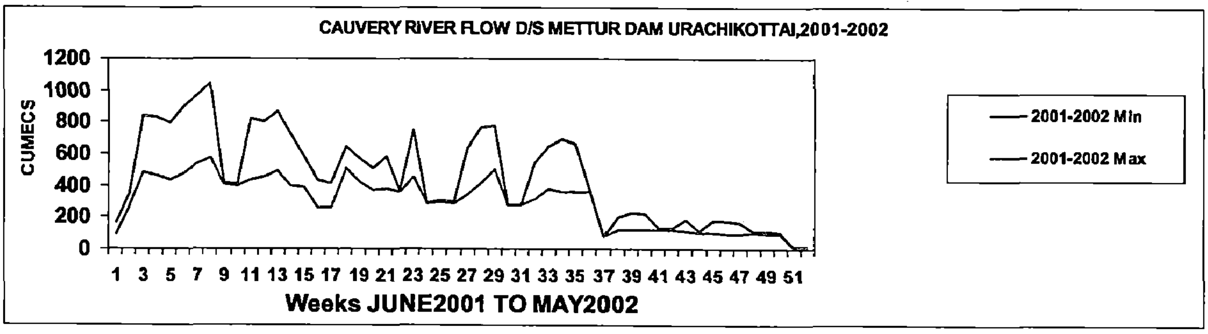


Chart 6.6

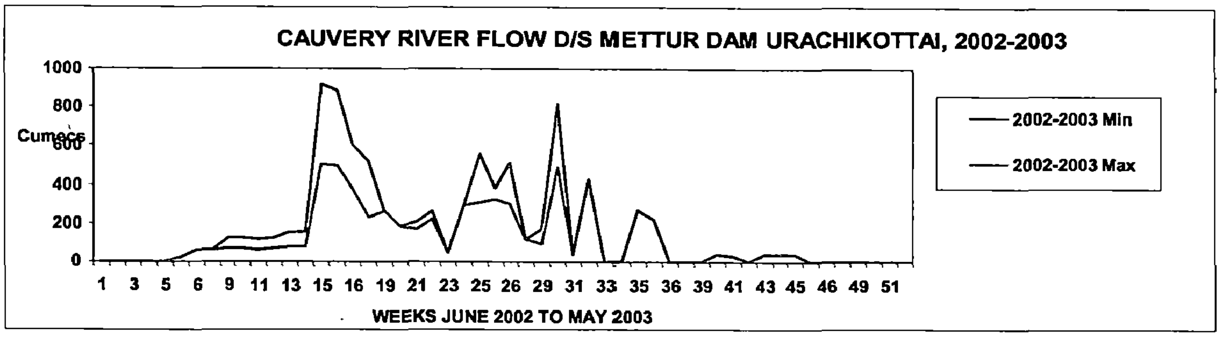


Chart 6.7

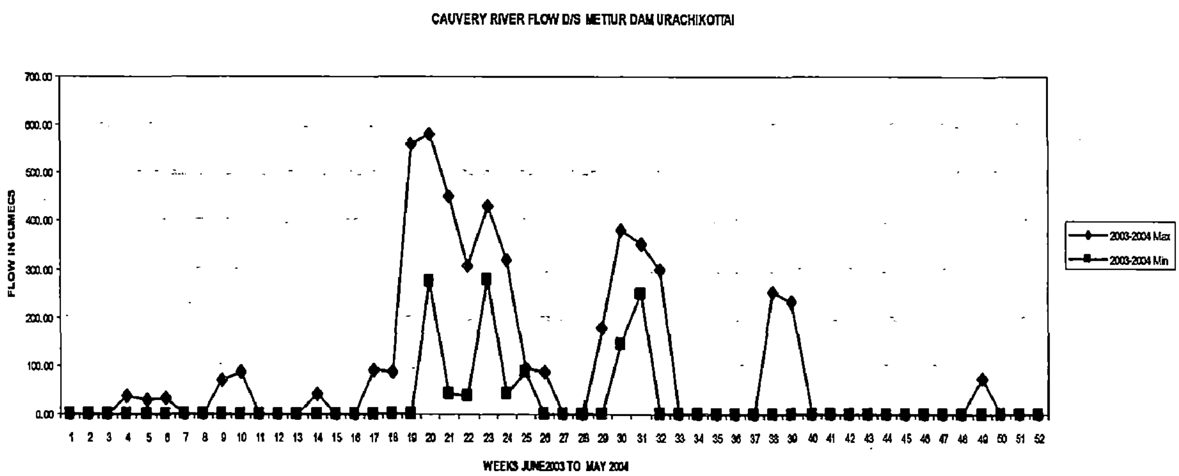


Chart 6.8

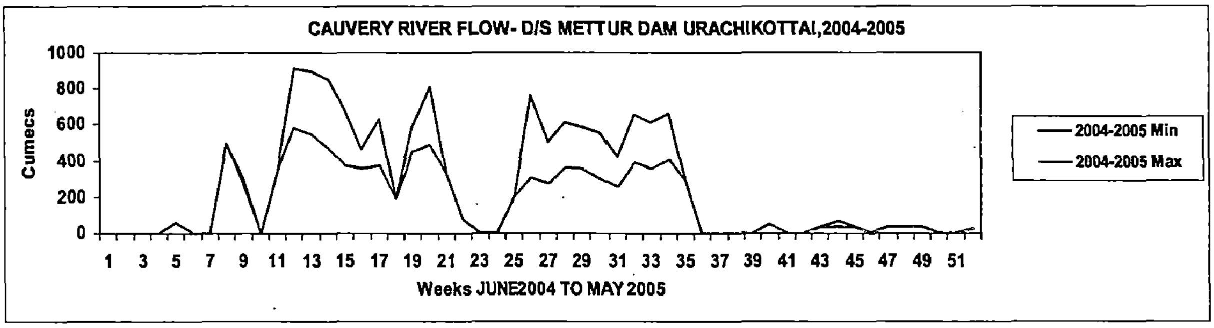


Chart 6.9

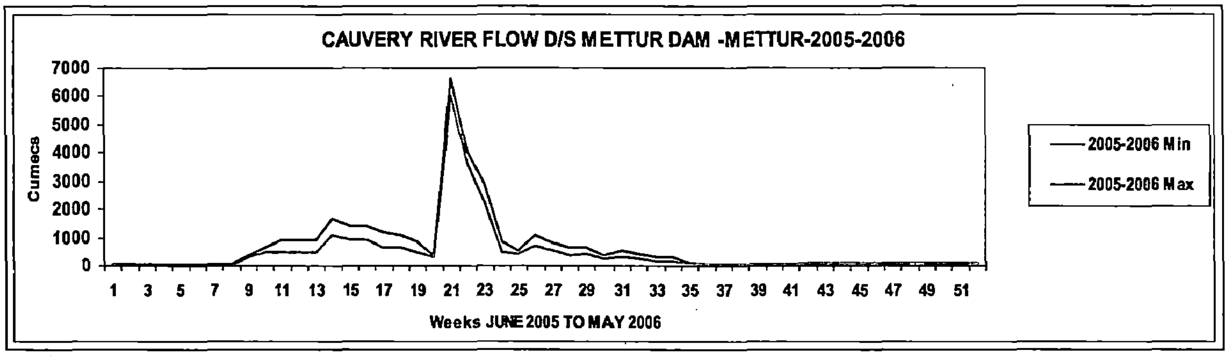


Chart 6.10

6.13 IMPLEMENTATION OF WATER ACT WITH SPECIFIC REFERENCE TO CAUVERY RIVER

Though about 70% of Earth is covered by water, water good enough for human consumption is only about 0.5%, distributed in surface and subsurface forms. To protect this limited vital natural resource, Government of India has enacted The Water (Prevention and Control of Pollution) Act as early as 1974. In the objectives, it has been clearly mentioned that this Act is enacted with objectives of controlling and prevention of water pollution and to restore the water quality and maintaining the wholesomeness of water. For the purpose of restoring the water quality, Pollution Control Boards which have been created under the Water Act, developed scale on the basis of water quality, in to various classes.

In India, there are 14 major river basins. They can classify into The Himalayan Rivers, The Deccan Rivers, The Coastal Rivers, and The Rivers of the Inland Drainage Basin. Cauvery River is one of the Deccan River system and important river in Southern India having a drainage area of 87,900sq kms (46,147, 38,823, 2,930 sq.km in Karnataka, Tamilnadu and Kerala respectively). It rises in Brahmagiri Range of the Western Ghats in Coorg District of Karnataka. After flowing 802km (381, 357, 64km in Karnataka, Tamilnadu and Kerala respectively) it joins the Bay of Bengal at Kaveripatnam. There are eight tributaries of Cauvery, five in Karnataka - the Harangi, the Hemavathi, the Lakshmantirtha, the Kabini and Swarnavathy and three in Tamilnadu- Bhavani, the Noyyal and the Amaravathi. Some of the important towns along the course of this River are Mysore, Erode, Vellore, Tiruchirapalli, Tanjavure etc. Thus various human activities along the course of river like agriculture, industrialization and other commercial activities have a impact on the quality of Cauvery river.

With growth of various economic activities, the river water has recorded a steady downfall in the quality. Both Karnataka Pollution Control Board and Tamilnadu Pollution Control Board have responsibility under the Water Act to restore the water quality and to maintain the wholesomeness of water quality in this river. The water quality as recorded by the Pollution Control Boards under the Global Environmental Monitoring Scheme (GEMS) at nineteen sampling stations spread over two states viz Karnataka and Tamilnadu from 1994 to 2006 is given in the Table : 6.7.

Table 6.7: Cauvery River Water Quality CPCP Classification

Location	Desire Classed	Existing Class												
		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Napokulu Brd(ds)	A	C	C	-	C	C	C	C	C	B	C	D	B	C
Kushal Nagar (us)	A	C	C	C	C	C	C	C	C	C	C	D	D	D
KR Sagar	C	C	D	B	A	B	D	C	C	B	D	D	C	C
Sri Ranga Patanam	B	C	D	-	-	D	D	C	C	C	D	C	C	C
Karekuara (ds)	C	C	C	D	C	C	C	C	C	B	D	C	C	C
Sathyagalam Brd	C	C	D	B	A	D	D	C	B	B	D	C	C	C
Mettur	C	D	D	D	D	E	B	C	B	B	D	C	B	C
1 Km ds after Confluence with Bhavani River	C	D	D	D	D	D	D	C	C	C	E	D	C	D
Pallippalayam	C	D	D	E	D	D	C	C	C	C	E	E	E	E
Erode	C	D	E	D	D	D	D	C	C	C	E	E	D	E
Vel ere	C	D	D	D	D	C	B	C	B	B	D	D	C	D
Mohanur	C (B)	D	D	D	C	C	B	B	B	B	D	D	C	C
Tirumukkadal	B	-	-	B	C	C	C	C	B	B	B	C	B	B
Musiri	C	D	E	D	C	C	C	C	C	B	B	C	B	B
Tiruchirappalli (upstreams)	B	D	E	D	D	D	C	C	D	C	C	D	C	C
Tiruchirappalli (down stream)	B	D	D	D	D	D	C	C	C	B	B	D	C	C
Trichy	B	D	D	D	C	C	C	C	C	C	C	C	C	C
Tanjavur	C	-	-	-	C	-		C	B	B	C	B	B	C
Coleroon	C	D	E	D	C	D	D	C	C	C	C	D	C	C

It becomes clear from the Table that, the quality of the river water is always short of the desired class. The degradation in the water quality can be noticed right from the point of origin. At Napokulu and Kushal Nagar the river water shall be in Class A. But the existing class is only C. The interesting point is that these two stations are not even industrialized areas. As we go further downstream, the water quality represents a sad picture of the failure of proper implementation of Water Act. In Tamilnadu state, at Mettur, the water quality reached the Class E bringing into focus the sad state of natural resource management. Even after the confluence with River Bhavani, (with more dilution) the water quality remained short of desired class. All along its course, the water quality was never found to be better or equal to the desired qualities except only once, i.e. near Krishna Raja Sagar near Mysore.

This kind of failure of effective implementation of Water Act may result in many ecological backlashes. For instance, throughout its drainage basin, Cauvery river is the primary source for potable water. If the quality of water is not good, it will put more burdens on the economy to provide safe drinking water, it may cause reduction or change in species diversity in the riverine ecosystem etc. Further, this may slowly but surely poison the agricultural field in the basin.

The reasons for this kind of failure in the proper, effective implementation can be ascribed to two major players viz polluters and pollution control boards.

The first segment of polluters can be further be divided into three major categories viz. Municipal sewage disposal, industrial units and non point source like agriculture etc. Most of the municipal disposals all along the river course are practicing only the conventional treatment with partial removal of BOD, Suspended Solids. At times, it is common to release effluents without even the primary treatment. Often quoted reasons for kind of practice are non availability of resources, financial constraints etc. To prevent these practices, Pollution Control Boards can seek the help of judiciary as in the case of State Prevention and Control of Pollution Control Board Vs Berhampur Municipality Corporation 1992 Cri. L.J. p. no. 2909.

Second important group of polluters is the Industrial Units. According to one survey, the majority of the industrial units in the river Cauvery basin belong to the small scale and individual effluent treatment plants may not suit this sector. But the Common Effluent Treatment Plants suits this scenario well. Pollution Control Boards and State Governments may encourage the construction of CETPs. For the third group of polluters, one best way is to increase the awareness about the natural resource management. Towards this end, CEERA is planning to carry out various sensitization programs in association with Partner Institutes for various stake holders like Non Governmental Agencies, Local Self Government Agencies etc. Coming to the problems faced by the Pollution Control Boards during the implementation, lack of cooperation from the industrial units, lack of the infrastructure and man power can be said to be important aspects to be dealt at once for the effective implementation of Water Act.

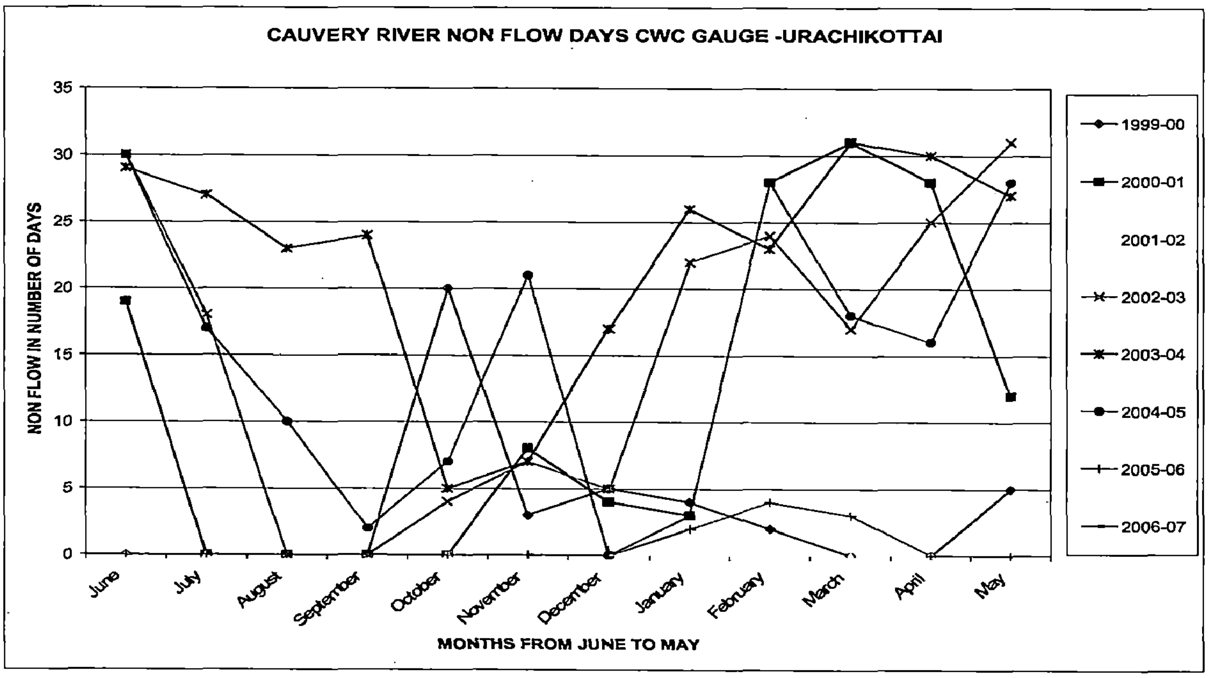


Chart 11

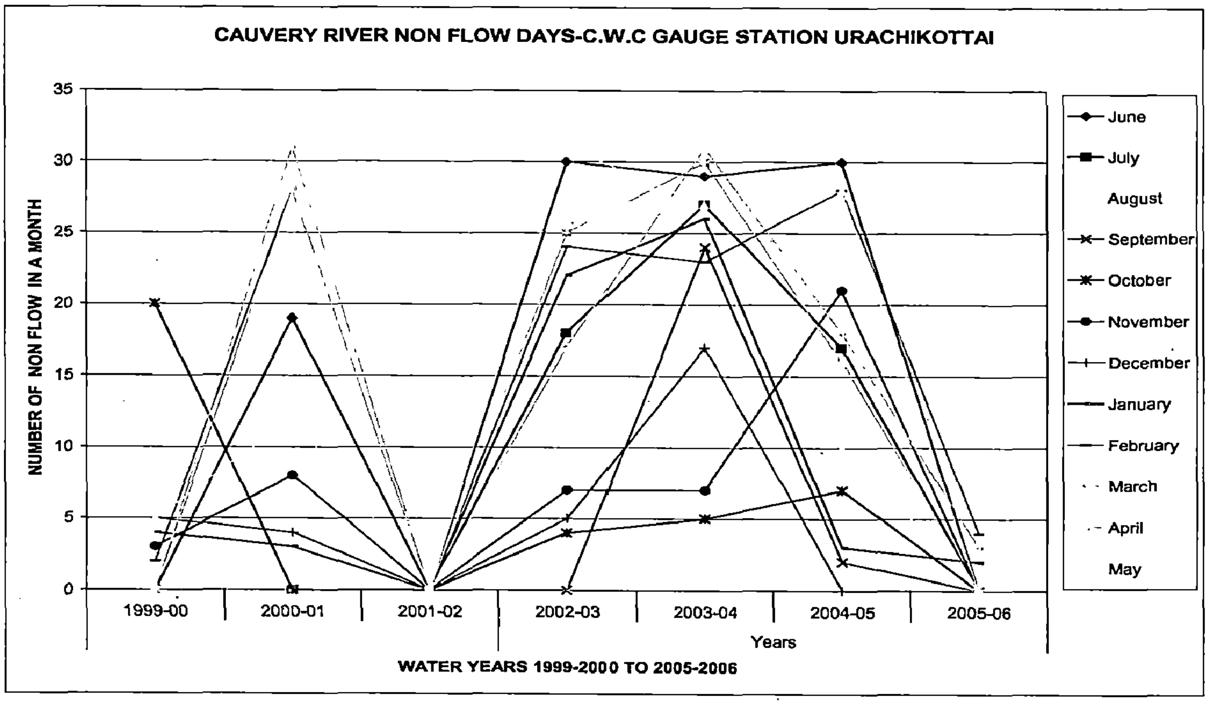


Chart 12

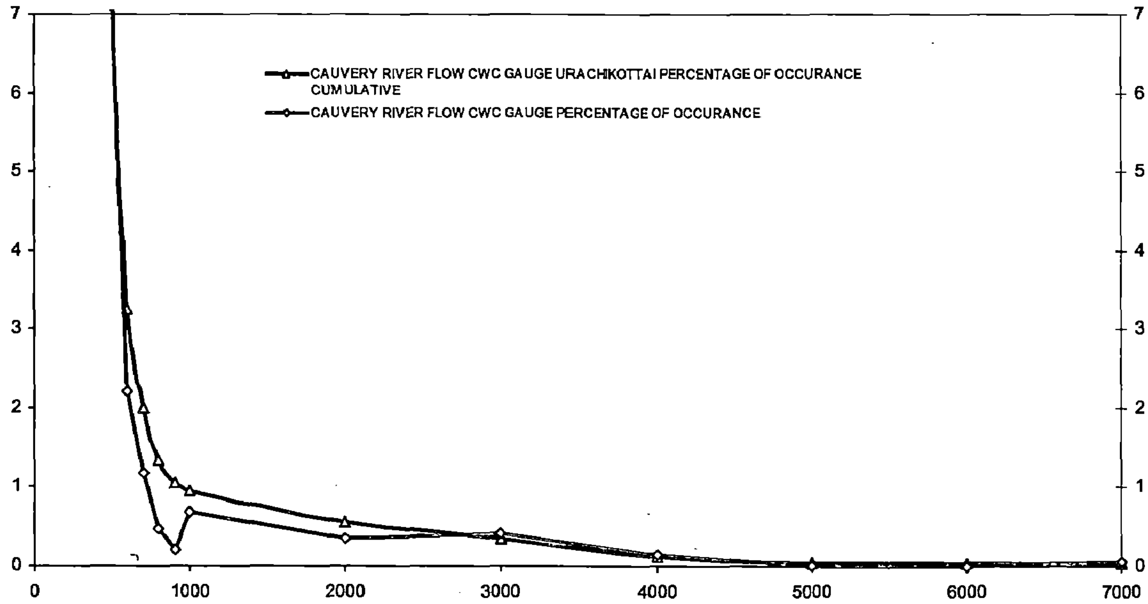


Chart 13

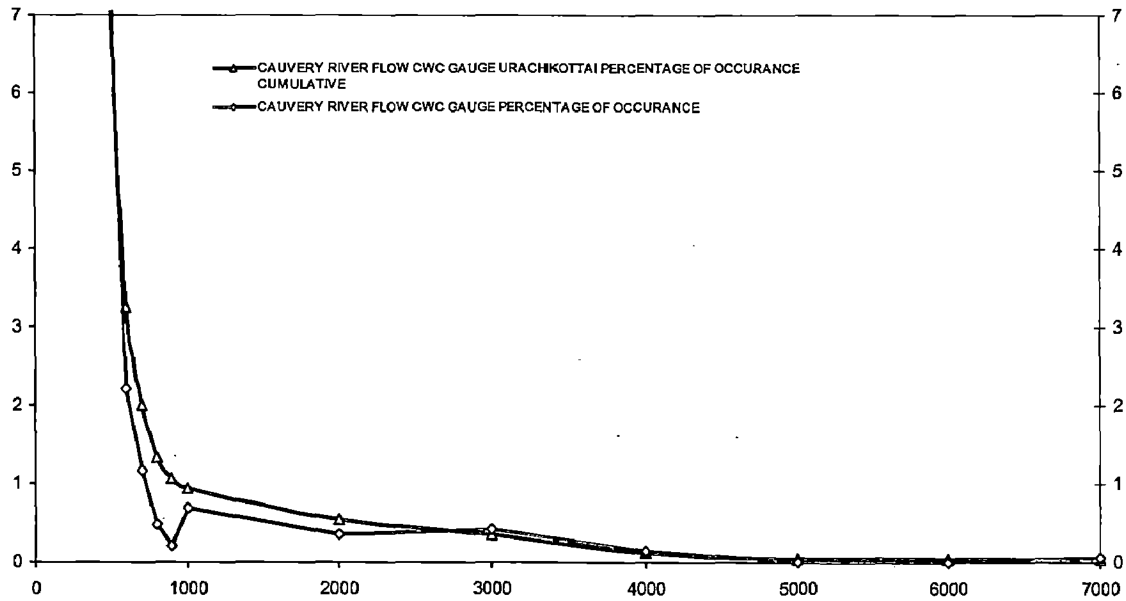


Chart 14

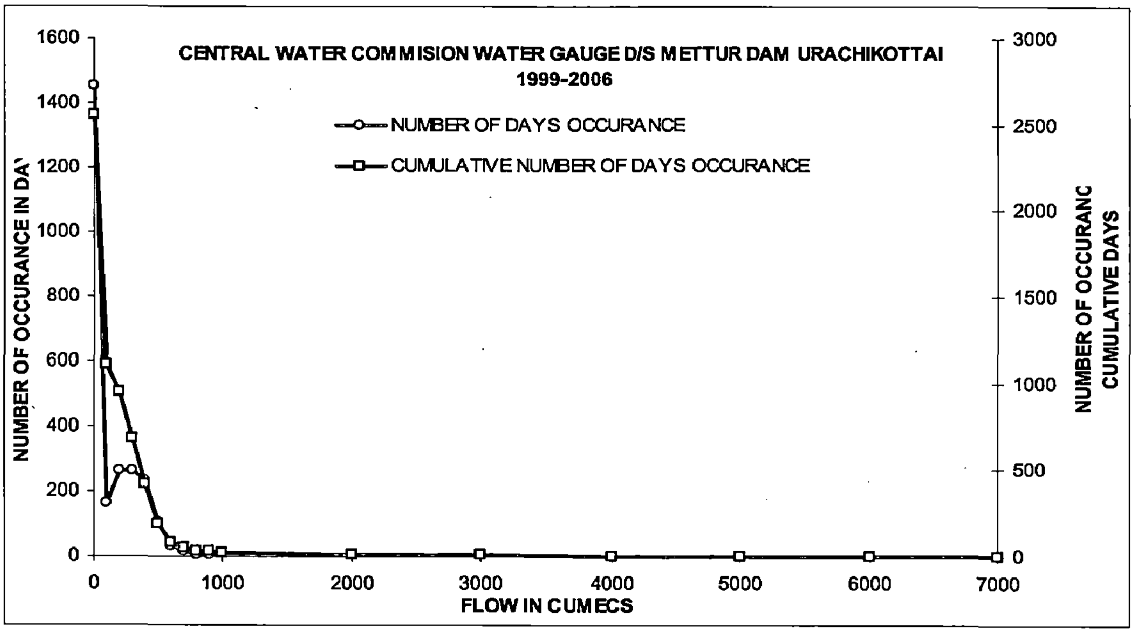


Chart 15

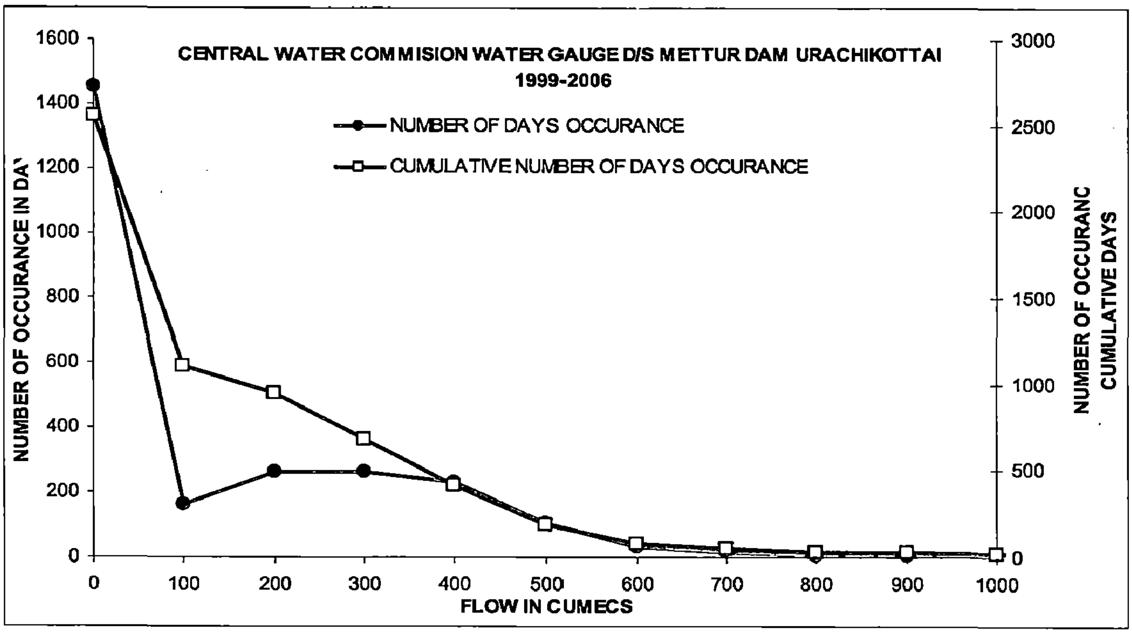


Chart 16

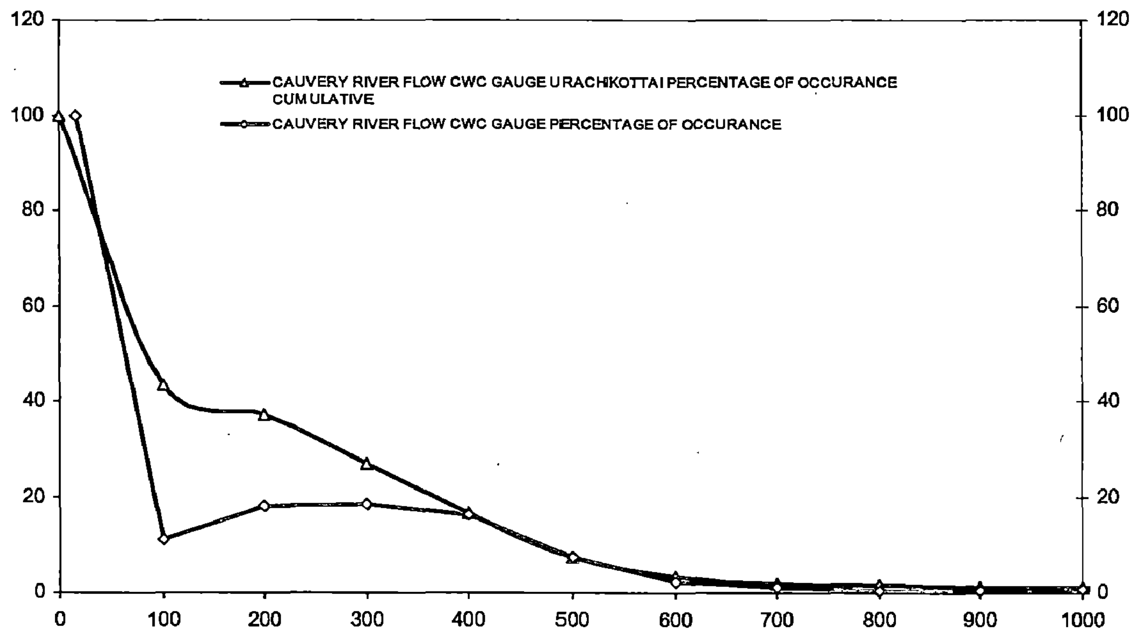


Chart 17

CAUVERY RIVER FLOW METTUR DAM D/S CWC GAUGE URACHIKOTTAI JUNE 1999 TO MAY 2006

Sl.No	Flow Range	Number of Days	Cumulative	%age occurrence normal	%age occurrence cumulative
1	7000	1	1	0.1	0.0
2	6000	0	1	0.0	0.0
3	5000	0	1	0.0	0.0
4	4000	2	3	0.1	0.1
5	3000	6	9	0.4	0.4
6	2000	5	14	0.3	0.5
7	1000	10	24	0.7	0.9
8	900	3	27	0.2	1.1
9	800	7	34	0.5	1.3
10	700	17	51	1.2	2.0
11	600	32	83	2.2	3.2
12	500	104	187	7.2	7.3
13	400	232	419	16.0	16.4
14	300	264	683	18.2	26.7
15	200	262	945	18.1	37.0
16	100	161	1106	11.1	43.3
17	0	1451	2557	100.0	100.0

6.14 SUMMARY

The river Cauvery requires certain environmental flow for carrying away the pollutants and maintains its life of the riverine eco system. Cauvery requires at least 27.3 cumecs as minimum environmental flow from Mettur Dam during non releasement of irrigation water to delta region as described by the Hon'ble Cauvery Water Dispute Tribunal.

INDUSTRIAL EFFLUENTS

7.1 GENERAL

Surface Water

All the major river basins are not perennial. Only four of the thirteen major basin posses areas of high rainfall, i.e. Brahmaputra, Ganga, Mahanadi and Brahamani having annual average discharge of a minimum of 0.47 million cubic meter per Km2, and they are perennial. Six basins (Krishna, Indus, Godavari, Narmada, Tapi and Subernarekha) occupy the area of medium rainfall and have annual average discharge of a minimum of 0.26 million cubic meter per Km2, and the remaining four (Cauvery, Mahi, Sabarmati and Pennar) occupy the area of low rainfall and have annual average discharge between of 0.06 and 0.24 million cubic meter per Km2. Thus, many of the major river basins also go dry during summer leaving no available water for dilution of waste water discharged in them. State wise perennial riverine length in India is given in figure.

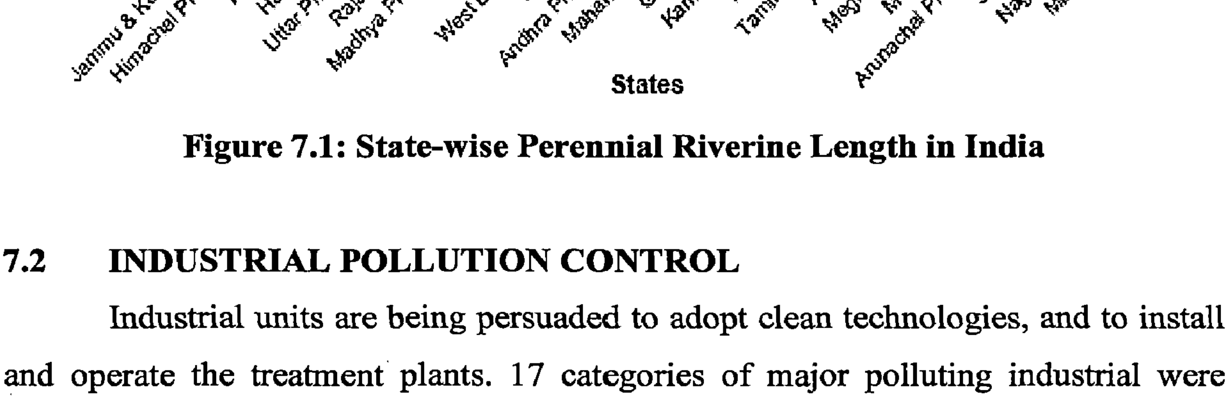


Figure 7.1: State-wise Perennial Riverine Length in India

7.2 INDUSTRIAL POLLUTION CONTROL

Industrial units are being persuaded to adopt clean technologies, and to install and operate the treatment plants. 17 categories of major polluting industrial were identified and targets were fixed to adopt pollution control measures by CPCB.

7.3 COMMON EFFLUENT TREATMENT PLANTS

Urbanization and need for better living has incessantly generated requirement of consumer goods and infrastructural inputs. With market potential and easy finance available, the mushrooming rise in the number of small scale industries can be seen in any Indian city. Besides being a resource for market economy and production of large number of consumer items, it is generally observed that, either due to their economies of scale coupled with their unplanned growth and dearth of affordable and cost- effective treatment technology, efforts by small scale units in achieving the environmental compliance have not been effective. Their large number and diverse trade has further aggravated the problem. Under these constraints, setting-up of individual full-fledged treatment device is no longer feasible. Hence the desirable option is of the shared or combined treatment, wherein, managerial and operational aspects are collectively addressed and the cost of treatment , becomes affordable as enunciated in the scheme of the common effluent treatment plants, which are proving to be a boon especially for small entrepreneurs, given the methodical planning, regular operation and equitable contribution of member units. Such common facilities also facilitate proper management of effluent and compliance of the effluent quality standards

7.4 PROMOTION OF COMMON EFFLUENT TREATMENT PLANT

This scheme has been designed to assist in setting up of Common Effluent Treatment Plants for clusters of small scale units. The financial assistance under this scheme is provided as follows:

Central Government: 25% subject to maximum of Rs.50 lakhs

State Government: 25% subject to maximum of Rs.50 lakhs

Promoters' share: 20%

Loan component (IDBI): 30% (at concessional rate of interest from the World

Bank line of credit)

Under this scheme assistance been provided to clusters of tanneries, textile units, and chemical units.

7.5 CONCEPT OF COMMON TREATMENT

The concept of effluent treatment, by means, of a collective effort, has assumed reasonable gravity by being especially purposeful for cluster of small scale industrial units. Common effluent treatment plant (CETP) not only helps the industries in easier control of pollution, but also act as a step towards cleaner environment and service to the society at large. Small scale industries, by their very nature of job cannot benefit much from economies of scale and therefore the burden of installing pollution- control equipment, falls heavy on them. Realizing this practical problem, under the policy statement for abatement of pollution the Govt. felt to extend the scheme for promoting combined facilities for treatment of effluent and management of solid waste for clusters of small scale industrial units and also to provide technical support to them. Accordingly, Ministry of Environment & Forests, Govt. of India, had instructed various State Pollution Control Boards, to examine the possibilities of establishing CETPs in various Industrial estates in the respective states.

The concerted approach of joint or common effluent treatment provisions has many advantages. Wastewater of individual industries often contain significant concentration of pollutants; and to reduce them by individual treatment up to the desired concentration, become techno-economically difficult The combined treatment provides a better and economical option because of the equalization and neutralization taking place in the CETP.

7.6 CONCEPT OF COMMON TREATMENT

Other important issues for the merit of common treatment include scarcity of land at the industry's level and a comparatively easier availability of professional and trained staff for the operation of CETP, which can otherwise be difficult, at the individual industry level. For the regulatory authorities also, common treatment facility offers a comparatively easier means of ensuring compliance of stipulated norms. The handling and disposal of solid- waste also becomes increasingly easier as the infrastructure is created in the project itself. The concept of common treatment, based on feasibility, should be part of the new industrial estates as essential component of infrastructure, In fact, the location of industries should always be such that units with compatible nature of activity are located in a cluster which in-turn can facilitate in providing common treatment .

7.7 MEASURES FOR OPTIMUM EFFICIENCY

Operation of CETP being a participatory mechanism, the primary requirement is hence to define the ultimate responsibility for the proper functioning of the plant after it is commissioned. The important issues which merit consideration are:

7.8 ASPECT OF OWNER SHIP

Various owner ship alternatives include the plant owned by government, consortium of industries or by an independent body. What ever be the case, the primary emphasis should be on responsiveness in terms of effective and optimal operation of the plant and accountability. The member industries should also be made to realize that they are equally responsible for the sustenance of the plant.

7.9 CONVEYANCE SYSTEM

Different from the discharge characteristics of an integrated (big) industrial unit, small scale units usually generate higher proportion of floating or suspended particles in their effluent streams. At times their job operation result in high corrosive effluent. In either of these cases, to effectively convey their effluent to the CETP, it becomes necessary for individual units to set-up a 'pre - treatment' device. It is also necessary that the conveyance network be so designed as to ensure their periodic de-sludging. Care should also be taken to minimize on cost of operation by facilitating conveyance through gravity flow, instead of multistage pumping. In fact the location of CETP should be selected after a careful topographical survey of the drainage area to keep the conveyance route as short as possible. The chances of flooding in monsoon and accidental surface run-off into the conveyance route should also be looked into. Conveyance by tankers is another option, provided the chances of leakage are effectively checked and their transit is strictly monitored in accordance to a properly laid down system.

7.10 COST OF TREATMENT

The cost effective treatment supported with a system of regular collection / payment of treatment charges by each member unit, while maintaining its effluent quality within acceptable norms are some of the prerequisites. The system of payment should be legally supported to provide a check for non-payment of dues and to take steps against defaulters.

7.11 CRITERIA FOR COST

The cost sharing should be decided in such a way that volume of effluent becomes an important norm, but its share in the total cost should not be such as to encourage by-passing of dilute streams and conveying highly toxic / non-biodegradable waste to CETP. The treat ability factor should also be given due consideration in cost estimation. An effort by the industry to segregate toxic, highly acidic / highly basic, or toxic metal bearing waste be made to explore the possibility to de-toxify / neutralize or to attempt the recovery of metals by installing recovery plants, which are feasible and economically viable on account of their pay-back potentials.

7.12 PLANT DESIGN

The approach to provide treatment at low cost, an important factor in common treatment, depends on appropriate design of CETP. In keeping with the diverse nature and scale of operations, typical of small scale units, low capital investment and lower operation and maintenance cost incurred on treatment is a prime factor. In such a situation mechanical and chemical processes are advantageous over bio-logical systems. And the least preferred are conventional anaerobic processes on account of huge space requirements and least flexibility. Though,, the advanced UASB technique with less hydraulic retention and space requirement being significantly low, anaerobic system is also a possible option. In order to obviate the need of excessive civil work at CETP in making huge equalization and settling units, the member units should also provide settling and neutralization of their individual waste. In order to minimize on the electrical cost, the possibility of substituting bio-energy should be explored to the extent possible. Proper management of sludge with its nutritive value would mobilize resources to substitute the operational cost. While designing the plant it would be of additional advantage to keep manpower requirement as low as possible but high in technical skills to reduce down-time for maintenance.

- **Advantages of Common Treatment**
  - Saving in Capital and operating cost of treatment plant. Combined treatment is always cheaper than small scattered treatment units.
  - Availability of land which is difficult to be ensured by all individual units in the event they go for individual treatment plants. This is particularly important in case of existing old industries which simply do not have any space.
  - Contribution of nutrient and diluting potential, making the complex industrial waste more amenable to degradation.
  - The neutralization and equalization of heterogeneous waste makes its treatment techno-economically viable.
  - Professional and trained staff can be made available for operation of CETP which is not possible in case of individual plants.
  - Disposal of treated wastewater & sludge becomes more organized.
  - Reduced burden of various regulatory authorities in ensuring pollution control requirement.

Table 7.1 : Ongoing CETP projects in study area

S.No	Name of the scheme	Member units	Capital Investment(Rs. in Lakhs)
1	Erode-1	77	1025
2	Erode-2	211	102
3	Erode-3	191	400
4	Bhavani-Dying	62	106
5	Chennimalai	71	97
6	Komorapalayam	120	100
7	Kasipalayam	76	500
	Total	727	2331

Source: www.nic.in.cpcb

7.13 VIABILITY OF COMMON EFFLUENT TREATMENT PLANTS

Different View points

Since last few years there has been a debate on various aspects regarding participation of large & medium units (located in industrial area) in the CETP. There are different views of experts on this issue. An effort has been made to compile various opinions.

Viewpoint no.1

- To allow all categories of industries to join CETP is against the spirit of CETP.
- In case of large scale industries, the responsibility of controlling pollution will be diluted
- In case of failure of CETP the entire untreated effluent shall be released to environment. The volume of effluent shall be phenomenal considering the inclusion of large & medium units also contributing to CETP
- Hence the idea of CETP should be kept limited to small scale industries however the present limit of 25 m3/d for discharging to CETP may be revised
- The large & medium units joining CETP shall not be entitled for Central subsidy, although SPCBs may consider allowing subsidy to CETP as per merit.
- Large & medium industries will have to pay differential treatment cost to CETP Company on "Polluter Pays Principle.

Viewpoint no.2

- Although CETPs are intended for small scale industries where the maximum flow is up to 25 cubic meters/day, there are many instances of the limit is exceeded.
- It is imperative to consider the removal of criteria of maximum flow for joining the CETP schemes as some small scale units may send effluent for higher pollution potential and lesser quantity and vice-versa.
- There are quite a few advantages of considering large & medium units in CETP. Some of these advantages are
    a. Enough quantity of effluent is always available
    b. With large & medium units as nuclius members along with the small scale units, this is a greater chance of efficient running of the CETP inb mutual interest.

c. Many large & medium units don't have high quantum of wastewater generation hence they can ensure cost effective treatment through CETP.

Although the policy decision for inclusion of large and medium industries in CETP is yet to be taken the above view points are significant to frame an idea,

In the study area the above 7 Common Effluent Treatment Plants are under construction. It is observed that the total treated effluents nearly 50 MLD has to be utilized for irrigation and fodder cultivation purpose, so as to avoid, to let out in River Cauvery, where there is flow in specific period and more over availability of dilution factors are limited depending up on the release of water from Mettur for irrigation period June to January and for water supply and environmental purposes Feb to May.

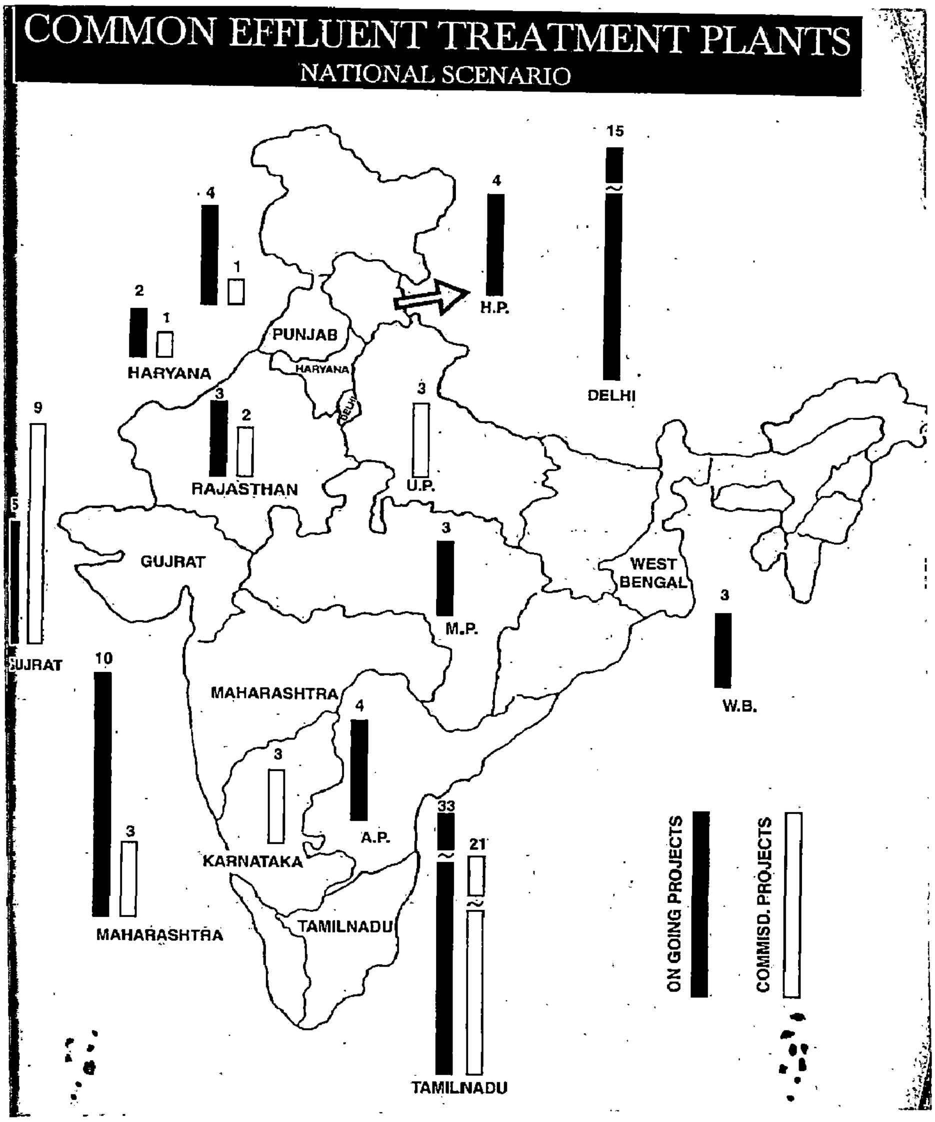
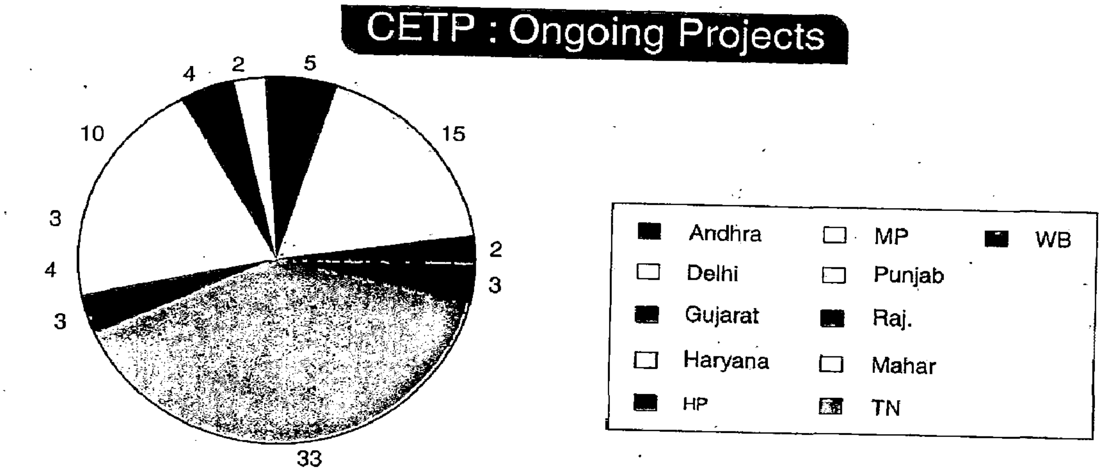


Figure 7.2: Common effluent treatment plants National scenario



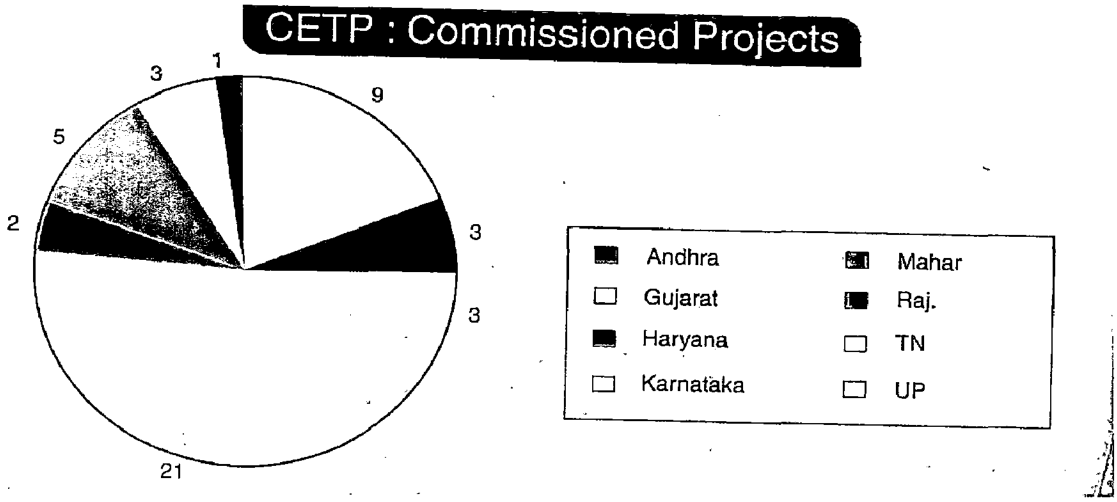


Figure 7.3: Common Effluent Treatment Plant Indian Scenario

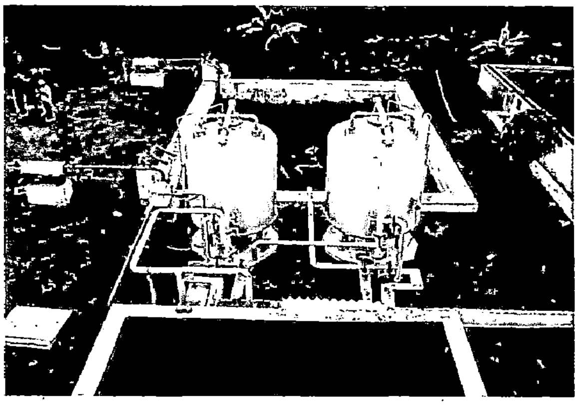


Figure 7.4 & 7.5 : Common Effluent Treatment Plant New Tiruppur Apparal Complex

EFFLUENTS DISPOSAL

8.1 WASTEWATER REUSE: POLICY, PLANNING AND MANAGEMENT ISSUES

Water is a prime need for human survival and industrial development. Demand on water resources for domestic, commercial, industrial and agricultural purposes is increasing significantly in the recent past. The situation is exacerbated by growing urbanization. Many cities have fully exploited the readily available water resources and are now obliged to develop and treat sources of lower quality or reach long distances to develop new supplies, both expensive options. The need to conserve potable water supply has thus become an increasingly important part of urban and regional planning. On the other hand, wastewater discharges into water courses are polluting water to unacceptable levels. If water quality in the streams is to be maintained for the designated use, wastewater will require adequate treatment prior to disposal to prevent water quality degradation, and to protect public health. Effective management of water resources and control of pollution are thus essential elements in sustainable development and human welfare apropos water resources.

With many communities throughout the world approaching or reaching the limits of their available water supplies, water reclamation and reuse has become as attractive option for conserving and extending available water supplies to meet current and future demands. While the need for additional water discharge of wastewater into water bodies, particularly for removal of phosphorous and nitrogen would entail reclamation and reuse of wastewater, as a cost- effective alternative in the future.

8.2 POTENTIAL FOR WASTEWATER REUSE

Traditionally, public water supplies are designed to provide water of potable quality to serve the water demands for various purposes. When water demand exceeds the yield of good quality water sources, lower quality water can be substituted to serve the non-potable Purposes. In some coastal cities, such as Hong- Kong, sea water has been substituted for high quality fresh water for toilet flushing. In the British Midlands, highly polluted Trent River water has been used for industrial purposes. Many water demands such as industrial, agriculture can be satisfied with water of less than potable water quality. The use of reclaimed water for non-potable purposes offers the potential for exploiting a new resource that can be substituted for existing sources. By replacing the potable water used for non- potable purposes an increased population can be served from the existing source. The greatest benefit of urban reuse systems could be their contribution in delaying or eliminating need to expand potable water supply and treatment facilities. Wastewater reuse for agriculture presents not only a low cost appropriate disposal medium but also an opportunity to manage wastes with minimum adverse environmental effects as the treatment requirements prior to land application are less rigid than those for disposal into water bodies. Application of sewage sludge and municipal wastewater on land has been practiced since time immemorial. The challenge is to utilize the chemical, physical, and biological properties of soil as an acceptor with minimum adverse effects on crops to be grown, soil characteristics, and ground and surface water quality. The capacity of soil to assimilate, treat, and stabilize wastes depends on the soil composition, environmental conditions, and crops to be grown. Wastewater management through land application basically involves renovation of waste, reuse of nutrients and water for biomass generation, return of minerals and water to natural resources, and recharge of ground water.

8.3 PROBLEMS IN WASTEWATER REUSE

The overriding consideration in developing a wastewater reuse system is the compatibility of the reclaimed water with its intended usage. Higher level uses, such as irrigation of public access lands or vegetables to be consumed without processing, require a higher level of wastewater treatment prior to reuse than lower level uses such as pasture irrigation. In urban settlements where there is a high potential for human exposure to reclaimed water used for irrigation, industrial purposes, toilet flushing etc. There must be minimal hazard. Likewise, when treated wastewater is used for agriculture and aquaculture health impacts on farm workers as also bioaccumulation of heavy metals may lead to health hazards. In order to minimize public inhibition to wastewater reuse, the reclaimed water must be colorless and odorless to ensure that it is aesthetically acceptable to the potential users.

There is a grave risk of pathogen transmission through raw domestic wastewater irrigated soils and vegetables due to high concentration of enteric pathogens in raw wastewater. Disease causing pathogens, of concern are bacteria like

Escherichia coli, Salmonella, Shigella, Vibro cholerae Bacillus cereus; viruses like polio virus, hepatitis A virus, Coxsackie virus; helminthes like *Ascaris lumbricoides, Trichuris trichicaura, Ancyclostome deodenal* etc. These organisms survive for 6 to more than 800 days in soil, and 2 to 60 days on plants Further, excessive hydraulic and nutrient loading, pose the problem of water logging, salinization excessive nitrate in the ground water, and imbalance in nutrient uptake causing upset in fruit setting. Problems in wastewater reuse for aquaculture relate to non availability of guidelines for selection of species and stocking density.

8.4 ROLE OF NATIONAL POLICIES IN PROMOTING WASTEWATER REUSE

National policy could be instrumental in:

- Development of National information system for water resources,
- Consideration of drainage basin as planning unit,
- Recycling arid reuse of water to form an integral part of water resources development,
- Periodic re-assessment of ground water potential,
- Exploitation of ground, water not exceeding the recharging possibilities,
- Conjunctive use of Surface and ground water,

8.5 PLANNING ISSUES

Wastewater management in metropolitan cities essentially comprises its collection, treatment and disposal. The traditional approach towards wastewater management is addressed to getting rid of waste without any consideration of the fact that the waste is a misplaced resource and it pragmatic management could result in savings for municipal corporations and municipalities.

Planning of organized wastewater reuse system involves identification of:

- Potential demands for reclaimed water ,
- Existing sources of reclaimed water to determine their potential for reuse,
- Treatment requirements for producing a safe and reliable water that is suitable for intended applications,
- Storage facilities required to balance seasonal fluctuations in demand
- Supplementary facilities required to operate a water reuse system such as

conveyance and distribution networks, operational storage facilities, and alternative disposal facilities,

- Potential environmental impacts of' implementing water reclamation. One of the most critical objectives in any reuse programme is to assure that health protection is not compromised through the use of reclaimed water. Protection of public health could be achieved through:
- Reducing concentrations of pathogenic bacteria, enteric viruses and parasites in the reclaimed water.
- Controlling chemical constituents in the reclaimed water.
- Limiting public exposure (contact, ingestion) to reclaimed water,

Yet another concern that guides design, construction and operation of a reclaimed water distribution system is the prevention of cross connections and improper use or inadvertent use of reclaimed water as potable water. To protect the public health from the outset, a reclaimed water distribution system should be planned, designed and implemented incorporating health codes, procedures for approval and disconnection of service, regulations governing design and construction specifications, inspections, operation and staffing. Accordingly, the planning for wastewater reuse system should:

- Establish that public health is the overriding concern,
- Devise procedures and regulations to prevent cross connections,
- Prevent improper or unintended use of non-potable water,
- Develop a uniform system to mark all non-potable components of the system,
- Provide for routine monitoring and surveillance of the non- potable system,
- Establish special staff responsible for operations, maintenance, inspection, and approval of reuse connections,
- Develop construction and design standards,
- Provide for the physical separation of the potable water, reclaimed water, and sewer lines and appurtenances.

As the construction of reclaimed water transmission and distribution lines to all users would be expensive, a pragmatic approach would be the supply of water to large users in the initial phase and then extending the network to serve more diverse users. The reclamation and reuse of wastewater is more likely to be attractive in newly developing areas where installation of dual distribution mains would be far more economical than in already developed areas.

The risk of pathogens and excessive fertilization can be minimized appreciably, if biologically (primary/secondary) or physicochemical treated wastewater is used with judicious crop selection and appropriate system design. Conventionally technology for treatment of municipal wastewater is solely decided by the minimum capital investment criterion whereas the selection of the most appropriate technology must be based on an agglomerated index of environmental, health and aesthetic risks besides costs.

The methodology for ranking of technology options for the municipal wastewater treatment involves considerations of local conditions such as climate; availability of land, equipment, power, and skilled personnel; facilities for operation and maintenance; and environmental, health and aesthetic risks associated with various feasible alternatives.

8.6 MANAGEMENT ISSUES

Management issues in wastewater reuse relate to the lack of trained manpower and effective public participation. Efficacy of wastewater reuse systems depends on how these systems are maintained. Deficiencies in operating and maintenance of facilities lead to deterioration of systems, unproductive use of investments and exposure of the public at large to health risks. Therefore, the aspect of operation and maintenance needs as much importance, if not more, as the implementation of the systems. The concept of associating qualified, experienced and dedicated personnel in operation and maintenance supported by adequate resources (financial, manpower and material) would go a long way in achieving the objectives. Information is essential for the planning, design, and operation and maintenance of wastewater reuse facilities if programmes are to meet the criteria of cost-effectiveness, simplicity of operation, maintenance and repair, and are to encourage community participation. There is a general agreement that the principal constraint is not the lack of such information but rather failure to disseminate it due to the relegation of its collection and, use to a low priority.

In-service training programme and manpower development should be aimed at upgrading of technical and managerial skills of personnel associated with wastewater reuse programmes. Emphasis should be placed on training of sub-professionals as they would be involved directly in routine operation and maintenance as well as preventive maintenance of these systems. In view of the health risks associated with the wastewater reuse it is necessary to monitor quality of wastewater as also nearby surface and ground water resources. Towards this end, it is necessary to set up water and sewage testing laboratories in all the major cities and towns (population one lakh and above) in the first stage. Once all the above mentioned 'category of cities and towns are covered, small and medium towns may be provided with such facilities in the second stage.

In order to make the wastewater reuse schemes cost effective and financially viable, it is essential to evolve a realistic tariff structure for the system facilities. Realization of revenue through such tariff and taxes should be ensured through proper billing and collection arrangements for full cost recovery. Sharing of capital investments between the State Governments and Local Bodies needs urgent attention. Community participation plays an important role as it creates a sense of belonging and self-reliance in the whole project if the community is taken as a partner in the development programme, and is involved in all the stages of planning, execution, and operation and maintenance. Voluntary agencies can play a very useful and necessary role in ensuring water conservation and promoting wastewater reuse. They could be involved in helping public agencies to share the burden of community level dialogue, motivation and monitoring. They could help in increasing awareness regarding advantages of wastewater reuse.

8.7 WASTE WATER REUSE

The sewage Effluent treated or diluted is generally disposed of by applying to land. How ever, the effluent being used as irrigation water must be made safe. When raw or partly treated sewage is applied on to the land, a part of it evaporation, and the remaining portion percolates through the ground soil. While percolating through the soil, the suspended particles present in the sewage are caught in the soil voids. If proper aeration of these voids is maintained, the organic sewage solids caught in these voids get oxidized by aerobic process. Such aeration is aerobic condition will more likely prevail, if the soil is sufficiently porous and permeable such as sands and porous loams. The degree of treatment required will, however, considerably depend upon the type of the soil of the land. If the soil, to be irrigated, is sandy and porous, the sewage effluents may contain more solids and other wastes, and thus requiring lesser treatment as compared to the case where the soil is less porous and sticky.

The Municipal Wastewaters after pre treatment and further treatment in Waste Stabilization pond, Facultative pond and Maturation pond, the final effluents reuse for agriculture present not only a low cost appropriate disposal medium but also an opportunity to manage wastes with minimum adverse environmental effects as the treatment requirements prior to land application are less rigid than those for disposal in to Water bodies. The application of sewage on land has been practiced since time immemorial. The challenge is to utilize the chemical, physical, and the capacity of soil to assimilate, treat and stabilize wastes depends on the soil composition, environmental condition, and crops to be grown. Biological properties of soil as an acceptor with minimum adverse effects on crops to be grown, soil characteristics, and ground surface water quality.

The Wastewater management through land application basically involves renovation of wastes, reuse of nutrients and water for biomass generation, return of minerals and water to natural resources, and recharge of ground water. Many of the researchers pointed out that sewage effluent is very good sources of irrigation for vide range of crops. But their suitability depends on the metal concentrations that are toxic in the food chain.

8.8 NEED FOR WASTEWATER REUSE IN AGRICULTURE AND FORESTRY

The wastewater treatment processes developed during 1850-1815 and are widely used today viz. trickling filter, activated sludge, extended aeration, etc. proved to be highly efficient, and more reliable for adoption in resolving the wastewater treatment problem. However, the in plant treatment of wastewater using sophisticated treatment technologies are energy and cost intensive processes, and beyond the reach of developing countries. Further, the discharge of treated wastewater in the river creates the problem of eutrophication due to presence of appreciable amount of nitrogen and phosphorus in the treated wastewater. The appropriate solution to resolve the wastewater disposal problem with resource recovery relies on the adoption of disposal of wastewater on land for crop irrigation. The assimilative capacity based land application system promotes treatment of wastewater through Nature's own treatment process, recycling and reuse of wastewater through crop irrigation, conversion of nutrient energy into biomass and provide exploitation of food, fuel and fodder production beside ecorestoration. The 5R concept of wastewater management, recycling and reuse, and ecorestoration is as follows:

1. Renovation of wastewater by exploiting the degration and renovative potential of soil eco-system.
2. Reuse of nutrient energy into food grain and biomass,
3. Replenishment of mineral and water excavated from natural earth resource,
4. Return of the renovated wastewater to ground water resource for future use,
5. Restoration of land.

8.9 AGRONOMIC AND ECONOMIC BENEFITS OF WASTEWATER USE

Scientifically designed and planned use of domestic wastewater based on soil-plant assimilative capacity alleviates surface water pollution problems. It not only conserves valuable water resources but also takes advantage of the nutrients contained in wastewater to grow crops. The nitrogen, phosphorus and potassium content in domestic wastewater reduce or eliminate the requirements for chemical fertilizers. It is generally accepted that wastewater use in agriculture and agro forestry justified on agronomic, economic grounds and environment, but care must be taken to minimize adverse health and environmental impacts.

8.10 WASTEWATER TREATMENT AND RESOURCE CONSERVATION THROUGH CROP IRRIGATION

Wastewater management through land application basically involves renovation of waste, reuse of nutrients and water for biomass generation, return of minerals and water to natural resources, and recharge of ground water.

During land treatment, soil and its associated ecosystem components act as a physico-bio-chemical reactor capable for treating or stabilizing the pollutants of solid and/or liquid origin through degradation, adsorption, precipitation and utilization by crops. The soil mantle acts as a biochemical reactor. Wastewater while passing through the soil matrix provides filtration on the soil surface leading to removal of coarse particles (primary clarifier). The degradation of soluble material while moving through the soil profile by bacterial action in relation with mixing and aeration extended by macro soil habitat represent waste treatment process as occurring in the aeration tank. Removal of assimilable nitrogen, phosphorus, potash and micronutrients through plant utilization resembles the tertiary waste treatment. The effluent from soil reactor is subjected to final polishing renovation for metal removal through adsorption and ion-exchange and precipitation with hydroxides and carbonate indicates reaction process as occurring in secondary clarifier, ion exchange, carbon adsorption and disinfection leading to purification via land treatment.

8.11 QUALITY PARAMETERS FOR WASTEWATER USE IN AGRICULTURE AND FORESTRY

The quality of irrigation water is of utmost importance in arid zones where extremes of temperature and low relative humidity result in high rates of evaporation, with consequent deposition of salt which tends to accumulate in the soil profile. The physical and mechanical properties of the soil, such as dispersion of particles, stability of aggregates, soil structure and permeability, are very sensitive to the type of exchangeable ions present in irrigation water. Hence, when wastewater use is being planned, several factors related to soil properties must be taken into consideration. Wastewater quality parameters of importance from an agricultural viewpoint are:

8.12 TOTAL DISSOLVED SOLIDS

Total Dissolved Solids (TDS) in the wastewater significantly effect the growth of plants. Dissolved salts increase the osmotic potential of soil water. Increase in osmotic pressure of the soil solution increases the amount of energy which plants must use to take up water from the soil. As a result, respiration is increased and the growth and yield of plants decline progressively as osmotic pressure increases.TDS concentration is expressed in milligrams per litre (mg/l) or parts per million (ppm).

8.12.1 Electrical Conductivity

Electricity conductivity indicates the total ionized constituents of water. It is directly related to the sum of the cations (or anions), and is closely related with the TDS. Electrical conductivity is a rapid and reasonably precise determination and values are always expressed at a standard temperature of 25°C to enable comparison of readings taken under varying climatic conditions. The electrical conductivity of solutions increases approximately 2 per cent per °C increase in temperature. Mostly, the symbol ECw is used to represent the electrical conductivity of irrigation water and the symbol ECe is used to designate the electrical conductivity of the soil saturation extract. The unit of electrical conductivity is deciSiemen per metre (dS/m).

8.12.2 Sodium Adsorption Ratio

Sodium is a unique cation because of its effect on soil. When present in the soil in exchangeable form, it causes changes soil structure. It has the ability to disperse soil, when present above a certain threshold, value, relative to the concentration of total dissolved salts. Dispersion of soils results in reduced infiltration rates of water and air into the soil. When dried, dispersed soil form crusts which are hard to till and interfere with germination and seedling emergence. Irrigation water could be a source of excess sodium in the soil solution and hence it should be evaluated for this hazard.

The most reliable index of the sodium hazard of irrigation water is the sodium adsorption ration, SAR. The Sodium adsorption ratio is defined by the formula:

$$SAR = \frac{Na}{\sqrt{\frac{Ca+Mg}{2}}}$$

Where the ionic concentrations are expressed in mg/l.

8.12.3 Toxic Ions

Irrigation water may contains certain ions at concentrations above threshold values can cause plant toxicity problems. Toxicity normally results in impaired growth, reduce yield, changes in the morphology of the plant and even its death. The degree of damage depends on the crop, its stage of growth, the concentration of the toxic ion, climate and soil conditions. The most common phytotoxic ions that may be present in municipal sewage and treated effluents are: boron (B), chloride (Cl) and Sodium (Na). Hence, the concentration of these ions will have to be determined to assess the suitability of waste water quality for use in agriculture.

8.12.4 Trace Elements and Heavy Metals

A number of elements are normally present in relatively low concentrations, usually less than a few mg/l, in conventional irrigation waters and are called trace elements. They are not normally included in routine analysis of regular irrigation water, but if sewage effluents contaminated with industrial wastewater discharges are suspected their attention should be paid to them. These include Aluminium (Al), Beryllium (Be), Cobalt (Co), Fluoride (F), Iron (Fe), Lithium (Li), Manganese (Mn), Molybdenum (Mo), Selenium (Se), Tin (Sn), Titanium (Ti), Tungsten (W) and Vanadium (V). Heavy metals are a special group of trace elements which have been shown to create definite health hazards when taken up by plants. Under this group are included. Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu) Lead (Pb), Mercury (Hg) and Zinc (Zn). These are called heavy metals because in their metallic form, their densities are greater than 4g/cc.

8.12.5 pH

pH is an indicator of the acidity or alkalinity of water. The normal pH range for irrigation water is from 6.5 to 8.4; pH values outside this range are a good warning that the water is abnormal in quality. Normally, pH is a routine measurement in irrigation water quality assessment.

8.12.6 Parameters of Human Health Significance

The present of organic chemicals, heavy metals, and enteric pathogens are of special significance with regard to health risk to farm workers and consumers. The principal health hazards associated with the chemical constituents of wastewaters, therefore, arise from the contamination of crops or leaching of pollutants and its subsequent use for human consumption ground waters. These guidelines directly can be considered for groundwater protection purposes but, in view of the possible accumulation of certain toxic elements in plants the intake of toxic materials through eating the crops irrigated with contaminated wastewater must be carefully assessed.

8.12.7 Coliforms and Faecal Coliforms

The Coliforms group of bacteria comprises mainly species of the genera Citrobacter, Enterobacter, Escherichia and Klebsiella and includes Faecal Coliforms, of which Escherichia coli is the predominant species. Coliforms are unsuitable as a parameter for monitoring wastewater reuse system because several of them are able to grow outside of the intestine, especially in hot climates. The Faecal Coliform test also includes some non-faecal organisms which can grow at 44.C, so the *E. coli* count is the most suitable indicator parameter for wastewater use in agriculture.

8.12.8 Faecal Streptococci

This group of organisms includes species mainly associated with animals (Streptococcus bovis and S equinus), other species such as S.faecallis and S.faecium with a wider distribution occur both in man and in other animals reported to be present in both polluted and non-polluted environments. The enumeration of Faecal Streptococci in effluents is a simple routine procedure but possible presence of the non- faecal bitotypes as part of the natural micro flora on crops may detract from their utility in assessing the bacterial quality of wastewater irrigated crops; and the poorer survival of faecal streptococci at high than at low temperature.

8.12.9 Clostridium Perfringens

This bacterium is an exclusively faecal spore-forming anaerobe normally used to detect intermittent or previous pollution of water, due to the prolonged survival of its spores. Although this extended survival is usually considered to be a disadvantage for normal purposes, it may prove to be very useful in wastewater reuse studies, as Clostridium perfringens may be found to have survival characteristics similar to those of viruses or even helminthic eggs .The following pathogenic parameters can only be considered to assess the pathogen pollution due to wastewater irrigation.

8.12.10 Salmonella

In a tropical developing country several species of Salmonellae may be present in raw sewage from an urban community, including S.typhi and many others. It is estimated (Doran et al., 1877) that an approximate count of 7000 Salmonellae/litre and 800 Vibrio cholera/ litre is typical in a tropical urban sewage. Both Shigella spp and V. cholera are more rapidly killed than Salmonellae in the environment, so the removal of Salmonellae ensures removal of other bacterial pathogens.

8.12.11 Enterouiruses

This group of viruses causes diseases, such as Poliomyelitis and Meningitis, or a range of minor illnesses such as respiratory infections. Although there is no strong epidemiological evidence for the spread of these diseases via sewage irrigation systems, there is some risk and it is desirable to know to what extent viruses are removed by existing and new treatment processes, especially under tropical conditions viruses are removed by existing and new treatment processes, especially under tropical conditions.

8.12.12 Rotaviruses

These viruses are known to cause gastro-intestinal problems and, usually present in lower number than enteroviruses in sewage. They are known to be more persistent in the environment, so it is necessary to establish their survival characteristics relative to enteroviruses and relative to the indicator organisms in wastewaters. Removal of viruses in wastewater treatment occurs in parallel with the removal of suspended solids, as most virus particles are solids-associated. Hence, the measurement of suspended solids in treated effluents should be carried out as a matter of routine.

8.12.13 Intestinal Nematodes

Nematode infections, in particular from the roundworm Ascaris lumbricoides, can be spread by effluent reuse practices. The eggs of A. lumbricoides are fairly large (45-70 Jim x 35-50 11m) and several techniques for enumeration of nematodes have been developed.

Table 8.1: Recommended Doses for Farming In India

Type of soil	Doses of Sewage in Cubic metres per Hectares per Day	
	Raw Sewage	Settled Sewage
Sandy	120-150	220-280
Sandy loam	80-80	170-220
Loam	60-80	18-170
Clayey loam	40-50	60-18
Clayey loam	30-45	30-60

Table 8.2: Land Utilization in Hectares

Category		03-04	
		Area	**%**
1.	Forests	21,22,041	16.3
2.	Barren and uncultivable land	5,08,378	3.8
3.	Land put to non-agricultural uses	21,13,353	16.2
4.	Cultivable waste	3,78,438	2.8
5.	Permanent pastures and other grazing lands	1,13,474	0.8
6.	Misc. tree crops and groves not included in the net area sown	2,82,880	2.2
7.	Current fallow	8,53,863	7.3

8.	Other fallow lands	18,62,861	14.3
8.	Net area sown	46,88,156	36.0
Total Geographical area		**1,30,26,645**	**80.0**
Area sown more than once		**6,26,871**	**4.8**
Gross area sown		**53,16,027**	**40.8**

(Source Govt. of Tamilnadu-2004)

8.13 WASTEWATER UTILIZATION SCHEMES UNDER THE CENTRAL SECTOR PROGRAMME (18741878)

In Tamil Nadu under Wastewater Utilization Scheme 201.82 MLD of urban wastewater is used for Effluent irrigation for 5384.4 Hectares. These farms are mostly disposal oriented rather than utilization. The Tamil Nadu Agricultural University, Coimbatore made study and investigation to assess the suitability of sewage effluents from various districts of Tamil Nadu for land irrigation. Based on the recommended limits of the effluent for irrigation on land, the quality of the sewage effluent collected from various

Districts of Tamil Nadu were assessed. The result indicated that, the effluent has very good nutritive value besides having a suitable pH, soluble salts, $N0_3$-N, $S0_4$ content etc irrespective of population differences and districts. Hence the Effluents can be used for crop production after proper treatment or under correct dilution. But the negative point to be considered with the effluents of all the places for land irrigation was their Biological Oxygen Demand, [BO.D], residual sodium carbonate and the heavy metal load. In Tamilnadu there are 25 class-1 cities having population 1,00,000 and above, 42 Class-2 towns having population 50,000-88,000 and 71 class-3 towns having Population 20,000 –48,800. The wastewaters generated by the above towns are 865 MLD, 702 MLD, and 162 MLD respectively.

Table 8.3: Status of Sewage utilized for Agriculture

S.No	Town	Sewage handled in MLD	Used for Agriculture in MLD	Area coverage in Hectares
1	Chennai	1750.00	22.00	68.30
2	Madurai	363.00	20.00	213.00
3	Coimbatore	45.00	4.50	35.40
4	Trichy	15.00	1.50	6.00
5	18 municipalities	228.00	22.80	171.00
	Total	2402.00	70.80	484.70

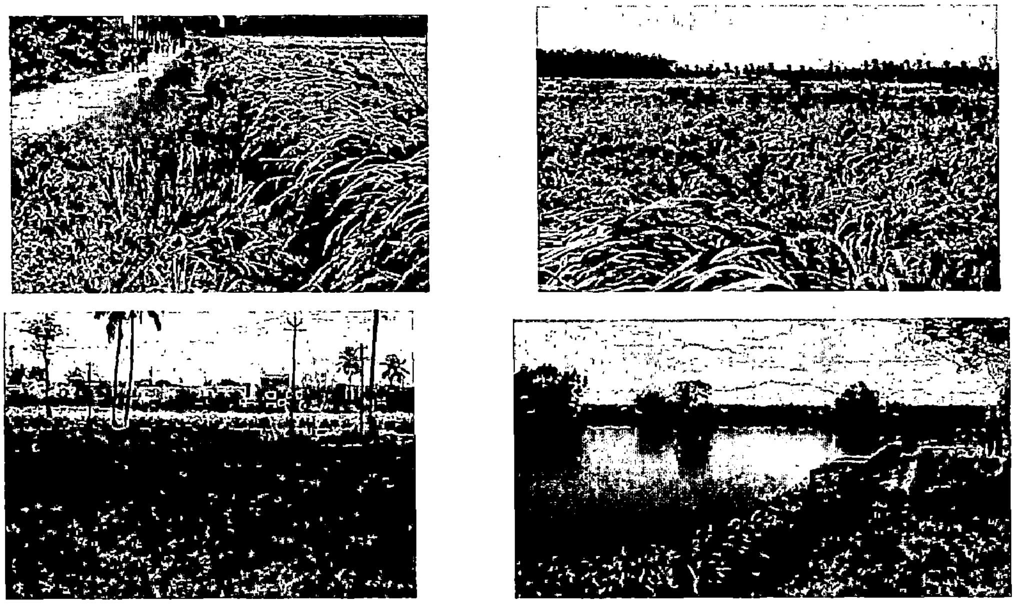


Figure 8.1; 8.2; 8.3; 8.4: Sewage farm and waste stabilization pond -Coimbatore Corporation, Tamil Nadu

Table 8.4: Present Status of Sewage Farms in Tamil Nadu

S.No	City	Sewage handled in MLD	Used for Agriculture in MLD	Area coverage in Hectares	Used for Agriculture in MLD	Area coverage in Hectares	Sewage Farm control
1	Chennai	1750.00	22.00	68.30	22.00	68.30	Corporation
2	Madurai	363.00	20.00	213.00	20.00	213.00	Corporation
3	Coimbatore	45.00	4.50	35.40	4.50	35.40	Corporation
4	Trichy	15.00	1.50	6.00	1.50	6.00	Corporation
5	18 municipalities	228.00	22.80	171.00	22.80	171.00	Municipality

Table 8.5: Control of Sewage Farms in Tamil Nadu

S.No	City	Sewage farm control	Crops grown
1	Chennai	Corporation	Guinea Grass
2	Madurai	Corporation	Para Grass, Coconut
3	Coimbatore	Corporation	Para Grass, Guinea Grass
4	Trichy	Corporation	Guinea Grass, Co 1 Grass
5	18 municipalities	Municipality	Para Grass, Guinea Grass

8.14 WATER QUALITY CRITERIA FOR WASTEWATER REUSE FOR AGRICULTURE AND FORESTRY

In the past wastewater treatment was considered to be the major control measure in controlled effluent use schemes, with crop restriction being used in a few notable cases. A more integrated approach to the planning of wastewater use in agriculture requires optimal combination of the health protection measures available and any soil/plant constraints in arriving at an economic system suited to the local sociocultural conditions.

Health protection measures which can be applied in agricultural use of wastewater include the following, either singly or in combination.

- Wastewater treatment
- Crop restriction
- Control of wastewater application
- Human exposure control and promotion of hygiene

The integration of the various measures must be adopted. To achieve effective health protection but limitations of the administrative or legal systems make some of these approaches difficult to implement.

8.15 WATER QUALITY GUIDELINES FOR IRRIGATION AND EVALUATION OF POTENTIAL HAZARDS

1 Salinity

The presence of excessive soluble salts affects the availability of water to crops due to osmotic pressure differences. The salinity effect is manifested through stunted growth, plants with smaller leaves and reduction in crop yield. Salinity of irrigation water is expressed as electrical conductivity (EC) and measured in "mS/cm.

2. Sodicity

The amount of sodium in relation to calcium and magnesium exhibit the Sodicity problem. Deterioration of soil structure, reduction in soil permeability arid imbalance in mineral nutrition problem is expressed through sodium adsorption ratio (SAR) and adjusted sodium adsorption ratio (SAR ad) when the alkalinity due to C03 and HC03 are very high.

3. **Specific Ion Toxicity**

Specific ion effect relates to the presence of chloride, boron and heavy metals. The effect is generally indicated by leaf burn, necrosis and defoliation. In addition to above, in the case of industrial wastewater, parameters like biochemical oxygen demand, chemical oxygen demand and colour need special consideration.

8.16 CHARACTERISTICS FOR PRO'TECTION OF PUBLIC HEALTH

Microbiological quality guidelines for wastewater use in agriculture to avoid health risk are shown in Table 3.2. These guidelines are based on the consensus view that the actual risk associated with irrigation with treated wastewater is much lower. The new guidelines are stricter than previous standards (WHO, 1873) in respect of the requirement to reduce the numbers of helminth eggs *(Ascaris* and *Trichuris* species and hookworms) in effluents for Category A and B conditions to a level of not more than one per litre and same is implied to the protozoan cysts. Although no bacterial pathogen limit is imposed for Category C conditions but it is felt that some degree of reduction in bacterial concentration is recommended for any effluent use situation.

Table 8.6: Guidelines for Interpretation of Water Quality for Irrigation

Potential irrigation	**Units**	**Degree of Restriction on Use**		
Problem		None	Slight to	Severe
			Moderate	
Salinity				
ECw 1 or	dSlm	<0.7	0.7-3.0	>3.0
TDS	mg/l	<450	450-2000	>2000
Infiltration				
SAR2 = 0 - 3 and ECw		>0.7	0.7-0.2	<0.2
3-6		>1.2	1.2-0.3	<0.3
6-12		>1.8	1.8-0.5	<0.5
12-20		>2.8	2.8-1.3	<1.3
20-40		>5.0	5.0-2.8	<2.8
Specific ion toxicity				
Sodium (Na)				
Surface irrigation	SAR	<3	3 - 8	>8

Sprinkler irrigation	me/l	<3	>3	
Chloride (Cl)				
Surface irrigation	me/l	<4	4 - 8	>8
Sprinkler irrigation	m3/l	<3	>3	
Boron (B)	mg/l	<0.7	0.7-3.0	>3.0
Trace Elements (see table)				
Miscellaneous effects				
Nitrogen (N03 - N)3	mg/l	<5	5 - 30	>30
Bicarbonate (HC03	me/l	<1.5	1.5-8.5	>8J>
pH				

The WHO Scientific Group considered the new approach to effluent quality would increase public health protection in areas where crops eaten uncooked and are being irrigated in an unregulated, and often illegal, manner with raw wastewater. The need to interpret the guidelines can be modified in the light of local epidemiological, sociocultural and environmental factors.

The effluent quality guidelines in Table 3.2 are intended as design goals for wastewater treatment systems, rather than standards requiring routine testing of effluents. Besides microbiological quality requirements of treated effluents used in agriculture, attention must also be given to those quality parameters of importance in respect of groundwater contamination and of soil structure and crop productivity.

Table 8.7: Recommended Microbiological Quality Guidelines for Wastewater Use in Agriculture

Category	Reuse condition	Exposed group	Intestinal nematodes (arithmetic mean no. of eggs per lit)	Faecal Coliforms (geometric mean per 80 ml	Waste water treatment expected to achieve the required microbiological quality
A	Irrigation of crops likely to be eaten uncooked, sports public fields public parks	Workers consumers public	<1	<800	A series of stabilization ponds designed to achieve the micro biological quality indicated or equivalent treatment
B	Irrigation of cereals Crops, industrial crops, fodder crops pasture and trees.	Workers	<1	No standard recommended	Retention in stabilization ponds for 8 to 8days or equivalent helminth and faecal coliform removal

C	Localized irrigation of crops in category B if exposure of workers and the public does not occur	None	Not applicable	Not applicable	Pretreatment as required by the irrigation technology, but less than primary sedimentation

A. In specific cases, local epidemiological, socio-cultural and environmental factors should be taken into account, and the guidelines modified accordingly

B. Ascaris and Trichuris spp. and hookworms

C. During the irrigation period

D. A more stringent guideline is appropriate for public lawns, such as hotel lawns, with which the public may come into direct contact

E. In the case of fruit trees, irrigation should cease two weeks before fruit is picked, and no fruit should be picked off the ground. Sprinkler irrigation should not be used Source: WHO (1888)

8.17 CONTROL OF HUMAN EXPOSURE

The objective of human exposure control is to prevent the population groups at risk from coming into direct contact with pathogens in the wastewater or to prevent any contact with the pathogens leading to disease. Four groups are identified at risk in agricultural use of wastewater:

- Agriculture workers and their facilities
- Crop handlers
- Consumers of crops, meat and "milk
- Those living near the areas irrigated with wastewater

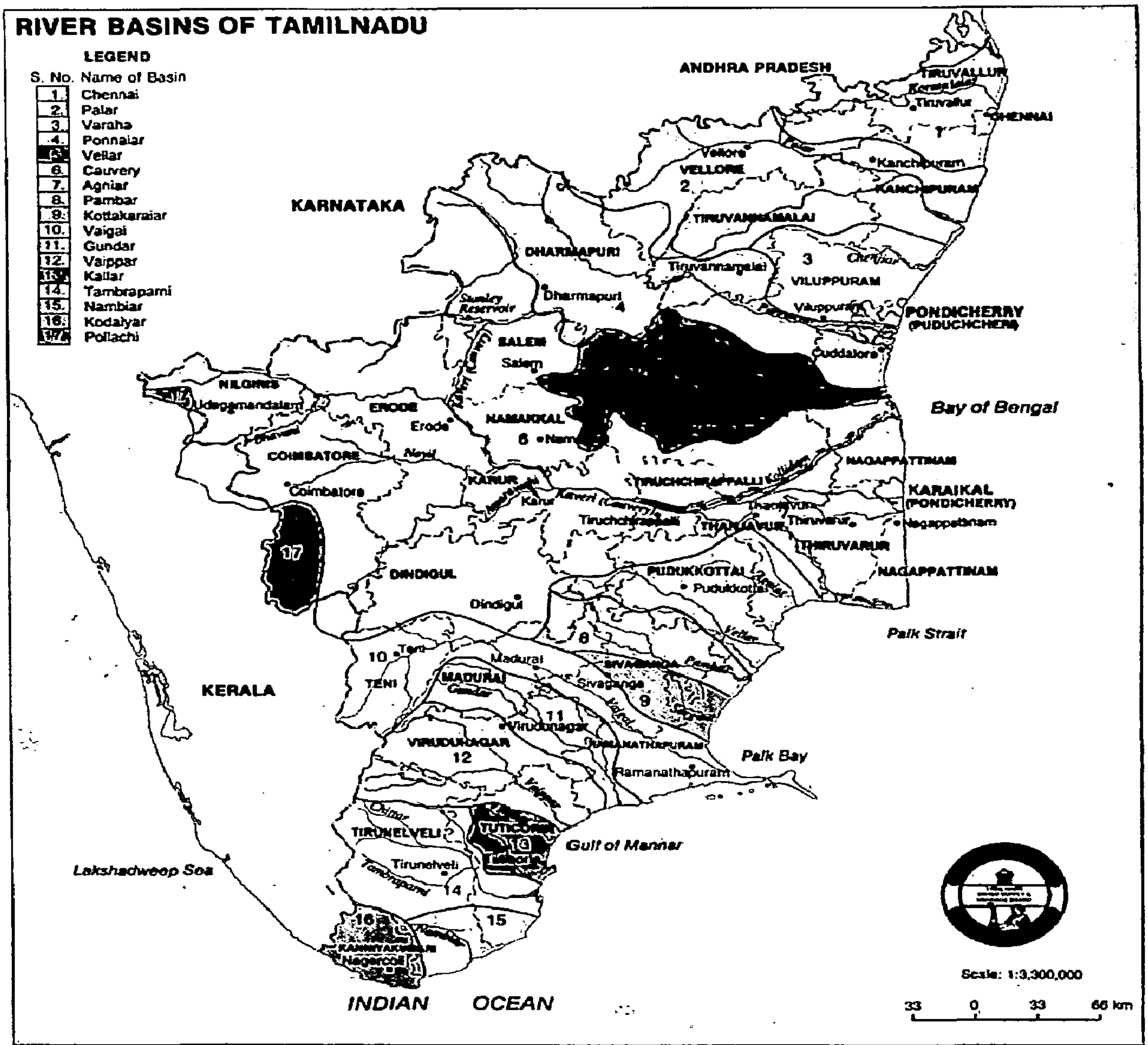
8.18 STATUS OF WASTE WATER POLLUTION TO RIVER CAUVERY

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 Cauvery River basin. In the study area from Mettur dam to Erode stretch 25 Million cubic metres of waste water have been generated per annum respectively from Six urban areas.[Table---]The facilities for waste water collection is totally Nil. The existing treatment facilities treat only 35.11MLD or 12.815 Million cubic metres of generated wastewater only 51.26% of the waste water and also mostly up to primary level and to some extent to secondary level before discharging to River Cauvery.

The nutrient value of 25 Million Cubic Meters of available Wastewater per annum is estimated to be equal to 15000 M.Tonnes of Nitrogen, 500 M.Tonnes of Phosphates and 800 M. Tonnes of Pottash. The economic value is worked out to be around Rs.27 Million per annum. If all the wastewater is collected and treated to desired levels, 858 Hectares of Land [Table 8.8] can be brought under irrigation in the study area.

Table 8.8: Study Area Urban Effluent Details

S.No	Town	Population	Ultimate population	Length of Roads	Present Effluent Quantity in MLD	Existing Treatment Facilities in MLD	Existing Treatment Technology	Quantity of Treated Effluent in MLD
1	Mettur	53633	80000	68.6	6.4	0		0
2	Bhavani	38645	80000	27.37	5	3.84	W.S.P	0
3	Komorapalayam	65868	84000	122.18	7	6	W.S.P	6
4	Erode	151184	345000	118.67	40	25.17	W.S.P	20
5	Veearpan chattram	72703	85000	54.54			U.A.S.B	5.17
6	Pallipalayam	52000	80000	40.07	8	0		0
	Total	434033	804000	432.43	68.4	35.11		31.17



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	4.55	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.	Kottakaraiar	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	600	1.04	69
14.	Tambrapami	5482	1110	6.09	744
15.	Nambiar	1561	950	1.48	275
16.	Kodaiyar	1533	1720	2.64	342
17.	Pollachi	2174	610	1.33	751
	Total	130369	–	122.73	–

Figure 8.5: River Basins of Tamil Nadu

8.19 SOIL QUALITY EVALUATION FOR WASTEWATER FOR IRRIGATION

The beneficial or harmful effects of using effluents for irrigating crops depends on complex physical, chemical, and biological interactions between the effluent, the soil/subsoil complex, the groundwater, and the crops being grown.

Measuring or estimating these interactions would be difficult enough but in most cases the situation is not static. Unlike normal irrigation water, the composition of the effluent may change daily, reflecting the normal process variations that occur in any mill. To some degree, though, treatment systems tend to dampen short term fluctuations.

The soil characteristics certainly do not change as rapidly, but they may vary significantly over a small area, meaning that many soil types must be checked for suitability. Cropping patterns also change as farmers make economic decisions about which crops to plant in a given year.

The environmental impacts of wastewater irrigation can be quantified only after ascertaining the horizontal and vertical conductivity of the soil. Infiltration of the applied wastewater may be slow or rapid depending upon the topography of the land and hydraulic properties of the soil. It is important therefore, to estimate the physical, chemical and microbiological properties of soil.

CHAPTER-9

SOLID WASTE MANAGEMENT

9.1 MUNICIPAL SOLID WASTE MANAGEMENT

The Municipal Solid Wastes (Management & Handling) Rules, 2000 (MSW Rules) are applicable to every municipal authority responsible for collection, segregation, storage, transportation, processing and disposal of municipal solid wastes.

The Rule contains four Schedules namely

Table 9.1: Municipal Solid Waste Management Schedule

S.No	Schedule	Relates to
1	Schedule-I	Relates to implementation Schedule
2	Schedule-II	Specifications relating to collection, segregation, storage, transportation, processing and disposal of municipal solid waste wastes (MSW).
3	Schedule-III	Specifications for land filling indicating; site selection, facilities at the site, specifications for land filling, Pollution prevention, water quality monitoring, ambient air Indicate waste processing options including; standards for composting, treated leachates and incinerations r quality monitoring, Plantation at landfill site, closure of landfill site and post care.
4	Schedule-IV	Indicate waste processing options including; standards for composting, treated leachates and incinerations

Table: 9.2 Authorities and Responsibilities

S.No	Authorities	Responsibilities.
1	Municipal Authorities	i. Ensuring that municipal solid wastes to be handled as per rules. ii. Seeking authorization from State Pollution Control Board (SPCB) for setting up waste processing and disposal facility including landfills. iii. Furnishing annual report. iv. Complying with Schedule I, II, III and IV of the rules.
2	**State Government** Secretary In-Charge of Department of Urban Development District Magistrates/ Deputy Commissioner	Overall responsibility for the enforcement of the provisions of the rules in the metropolitan cities. Overall responsibility for the enforcement of the provisions of the rules within the territorial limits of their jurisdiction.
3	Central Pollution Control Board (CPCB)	i. Co-ordinate with State Boards and Committees with reference to implementation and review of standards and guidelines and compilation of monitoring data. ii. Prepare consolidated annual review report on management of municipal solid wastes for forwarding it to Central Government along with its recommendations before the 15th of December every year. iii. Laying down standards on waste processing/ disposal technologies including approval of technology.

4	State Pollution Control Board (SPCB)	i.	Monitor the compliance of the standards regarding ground water, ambient air leachates quality and the compost quality including incineration standards as specified under Schedule II, III & IV.
		ii.	Issuance of authorization to the municipal authority or an operator of a facility stipulating compliance criteria and standards.
		iv.	Prepare and submit to the CPCB an annual report with regard to the implementation of the rules.

Some of the local bodies have taken initiatives to improve management practices relating to collection, segregation, storage and transportation of waste. Such efforts are restricted to either a few wards/ area or for entire town. Waste Processing and Disposal Many of the cities and towns have taken initiatives to set-up waste processing and disposal facilities.

9.2 METHANE EMISSION FROM MSW DISPOSAL SITES

Most of the waste disposal sites in the country are uncontrolled dumps. These sites are constant threat to ground water contamination and emit several gases including methane. Organic matter content in the deposited MSW at the landfill site tends to decompose anaerobically leading to emission of volatile organic compounds and gaseous by products. Emission of gaseous products from landfills

9.3 CHARACTERIZATION OF COMPOST QUALITY AND ITS APPLICATION IN AGRICULTURE.

Studies indicated that average concentration of heavy metals in the raw waste that was fed to the various compost plants was in the range of 47 to 185 mg per kg in respect of lead, 36-63 mg/kg for nickel and 1.5 to 6.5 mg/kg for cadmium. The levels of mercury in raw waste were between 0.01 and 0.23 mg/kg. Heavy metals in the finished compost were ranging as follows; Pb; 98-203 mg/kg; ni- 8-80 mg/kg; cd-3.8-12.4 mg/kg and mg – 0.01-0.31 mg/kg.

9.4 SOURCE OF GROUNDWATER POLLUTION

The sources of groundwater pollution are many and varied. Pollution by disease causing micro organisms occur when human and animal waste containing virus, bacteria and parasites come into contact with groundwater. Chemical pollutants can leach into groundwater from a variety of sources including hazardous waste dumps, sewage, land-treatment sites, injection wells, indiscriminate solid waste disposal, and percolation of pesticides and fertilizer from agricultural field and accumulation of industrial waste water on land. In the study area out of six towns the solid waste management collection status is only90 percentages. Table 3 .The balance 9 percentages have accumulated in the low laying areas and road sides. In a year nearly 7500 Tonnes are accumulated in various places. During rainy and flood season, the accumulated solid wastes get leaching and it contaminates ground water as well as Cauvery River. The compost yards dumped solid wastes also leaches and pollute the ground and surface water. It should be prevented by making secured land fill sites.

Table 9.3 : Details of Solid Waste Collection & Disposal

S.No	Town	Population	Waste generated	Waste collected	Method of disposal
1	Mettur	53633	15.00 M.T	13.00M.T	Dumping
2	Bhavani	38645	13.00M.T	9.50M.T	Dumping
3	Komorapalayam	65868	25.00 M.T	22.00M.T	Dumping
4	Erode	15984	95.00 M.T	90.00M.T	Dumping
5	Veearpan chattram	72703	28.00M.T	22.00M.T	Dumping
6	Pallipalayam	52000	15.00 M.T	12.00M.T	Dumping
	Total	434033	201.00M.T	180.50M.T	Dumping

9.5 IMPACT OF GROUNDWATER POLLUTION

The severity of groundwater pollution is of particular significance on account of the following:

1. Its vulnerability to pollution;
2. The associated complexity in pollution source identification;
3. Limited feasible options for treatment of groundwater, all of which are cost prohibitive;
4. Complicated process in fixing geophysical boundaries;

5. Difficulty in prediction of movement;
6. Insufficient dilution;
7. Slow movement;
8. Lack of any natural cleansing capability;

Moreover, in most of cases where Groundwater is observed polluted, the area is densely populated and as commonly seen, there is no immediate fresh water substitute available at such locations.

A variety of adverse impacts due to Groundwater contamination is possible - including effects on public health, the environment, agricultural productivity (e.g. due to increased salinity in irrigation water) and on the out put of industries requiring high quality water. Until recently one of the major reasons for the critical status of Groundwater pollution is a common myth that groundwater is pristine i.e. potential contaminant percolating through the subsurface would adhere to the soil or be degraded by natural process and therefore would not enter or greatly affect Groundwater quality. Thus the Groundwater had been regarded as a safe and convenient depository for the waste and non-waste by-products, generated by the society. However, with the passage of time and increasing number of serious incidences, there is a growing concern of Groundwater pollution. Its impact can be appreciated by categorizing the type of contaminants usually observed in Groundwater

9.6 BIOLOGICAL CONTAMINANTS

Pathogenic biological organisms that have been found in groundwater include

1. Bacteria
2. Viruses (e.g. Entero-viruses and hepatitis)
3. Parasites (e.g. Protozoa, worms and fungi)

The potential for bacterial contamination of groundwater depends on both the survival rate of the species and characteristics of the sub-surface eg. Moisture content, pH and temperature. Bacterial contamination most commonly result from the introduction of human (or animal) fecal material usually when septic tanks or cess pools leak or over flow. The most common pathway for organic compounds to reach groundwater is through excessive use of pesticides and herbicides and indiscriminate burial of their containers. Some of the commonly observed organic compounds in groundwater are aldrine, lindane, methoxychlor, toxaphene, DDT, trichloroethylene, carbon tetrachloride, tetrachloro ethylene etc. Almost all the above compounds are known to promote/cause carcinogenicity and their severity depends upon the extent and scale of exposure.

9.7 MONITORING OF GROUNDWATER QUALITY

In general, monitoring of groundwater quality involves collection of representative sample and simultaneous collection of hydro-geological information about the sampling location. The sample and hence the groundwater quality data may adversely affect if one or more of the following factors are not appropriately looked into.

a) Sample was taken from stagnant water in the open well or suddenly in case of bore well without removing the casing storage effect. The error can be largely overcome if 3 to 9 well-bore volumes are removed and in case of hand pumps-sufficient water is pumped out before taking the sample.

b) Samples are not taken at appropriate time intervals-seasonally and at improper locations.

c) Contamination due to entrained sediment.

d) Hydraulic characteristics of the (soil) formation near the screen, resulting in possible dilution of the contaminant.

e) Release of carbon-di-oxide during pumping and hence increase in pH which may cause many metallic ions to come out of solution.

f) The samples preservation is not properly done and analyzed without considering the parameter- specific prescribed period of retention.

9.8 GROUNDWATER PROTECTION

Contamination of Groundwater is more complex than surface water pollution mainly because of difficulty in its timely detection and slow movement, which requires special expertise to predict the path and rate of Groundwater movement. In addition the complex geo-chemical reactions taking place in the subsurface.

Table 9.4 : Compost Yard Details

S.No	Town	Population	Solid Waste generated	Length of Roads	Solid Waste collection	Compost yard area in Acres	Method of disposal	Compost yard area in Acres
1	Mettur	53633	15.00 M.T		13.00M.T	43..72	Dumping	43..72
2	Bhavani	38645	13.00M.T	27.37	9.50M.T	9.01	Dumping	9.01
3	Komorapalayam	65868	25.00 M.T	122.18	22.00M.T	0	Dumping	0
4	Erode	15984	95.00 M.T	98.67	90.00M.T	19.42	Dumping	19.42
5	Veearpan chattram	72703	28.00M.T	54.54	22.00M.T	2.4	Dumping	2.4
6	Pallipalayam	52000	15.00 M.T	40.07	12.00M.T	2.1	Dumping	2.1
	Total	434033	29.00M.T	432.43	180.50M.T	33.93	Dumping	33.93

Table 9.5: Compost Yard Solid Waste Disposal Details

S.No	Town	Additional Quantity of Solid Waste to be collected	Total Quantity of Solid Waste to be Disposed off in MLD	Ultimate Quantity of Solid Waste to be Disposed off in MLD
1	Mettur	2	15.00 M.T	22.5
2	Bhavani	1.5	13.00M.T	19.5
3	Komorapalayam	3	25.00 M.T	37.5
4	Erode	15	95.00 M.T	172.5
5	Veearpan chattram	6	28.00M.T	42
6	Pallipalayam	3	15.00 M.T	22.5
	Total	30.5	29.00M.T	316.5

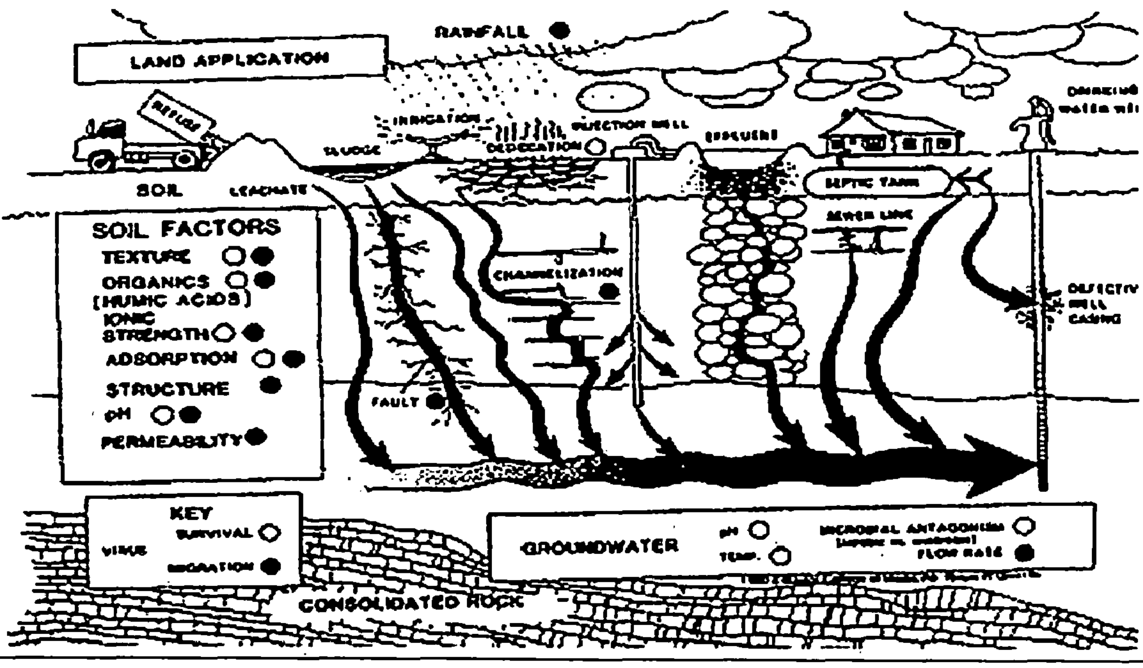


Figure 9.1: A Typical Groundwater Modeling Sequence

Between myriad contaminants and earth materials are not always well-understood. Ideally speaking contamination should be prevented from occurring. After a contaminant or several contaminants are found in groundwater, a decision must be made on whether to rehabilitate the aquifer or find alternative groundwater resources.

TWAD Lab. Erode
Result of Examination of Water Samples

Table 9.6 STP Works at Lakkapuram- 20MLD - W.S around STP 1km Radius

S.No	Location	Source	Turbidity	EC	TDS	NO_3	COD	BOD
1.	Balusamy Nagar	BW	5	1288	901	13	8	1.80
2.	Solar Pudur	BW	7	209	1407	98	8	2.6
3.	C.S.I Colony	BW	4	1491	943	54	12	2.8
4.	C.S.I Colony	BW	6	1728	1209	50	4	1.8
5.	Solar Pudur	BW	6	1303	912	72	4	1.1
6.	Transport Nagar	OW	4	1588	99	54	8	2.6
7.	R.P.P Thottam	OW	5	2220	1554	136	8	1.8
8.	Angamuthu Mudaliar Thottam	OW	7	960	812	60	4	2
9.	Near Facultative Pond	OW	3	970	749	40	8	1.6

The varying trends found in the ground water BOD clearly shows the presence the non - point source pollutant from the Erode sewage treatment plant. It should be control by suitable treatment.

CHAPTER-10

RIVER RESTORATION

10.1 TOWARDS SUCCESSFUL RIVER REHABILITATION

Returning a river to a former or more semi-natural state is a challenging prospect. In its purest sense, restoration means the full structural and functional return of a river to a pre-disturbance state, an opportunity which rarely occurs for the whole of a river. Indeed, this is even difficult to achieve for discrete sections or reaches of a river, because the conditions prior to the disturbance may not be fully known. Even if the natural conditions are known, they may not fit the present-day hydrological conditions as a result of, for example, land-use change and regulation in the upstream reaches. In most cases rehabilitation (a more achievable objective) indicates a process which can be defined as the partial functional and/or structural return to a former or pre-degradation condition or putting back to good working order. This challenge of rehabilitating rivers is one which truly shows the importance of emerging sciences such as landscape ecology. It involves at one end of the spectrum the understanding of interrelations between animals, plants, water and sediment and acquiring knowledge as to how to manipulate the processes involved. At the other end, it involves a more geomorphological and hydrological perspective, setting the river channel in its floodplain and catchment in order to ensure that manipulations at the local scale are sustainable into the future.

Successful river rehabilitation relies on bringing together the skills and determination of specialists from a range of disciplines at all stages of the process, from conception and planning through to implementation and appraisal. The co-operation of a range of practitioners enables them not only to achieve high standards within their own sphere of specialism but also to be appreciative and sensitive to the needs of other parts of the landscape and other specialists who are trying to manage them. The range of experts includes geomorphologists and hydrologists, ecologists, landscape architects and planners.

10.2 STATING THE AIM

The single most important stage in the rehabilitation process is to establish and agree the aim or aims which are both achievable within the time-scale of the project and sustainable thereafter. Different parties will have different expectations, and if a large measure of all-round satisfaction is to be achieved, it is important not to encourage false hopes. In order to return a river to a condition of better working order it is necessary to decide on the scope of the rehabilitation and what level of rehabilitation is to be achieved, i.e. visual, ecological, water quality, biodiversity or any combination of these etc are needed to describe the intent and the direction in which a project will go.

A common aim of rehabilitation projects is to make the river more natural, and 'naturalness' has become an important element of the enhancement ethos. Primarily it is controlled by river type, structure and geographical position in the landscape. Indications and insight into naturalness can be achieved through personal experience of the river and the region, information provided through river or water authorities, and data from local biological records centre(s) along with old maps and other relevant archives. A common term that is used in the rehabilitation process is that of the reference point, i.e. the former state or condition of the river or any of its attributes, or the vision of the return of the river to a better working order. These reference points will vary widely depending on the landscape type and its cultural history, and will be unique for each rehabilitation scheme embarked upon. One drawback of this is the difficulty of standardizing methodologies between different rehabilitation schemes. Techniques that will work in one scheme will not necessarily be of use in another project. Despite this, some degree of strategic planning is necessary for all rehabilitation schemes as they are invariably being undertaken in landscapes subject to a wide range of other uses, both consumptive, e.g. water abstraction and irrigation, and non-consumptive, e.g. recreation and landscape aesthetics.

10.3 ACTION PLAN TO CONTROL OF WATER POLLUTION

In order to achieve the compliance of the water quality criteria in the polluted stretches of River Cauvery from Mettur Dam to Erode for restoration of the riverine eco system following action is required:

- Inventory of sources which are discharging effluent in those stretches;
- Action Plan preparation to control the discharge of untreated effluent and implementation of the same; and,
- Location specific effluent standard based on water quality modelling exercise for the polluting sources.

Table: 10.1 Details of polluted stretch in Cauvery Basin

River	Polluted Stretch	Source/Town	Critical Parameters (in mg/l)
Cauvery	D/s of Mettur Dam to Erode city	Municipal sewage of Mettur, Bhavani, Komorapalayam, Veearpan chattram, Erode, Pallipalayam and Industrial Effluents.	BOD- 6.4-7

For restoration of degraded surface and ground water sources reduce the environmental impacts. The impacts of pollution and the cost of remedial actions are finally acknowledged, the cost of preventive precautionary measures is higher than if they had been implemented at the appropriate time. Thus, negligence of water quality problems often leads to a waste of economic resources, resources that might have been used for other purposes. If the water quality problems had been given proper attention in the first place. The principles for water resources management that have formed the basis for the guidelines reached in Dublin and Rio de Janeiro in 1992.

- Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.
- Land and water resources should manage at the lowest appropriate levels.
- The government has an essential role as enabler in a participatory, demand-driven approach to development.
- Water should be considered a social and economic good, with a value reflecting its most valuable potential use.
- Water and land use management should integrated.
- Women play a central part in the provision, management and safe guarding of water.
- The private sector has an important role in water management.

The water resources management cannot be conducted properly without paying due attention to water quality aspects. It is very important to take note of the integrated relationship between water resources management and water pollution control because past failures to implement water management schemes successfully may be attributed to a lack of consideration of this relationship. All management of water pollution should ensure irrigation with general water resources management and vice versa.

A step wise approach is proposed, comprising the following elements.

- Identification and initial analysis of water pollution problems.
- Definition of long and short term management objectives.
- Derivation of management interventions, tools and instruments needed to full fill the management objectives.
- Establishment of an action plan, including an action programme and procedures for implementation, monitoring and updating of the plan.

10.4 PRIORITIZATION OF WATER QUALITY PROBLEMS

In most cases the resources financial, human and others required for addressing all identified water quality problems significantly exceed the resources allowed to the water pollution control sector. Priorities, therefore, need to be assigned to all problems in order to concentrate the available resources on solving the most urgent and important problems. Some aspects to be considered when assigning priority to water quality problems can be identified as follows:

- Economic input.
- Human health impact.
- Impact on Eco system.
- Geographical extent of impact.
- Duration of impact.

A discharge of easily degradable organic material may cause considerable deterioration in water quality but only for the duration of the discharge, When the discharge ceases the impact also disappears, although there is often a time lag between the discharge ceasing and no further effects being detected, By contrast, the discharge of a persistent pollutant that is bioaccumulate in the aquatic environment can have an effect long after the discharge has ceased.

10.5 EXPLOITATION

In the recent past, due to rapid progress in communication and commerce, there has been a swift increase in the urban areas along the river Cauvery. As a result the river is no longer only a source of water but it is a channel, receiving and transporting urban wastes away from the towns. All the towns and industries along its length contribute to the population load. It has been assessed that more than 80 percent of the total pollution load BOD arises from domestic sources. Due to abstraction of water for irrigation in the upper regions of the river, the dry weather flow has been reduced to trickle and even zero.

The principle sources of pollution of the Cauvery River can be characterized as follows:

- Domestic and industrial wastes.
- Solid garbage thrown directly into the river
- Non-point sources of pollution from agricultural run off containing residues of harmful pesticides and fertilizers.
- Animal carcasses.
- Defecation on the banks and on the river flood plains and beds by the people s near by.
- Mass bathing and ritualistic practices.

It is very important to recognize that the river restoration action plan will have to significance if the action programme is not implemented, and unless all/ concerned parties are aware of the principles and procedures of the plan and are prepared to co-operate in its implementation. The action programme is the backbone of the action plan. Therefore, procedures for monitoring the progress of implementation should form part of the plan. Key indicators should identified illustrating the progress, as well as the associated success criteria. The restoration plan as a continuous process calls for frequent updating and the addition of new actions as contexts change, requirements develop, or as progress falls below expectation or schedules Modifications of earlier proposed actions may also be relevant. Regular monitoring reports should be accompanied by updated project action lists

10.6 POLLUTION LOAD DISCHARGED INTO CAUVERY RIVER FROM INDUSTRIES

As per the Tamil Nadu Government State Pollution Control Board statistics, the total pollution load admitted by giving consent to industries after necessary treatment to River Cauvery is follows:

Table: 10.2 Details of Pollution Load from Industries to River Cauvery

S.No	Type of Industry	No .of Units	Effluent Quantity KLD	Pollution Load in K.g/Day			
				Before Treatment		After Treatment	
				BOD	TDS	BOD	TDS
1	Chemical	2	390	10.5	0	0.35	0
2	Electroplating	1	0	0	0	0	0
3	Pesticides	1	0	0	0	0	0
4	Tannery	12	682	377	3327	9.81	1788
5	Textile	156	9805.3	2102.5	30050	1105	28829
6	Thermal Power	1	75000	75	43800	75	43800
7	Sago	1	40	0	0	0	0
	Total	174	85917.3	2595	77177	1190.16	74417

Source: Tamil Nadu Pollution Control Board 2006.

10.7 RIVER CAUVERY WATER QUALITY

On an average DO & BOD values have been found meeting the desired class in Mettur Dam down stream. But BOD, DO values were not within the desired level at down stream of Bhavani river confluence with river Cauvery, Erode, Pallipalayam and down stream of Erode near Chirapalayam. It is observed that the Total Coliforms values were exceeding the desired limits during non flow days at Erode, Pallipalayam and down stream of Erode at Chirapalayam. The BOD results of monitoring water quality parameters of the study area gauge stations data's indicate that, there is much problem in the river down stream of Mettur Dam probably due to the disposal of untreated and partially treated waste water with chemicals and dyes from industries and municipal domestic waste water treatment plants, leaching from compost yards and un collected wastes dumped on sided of the roads and low laying areas to river Cauvery or land creates severe pollution problems, and affects terrestrial eco systems. Due to non -availability of fresh water for dilution ,flushing, as well as flow and self purification velocity ,the river loss its assimilation capacity and its aquatic life as well the life of the riverine eco system.

If the study areas Mettur Dam to Erode reach Cauvery River maintained with out environmental flow for another one or two years, it is very very difficult to restore the river.

Eutrophication symptoms were observed in the down stream of Mettur Dam. It seems that due to eutrophication, the oxygen concentration has risen up to 20 mg/l, as the observations were taken during day time, when photosynthetic effects were prominent.

In general, there are three ways to improve the water quality of the Cauvery River

1) Reduction of pollution load
2) Increase of flow rate
3) Enhancement of the self-purification function of the River

Regarding the pollution load (BOD, in particular), the following are involved in BOD overload: the confluence of Bhavani River water , Drainage Channels water of Mettur,Komarapalayam,Bhavani,Erode, Veearpan chattram, and Pallipalayam Municipalities and drainage from wastewater treatment plants from Komorapalayam Wastewater Treatment Plant.

10.8 POLLUTION CONTROL MEASURES

The reduction of the pollution load is of primary importance for the improvement of river water quality. Therefore, it is necessary to promote the expansion of sewerage systems and the introduction of advanced water treatment technology in treatment plants.

An increase in flow rate during irrigation water release in Cauvery River the water quality gets improved significantly. In non flow season and the minimum lean flow periods the assimilation and self purification capacity of the river water is not enough to digest the pollutant load. The Self-purification Rivers is based on the self-purification function it varies depending on the biota that inhabits the rivers. Generally, rivers themselves are turbulent enough to allow for rapid mixing and dilution of the effluent. Mixing of the effluent occurs in rivers at various degrees. In rivers, complete mixing is likely to occur upon entry, provided that the stream volume and flow are greater than the volume of effluent being discharged. In larger streams, the effluent may form a plume, and complete mixing may be reached only over a long distance.

Total Sewage and Industrial effluents let out into River Cauvery = 153.2 MLD
In the Study area Mettur to Erode stretch
Considering "25 "as "Dilution factor" Minimum Flow Requirement = 44.33 Cumecs
Considering "50 "as "Dilution factor" Minimum Flow Requirement = 88.66 Cumecs
Considering "75 "as "Dilution factor" Minimum Flow Requirement = 103.00 Cumecs
Considering"100 "as "Dilution factor" Minimum Flow Requirement = 177.32Cumecs

Actually out of analysis period of 2802 days from 1st June 1999 to 31 st January 2007 virtually there is no flow for 815 days (details in annexure) .First the Government to maintain Environmental flow otherwise the thinking of restoration project is a wasteful exercise. With out release of freshwater from up stream of the study area i.e. From Mettur Dam how the river get freshwater to maintaining its riverine eco system.

10.9 ACTION REQUIRED FROM GOVERNMENT

If the River Cauvery has considered for restoration programme, first the river Cauvery requires certain environmental flow for carrying away the pollutants and maintain life of the riverine eco system.[Action: Government] Otherwise it is a waste full expenditure of public money. The State Government first should release at least 27.3 Cumecs as minimum environmental flow for Cauvery River from Mettur Dam during non releasement of irrigation water to delta region as described by the Hon'ble Cauvery Water Dispute Tribunal.

The Industries along the river are to make them as zero waste industries and their consents are immediately with drawn to conserve the Cauvery River. [Action: Government].

Formation of separate Authority with powers to Monitor and execute the work with in a targeted time.

The common effluent treatment plants effluents and Municipal treated effluents should be utilsed for farming suitable effluent irrigation farming as well as sewage wastewater for forestry .Scientifically designed land application systems, based on soil plant assimilative capacity, promotes treatment of wastewater through renovative capacity of living soil filter enabling recycling and reuse of wastewater, and conversion of nutrient energy into biomass there by bringing multiple benefits to society such as food,fuel,fruit,fibre and fodder production, environmental sanitation and ecorestoration.The forestry based land application systems enable of much desired green belt in cities that serve as sinks for green house gases, other air pollutants ,and debilitating noise levels .

Cauvery River restoration Project for reach Mettur Dam to Erode Town 62 kms length highly polluted stretch as identified by CPCB.

Table: 10. 3: Abstract of Cauvery River Restoration Authority

S.No	Project components	Proposal cost estimates Rs in lakhs
1	Sewerage schemes including treatment plants and effluent irrigation arrangements.	11600
2	River shore line development	100
3	Public Awareness	30
4	Compost yard Development cost	215
5	Compost yard land cost	195
6	Cauvery River restoration Authority-establishment cost 2 years (5% of the project cost)	510
7	Construction of Public Toilets with bath rooms	350
	Total project cost including Restoration Authority Establishment cost	10000 3

(Total Project Cost Rs. 100.00Crores Only) 3

10.10 FINANCIAL RETURN FROM THE PROJECT

1. Assured good drinking water for 2, 62, 39,416 populations of 15 districts to the total daily requirement of 2232 MLD.
2. Restoration of Immeasurable value Riverine eco system of Cauvery River.
3. Assured sewage land irrigation water supply of 96.2 MLD for 962 hectares for round the year or sewage waste water forestry for 4000 hectares with assured return of Rs 1, 32,000/ year after four years of formation.
4. Pollution under control
5. Fish and other natural native flora, fauna and endangered species like Otter, Palestine fresh water crocodile are protected from endanger list.

Table 10.4: Compost Yard Details

S.No	Town	Population	Solid Waste generated	Length of Roads	Solid Waste collection	Compost yard area in Acres	Method of disposal	Compost yard area in Acres
1	Mettur	53633	15.00 M.T		10.00M.T	43..72	Dumping	43..72
2	Bhavani	38645	10.00M.T	27.37	11.50M.T	10.01	Dumping	10.01
3	Komorapalayam	65868	25.00 M.T	122.18	22.00M.T	0	Dumping	0
4	Erode	151184	115.00 M.T	118.67	100.00M.T	19.42	Dumping	19.42
5	Veearpan chattram	72703	28.00M.T	54.54	22.00M.T	2.4	Dumping	2.4
6	Pallipalayam	52000	15.00 M.T	40.07	12.00M.T	2.1	Dumping	2.1
	Total	434033	211.00M.T	432.43	180.50M.T	33.93	Dumping	33.93

Table 10.5: Study Area Urban Effluent Details

S. No	Town	Population	Ultimate population	Length of Roads	Present Effluent Quantity in MLD	Existing Treatment Facilities in MLD	Existing Treatment Technology	Quantity of Treated Effluent in MLD
1	Mettur	53633	90000	69.6	6.4	0		0
2	Bhavani	38645	80000	27.37	5	3.94	W.S.P	0
3	Komorapalayam	65868	94000	122.18	7	6	W.S.P	6
4	Erode	151184	345000	118.67	40	25.17	W.S.P	20
5	Veearpan chattram	72703	105000	54.54			U.A.S.B	5.17
6	Pallipalayam	52000	90000	40.07	10	0		0
	Total	434033	804000	432.43	68.4	35.11		31.17

Table 10.6: Study Area Urban Effluent Details

S. No	Town	Population	Ultimate population	Length of Roads	Quantity of Treated Effluent in MLD	Additional Quantity of Sewage has Require Treatment in MLD	Total Quantity of Effluent to be Disposed off in MLD	Ultimate Quantity of Effluent to be Disposed off in MLD
1	Mettur	53633	90000	69.6	0	6.4	6.4	9
2	Bhavani	38645	80000	27.37	0	1.06	5	7.2
3	Komorapalayam	65868	94000	122.18	6	1	7	10
4	Erode	151184	345000	118.67	20	14.83	40	55
5	Veearpan chattram	72703	105000	54.54	5.17	0		
6	Pallipalayam	52000	90000	40.07	0	10	10	15
	Total	434033	804000	432.43	31.17	33.29	68.4	96.2

Table 10.7: Study Area Urban Effluent Details

S. No	Town	Population	Ultimate population	Additional Quantity of Sewage has Requires Treatment in MLD	Existing Treatment Technology	Total Quantity of Effluent to be Disposed off in MLD	Ultimate Quantity of Effluent to be Disposed off in MLD	Proposed Treatment Technology
1	Mettur	53633	90000	6.4		6.4	9	W.S.P
2	Bhavani	38645	80000	1.06	W.S.P	5	7.2	
3	Komorapalayam	65868	94000	1	W.S.P	7	10	
4	Erode	151184	345000	14.83	W.S.P	40	55	
5	Veearpan chattram	72703	105000	0	U.A.S.B			
6	Pallipalayam	52000	90000	10		10	15	W.S.P
	Total	434033	804000	33.29		68.4	96.2	

Table 10.8: Study Area Urban Effluent Irrigation Land Required Details

S.No	Town	Ultimate Quantity of Effluent to be Disposed off in MLD	Waste water Treatment Technology	Total Quantity of Effluent to be Disposed off in MLD	Ultimate Quantity of Effluent to be Disposed off in MLD	Total Quantity of Effluent for land irrigation in MLD	Waste water application rate per Hectare in cum per day	Total Land area required for land irrigation in Hectares
1	Mettur	9	W.S.P	6.4	9	9	100	99.00
2	Bhavani	7.2	W.S.P	5	7.2	7.2	100	79.20
3	Komorapalayam	10	W.S.P	7	10	10	100	110.00
4	Erode	55	W.S.P	40	55	55	100	610.50
5	Veearpan chattram		U.A.S.B					
6	Pallipalayam	15	W.S.P	10	15	15	100	151.50
	Total	96.2		68.4	96.2	96.2	100	1058.20

Table 10.9: Study Area Urban Effluent Irrigation Land Required Details

S.No	Town	Ultimate Quantity of Effluent to be Disposed off in MLD	Waste water application rate per Hectare in cum per day	Land area required for land irrigation in Hectares	Area required for roads and channels and drains in Hectares	Total Land area required for land irrigation in Hectares
1	Mettur	9	100	99	9	99.00
2	Bhavani	7.2	100	72	7.2	79.20
3	Komorapalayam	10	100	100	10	110.00
4	Erode	55	100	605	5.5	610.50
5	Veearpan chattram	combined	with	Erode	Scheme	
6	Pallipalayam	15	100	150	1.5	151.50
	Total	96.2	100	962	96.2	1058.20

Table 10.10: Total Cost of Sewerage Schemes

S.No	Town	Population	Sewerage scheme Estimated cost Rs. in Lakhs	Total Land area required for land irrigation in Hectares	River shore line development Rs. in Lakhs	Public Awareness Rs. in Lakhs	Total cost of the project Rs. in Lakhs
1	Mettur	53633	2500	99.00	15	5	2520
2	Bhavani	38645	1100	79.20	15	5	1120
3	Komorapalayam	65868	1437	110.00	15	5	1457
4	Erode	151184	3563	610.50	25	5	3593
5	Veearpan chattram	72703	1100		15	5	1120
6	Pallipalayam	52000	1900	151.50	15	5	1920
	Total	434033	11600	1058.20	100	30	11730

Table 10.11: Details of Proposed Compost Yard Developments

S.No	Town	Waste generated	Compost yard extend in Acres	Compost Development cost Rs in Lakhs	Land cost Rs in Lakhs	Total cost Rs in Lakhs
1	Mettur	15.00 M.T	43..72	30	0	30
2	Bhavani	10.00M.T	10.01	25	25	50
3	Komorapalayam	25.00 M.T	0	30	25	55
4	Erode	115.00 M.T	19.42	70	50	120
5	Veearpan chattram	28.00M.T	2.4	30	25	55
6	Pallipalayam	15.00 M.T	2.1	30	25	55
	Total	201.00M.T	33.93	215	150	365

Table 10.12: Cauvery River Restoration Project Mettur Dam to Erode Reach Abstract

S. .No	Town	Collection System cost Rs in lakhs	Treatment plant cost Rs in lakhs	Solid waste management & compost-yard cost Rs in lakhs	Sewage farm development cost Rs in lakhs	River shoreline development Rs in lakhs	Construction of toilets Rs in lakhs	Awareness creation Rs in lakhs	Total Rs in lakhs
1.	Mettur	2000	500	30	30	15	50	5	2630
2.	Bhavani	800	300	25	25	15	50	5	1220
3.	Komarapa-layam	1100	337	30	30	15	50	5	1567
4.	Erode	3000	563	50	70	25	100	5	3810
5.	Veerappanch-atram	800	300	30	30	15	50	5	1230
6.	Pallipalayam	1200	700	30	30	15	50	5	2030
	Total	8900	2700	195	215	100	350	30	12490

Source: Govt of Tamil Nadu.

CONCLUSIONS

- Prevention of pollution at source treating the pollutants and recycling for various applications has been requested. For polluting industries strict enforcement of acts for make them as zero discharge effluent industries.
- Technology particularly in terms of performance and available treatment options economically viable natural treatments such waste stabilization pond with effluent irrigation or sewage farming and wastewater effluent forestry are developed so as to minimize the pollution and the intrinsic value of resources in domestic sewage recovered by reuse.
- Pollution on Cauvery River can be minimized by recovery technologies and public awareness. Industrial waste water effluent quality can be improved through recovery technologies, waste minimization, and process modification.
- The technology selection for treatment plants and site selection to be done in consultation with local residents, effluent quality control is typically aimed at public health protection for preservation of the oxygen content in the Cauvery River.
- The flow in the River Cauvery is mainly controlled by Mettur Dam water releasement schedule and storage position. First priority should be given to drinking water supply and ecological needs minimum environmental flow needs. Minimum environmental flow as indicated by the Hon'ble Cauvery Water Dispute Tribunals final verdict 27.3 Cumecs or considering dilution factor as 15, to release minimum dependable flow considering River Cauvery polloution load for maintain its ecological sustainability of the riverine system.
- River Cauvery has virtually zero velocity and zero flow condition for 269 days in the year 2003-2004, and an average 116 days in a year. Due to zero velocity all the floating, suspended materials and nutrients present in the domestic sewage and chemicals and dyes present in the industrial effluents are settled in the bed of the river. It should be controlled as per prevailing Environmental acts by the pollution control boards.
- The life of the riverine eco system of Cauvery is under severe threat due to heavy industrial effluents and non availability of flow, dilution factors with

reference to flow Vs effluent loading, chemicals, dyes, nutrients, leaching from compost yards, open defecation, encroachments, dumping of wastes etc. River should is totally away from pollutants, this has to be enforced by the pollution control board authorities.

- The wastewater treatment systems are capital intensive and require expensive, specialized operators. Before seeking selecting and investing in waste water treatment technology it is always preferable to investigate whether pollution can be minimized or prevented.
- Industrial pollution, un controlled domestic sewage discharges and diffused pollution from agriculture, live stock rearing and alterations in land use has to be controlled to maintain sustainable use of water resources.
- Pollution has to be minimized by recovery technology and public awareness.
- Polluter pays the principle should be followed by amending and enforcing the laws.
- Any consent given for let of discharge effluents in to River Cauvery including local bodies it has to reviewed and even with drawn for defaulters considering the available Zero dilution factor and existing drinking water intakes.
- The drinking water intakes are under severe threat of contamination. . Due to the absence of upstream flow for continuous more with drawl of drinking water in the study area will develop ground water contamination due to non availability of fresh water balancing.
- Practically the Water supply intakes in the study area are flooded with waste water having chemicals, dyes and heavy oxygen demanding septic effluents during non flow days.
- The flora fauna, and trees are also affected due to toxic nature of the pollutants presence in the Cauvery stagnated water in Erode.
- The restoration measures including total control of effluents, and disposal has to be effected immediately otherwise mass water borne diseases and water related diseases are out break due to severe contamination of drinking water sources.

- Early warning surveillance and associated net works are provided for at least.

Major drinking water treatment plants. It must give instantaneous information on the over all water quality.

- The agencies that design and constructed the treatment plants should be engaged for operating for certain specific periods like BOOT. So as to avoid operating problems after trial run.
- In the study area none of the treatment plant functioning as per the design both quality as well as quantity wise. This sort of backlogs should be rectified by the administration then and there to achieve the River restoration programme goals.
- Proper monitoring ,critical review of works,penalising, vigilance, strict quality control are to be enforced by forming separate authority for River restoration works under the control of eminent technocrats like Delhi Metro. Other wise delay in execution cause financial burden to the Government funds.
- The industries including state owned Mettur thermal power plant and other industries effluents disposal consents already given may with drawn considering the minimum and available dilution flow, velocity of flow and assimilation capacity of the Cauvery River system in consultation with scientific institutions.
- Reclaimed waste water has been used mainly for non-potable applications such as public parks, playing fields, edges and central reservations of highways.
- Public awareness campaign, hearing of public opinions, stack holders meet, vigilance information, education and communication leads transparency about the programme.
- Increased co-ordination between the agencies and organizations involved in the programme through closer review of the plans for implementation, common efforts at capacity building, and critical support to key projects.
- Another important element is the institutionalization of the co-ordination system that has been established, either through the establishment of a new agency with a limited tenure or the strengthening and incorporation of this function in an existing government agency. A strong law needs to be passed by the legislature in the immediate future to realize this.

- Constant review and upgrading of the plan of operation. The programme should be flexible in order to respond to rapid changes in the economic and political environment. If there is an effective system of co-ordination among all the agencies involved, it should not be difficult to amend plans, to rectify errors and to take advantage of new opportunities.
- An aggressive campaign to raise resources to ensure the implementation of the key projects in the Plan of Operation. It will be impossible to secure funding support for all the projects in a short period of time and, therefore, resource generation should be prioritized. If the co-ordination system has been put in place, major efforts should be made to obtain the necessary funds to ensure programme implementation. Lack of funds should not be used as an excuse for delays in project implementation.
- Instead, innovative should be exercised in revising plans or breaking up the projects into early implement able sizes to prevent delays. The worst thing that could happen to the programme is for it to lose its momentum and, in the process, to lose public and political interest.
- Strengthening public participation in the river restoration and pollution abatement programme. Private organizations and NGO's are usually more capable than a government of sustaining initiatives because they are less affected by political considerations.
- The active participation of private organizations and NGO's, especially those who can provide special technical expertise will ensure continuity of the programme.

SUGGESTED SCOPES FOR FUTURE STUDY

- Modelling of water quality with pollution loads in different discharges and pollution conditions may be taken up to building more confidence in the stack holders.
- Institutional arrangements and legal provisions for achieving the targets may be designed developed and suggested.

WATER QUALITY

Station Mettur Dam Year

S.No	Factor	Weight	2000	2001	2002	2003	2004	2005	2006	2007
1	Dissolved oxygen	0.17	8.3	6.5	7.7	7.6	7.2	7.6	7.4	5.5
2	Fecal coliform	0.16	33	47	60	648	920	421	166	180
3	pH	0.11	8	8	8.5	8.5	8	8.2	8.3	8.1
4	Biochemical oxygen demand	0.11	0.7	0.7	1.3	1.9	2	2.4	2.6	2.2
5	Temperature change	0.1	3	3	3	2.5	3	3	3	3
6	Total phosphate	0.1	0.07	0.05	0.08	0.1	0.09	0.08	0.09	0.08
7	Nitrates	0.1	0.15	0.02	0.3	0.3	0.3	0.18	0.19	0.18
8	Turbidity	0.08	4	4	4	5	5	4	4	4
9	Total solids	0.07	290	316	320	289	312	432	296	275

WATER QUALITY

Station Bhavani Town Year

S.No	Factor	Weight	2000	2001	2002	2003	2004	2005	2006	2007
1	Dissolved oxygen	0.17	7.2	7.2	7.2	6.1	6.7	5.8	7	6
2	Fecal coliform	0.16	420	206	924	973	240	563	501	924
3	pH	0.11	8	8.1	8	8.2	8.1	7.91	8.24	8.1
4	Biochemical oxygen demand	0.11	2.8	0.9	2.2	2	2.2	2.2	2.2	3.8
5	Temperature change	0.1	3	3.2	3	3	1	4	2	1
6	Total phosphate	0.1	0.07	0.08	0.05	0.06	0.05	0.06	0.06	0.05
7	Nitrates	0.1	0.131	0.304	0.21	0.212	0.12	0.23	0.18	0.16
8	Turbidity	0.08	4	3	5	6	6	9	9	8
9	Total solids	0.07	296	420	348	278	341	316	280	284

WATER QUALITY

Station Urachikottai Year

S.No	Factor	Weight	2000	2001	2002	2003	2004	2005	2006	2007
1	Dissolved oxygen	0.17	7.6	7.8	7.6	7.8	8.3	7.5	7.6	
2	Fecal coliform	0.16	285	206	400	973	240	563	500	
3	pH	0.11	7.98	8.06	7.8	7.9	8.29	8.43	8.64	
4	Biochemical oxygen demand	0.11	1.6	3	4.4	4.2	4.4	3.4	4.4	
5	Temperature change	0.1	2	2	2	2	2	2	2	
6	Total phosphate	0.1	0.08	0.06	0.07	0.09	0.12	0.13	0.06	
7	Nitrates	0.1	0.13	0.128	0.131	0.058	0.5	0.46	0.46	
8	Turbidity	0.08	3	3	3	3	4	3	4	
9	Total solids	0.07	310	329	280	310	296	310	296	

WATER QUALITY

Station Pallipalayam Year

S.No	Factor	Weight	2000	2001	2002	2003	2004	2005	2006	2007
1	Dissolved oxygen	0.17	7	7.1	7	5.6	6.3	6.4	6.5	7.5
2	Fecal coliform	0.16	424	359	710	172	932	468	468	710
3	pH	0.11	8	8.2	8.2	8.5	8	7.89	8	7.9
4	Biochemical oxygen demand	0.11	3.2	0.9	3.2	2.7	3.2	2.7	2.7	2.9
5	Temperature change	0.1	2	2.1	1	1	1	1	2	1
6	Total phosphate	0.1	0.07	0.05	0.05	0	0	0	0	0
7	Nitrates	0.1	0.2	0.348	0.2	0.143	0.082	0.2	0.23	0.18
8	Turbidity	0.08	4	5	5	4	5	5	5	4
9	Total solids	0.07	360	296	340	247	226	298	320	301

WATER QUALITY

Station Erode d/s Year

S.No	Factor	Weight	2000	2001	2002	2003	2004	2005	2006	2007
1	Dissolved oxygen	0.17	6	5.8	7	6.7	5.7	5.2	5.6	5.6
2	Fecal coliform	0.16	410	263	420	760	2179	1918	809	1910
3	pH	0.11	8	8.2	8.2	8.4	8.1	8.05	8	8.2
4	Biochemical oxygen demand	0.11	3.5	1.8	3.3	3.3	3.5	3.5	3.2	3.6
5	Temperature change	0.1	1	1	1	1	1	1	1	1
6	Total phosphate	0.1	0.1	0.1	0.1	0.05	0.08	0.08	0.08	0.08
7	Nitrates	0.1	0.19	0.292		0.292	0.169	0.41	0.25	0.22
8	Turbidity	0.08	4	4	5	4	4	5	5	4
9	Total solids	0.07	325	290	314	260	240	290	314	293

S.No.	PARAMETERS	CAUVERY RIVER WATER ANALYSIS URACHIKOTTAI 2000-2001- C.W.C -CODE -CC000K5											
		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	Physical												
	Q(Cumec)	67.82	345.5	429.1	501.7	185.8	583.0	205.6	237.9	-	-	-	-
	Temp(°C)	28.0	28.5	28.5	28.5	27.5	27.0	26	25	-	-	-	-
	pH	7.98	7.68	7.59	8.25	8.01	8.06	7.86	8.5	-	-	-	-
	Sp.Conductance (micromhos/cm)	462	423	279	311	355	368	398	490	-	-	-	-
2	Chemical												
	K^+	0.22	0.08	0.06	0.06	0.06	0.06	0.12	0.08	-	-	-	-
	Na^+	2.02	1.65	1.12	1.00	1.11	1.14	1.31	1.57	-	-	-	-
	Ca^{++}	0.96	1.28	1.04	1.36	1.28	1.20	1.36	1.6	-	-	-	-
	Mg^{++}	1.44	1.52	0.56	0.80	1.28	1.20	1.52	1.76	-	-	-	-
	Al^{+++}	0.010	0.012	0.010	0.006	0.012	0.008	0.011	0.008	-	-	-	-
	Fe^{+++}	0.004	0.005	0.005	0.004	0.004	0.003	0.004	0.004	-	-	-	-
	NH_4^+	0.001	0.004	0.001	0.002	0.003	0.001	0.002	0.004	-	-	-	-
	Cationic Total	**4.655**	**4.551**	**2.796**	**3.232**	**3.749**	**3.612**	4.327	5.026				
	CO_3^{--}	0.00	0.00	0.00	0.00	0.00	0.00	0	0.42	-	-	-	-
	HCO_3^-	2.72	3.38	2.16	1.80	2.91	2.75	3.39	3.41	-	-	-	-
	Cl^-	1.43	0.85	0.65	0.60	0.60	0.57	0.67	0.75	-	-	-	-
	F^-	0.054	0.049	0.032	0.036	0.040	0.043	0.046	0.057	-	-	-	-
	SO_4^{--}	0.260	0.238	0.160	0.175	0.194	0.021	0.224	0.275	-	-	-	-
	SO_3^{--}	-	-	-	-	-	-	-	-	-	-	-	-
	NO_3^-	0.119	0.109	0.072	0.080	0.089	0.095	0.103	0.126	-	-	-	-
	NO_2^-	0.000	0.001	0.003	0.002	0.001	0.001	0.001	0.001	-	-	-	-
	PO_4^{---}	0.001	0.002	0.002	0.001	0.001	0.001	0.001	0.001	-	-	-	-
	SiO_3^{--}	0.87	0.80	0.53	0.59	0.98	0.70	0.75	0.93	-	-	-	-
	Anionic Total	**5.454**	**5.429**	**3.609**	**3.284**	**4.815**	**4.181**	5.185	5.97				
3	Biological and Bacteriological												
	D.O.(mg/l)	7.6	7.1	7.9	8.1	7.8	7.8	7.4	7.7	-	-	-	-
	B.O.D.(mg/l)	-	-	-	-	-	-	-	-	-	-	-	-
	Total Coliform (No. per 10 ml)	-	-	-	-	-	-	-	-	-	-	-	-
	Faecal Coliform (No. per 10 ml)	-	-	-	-	-	-	-	-	-	-	-	-
	Total Plate Count (No. per 10 ml)	-	-	-	-	-	-	-	-	-	-	-	-
	Phytoplankton (No. per ml)	-	-	-	-	-	-	-	-	-	-	-	-
	Zooplankton (No. per litre)	-	-	-	-	-	-	-	-	-	-	-	-
4	Trace and Toxic												
	Arsenic (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-
	Boron (mg/l)	0.25	0.13	0.3	0.15	0.27	0.26	0.34	0.37	-	-	-	-
	Cadmium (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-
	Chromium (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-
	Copper (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-
	Cyanide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-
	Lead (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-
	Manganese (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-
	Mercury (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-
	Zinc (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-
5	Chemical Indices												
	Hardness number	120	140	80	108	128	120	144	168	-	-	-	-
	Sodium percentage	43.53	36.42	40.29	31.06	29.76	31.67	30.39	31.34	-	-	-	-
	S.A.R.	1.84	1.39	1.25	0.96	0.98	1.04	1.09	1.21	-	-	-	-
	R.S.C.	0.32	0.58	0.56	0	0.35	0.35	0.51	0.47	-	-	-	-
	Classification	C2S1	C2S1	C2S1	C2S1	C2S1	C2S1	C2S1	C2S1	-	-	-	-

S.No.	PARAMETERS	CAUVERY RIVER WATER ANALYSIS URACHIKOTTAI 2001-2002- C.W.C -CODE -CC000K5											
		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	Physical												
	Q(Cumec)	72.80	396.0	196.9	401.1	161.1	293.6	308.4	215.5	359	102.1	No flow	80.41
	Temp(°C)	26.0	26.5	26.5	25.5	25.0	25.5	25	25	25	26	-	26.5
	pH	8.44	7.96	8.25	7.50	7.81	8.34	8.11	8.4	8.3	7.99	-	8.06
	Sp.Conductance (micromhos/cm)	472	438	290	345	462	495	508	476	471	419	-	486
2	Chemical												
	K^+	0.07	0.08	0.06	0.05	0.07	0.07	0.08	0.07	0.06	0.07	-	0.07
	Na^+	1.71	1.73	0.91	0.84	1.80	1.70	2	1.84	1.6	1.78	-	1.9
	Ca^{++}	1.60	1.20	1.44	1.36	1.60	0.72	2	1.6	1.28	1.36	-	1.2
	Mg^{++}	1.84	1.68	0.56	1.52	1.36	2.48	0.96	1.68	1.6	0.96	-	1.68
	Al^{+++}	0.006	0.014	0.010	0.010	0.010	0.008	0.013	0.01	0.08	-	-	0.005
	Fe^{+++}	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004	-	-	0.009
	NH_4^+	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.004	0.003	-	-	0.003
	Cationic Total	**5.234**	**4.712**	**2.987**	**3.786**	**4.846**	**4.984**	5.059	5.208	4.627	4.17		4.867
	CO_3^{--}	0.34	0.00	0.00	0.00	0.00	0.52	0	0.27	0.44	0	-	0
	HCO_3^-	3.31	3.55	2.24	2.69	2.86	2.78	3.11	3.37	2.84	2.86	-	3.76
	Cl^-	0.96	0.78	0.58	0.58	0.92	0.96	1.06	0.88	0.82	0.95	-	1.07
	F^-	0.054	0.050	0.031	0.026	0.054	0.057	0.022	0.023	0.027	0.027	-	0.025
	SO_4^{--}	0.260	0.220	0.202	0.230	0.493	0.470	0.351	0.34	0.312	0.381	-	0.346
	SO_3^{--}	-	-	-	-	-	-	-	-	-	-	-	-
	NO_3^-	0.119	0.111	0.068	0.054	0.119	0.128	0.131	0.101	0.122	0.108	-	0.169
	NO_2^-	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	-	-	0.001
	PO_4^{---}	0.001	0.001	0.002	0.001	0.001	0.001	0.002	0.002	0.002	-	-	0.002
	SiO_3^{--}	0.88	0.81	0.50	0.53	0.87	0.94	0.96	0.9	0.89	0.79	-	0.69
	Anionic Total	**5.925**	**5.523**	**3.624**	**4.112**	**5.318**	**5.857**	5.637	5.887	5.454	5.116		6.063
3	Biological and												
	Bacteriological												
	D.O.(mg/l)	7.8	7.7	7.4	7.5	6	6	5.9	7.5	7.7	7.6	No flow	7.8
	B.O.D.(mg/l)	-	1.3	1.6	1.45	1.3	3.3	3	3	1.3	1.9	-	2.8
	Total Coliform (No. per 10 ml)	-	-	-	-	-	-	-	-	-	-	-	-
	Faecal Coliform (No. per 10 ml)	-	-	-	-	-	-	-	-	-	-	-	-
	Total Plate Count (No. per 10 ml)	-	-	-	-	-	-	-	-	-	-	-	-
	Phytoplankton (No. per ml)	-	-	-	-	-	-	-	-	-	-	-	-
	Zooplankton (No. per litre)	-	-	-	-	-	-	-	-	-	-	-	-
4	Trace and Toxic												
	Arsenic (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-
	Boron (mg/l)	0.41	0.41	0.29	0.31	0.29	0.41	0.29	0.3	0.27	-	-	0.28
	Cadmium (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-
	Chromium (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-
	Copper (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-
	Cyanide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-
	Lead (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-
	Manganese (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-
	Mercury (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-
	Zinc (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-
5	Chemical Indices												
	Hardness number	172	144	100	144	148	160	148	164	144	116	-	144
	Sodium percentage	32.76	36.89	30.64	22.28	37.27	34.21	39.68	35.45	35.24	42.69	-	39.18
	S.A.R.	1.30	1.44	0.91	0.70	1.48	1.34	1.64	1.44	1.33	1.65	-	1.58
	R.S.C.	0.21	0.67	0.24	0	0	0.1	0.15	0.36	0.4	0.54	-	0.88
	Classification	C2S1	C2S1	C2S1	C2S1	C2S1	C2S1	C2S1	C2S1	C2S1	C2S1	-	C2S1

S.No.	PARAMETERS	CAUVERY RIVER WATER ANALYSIS URACHIKOTTAI 2002-2003- C.W.C -CODE -000K5											
		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	Physical												
	Q(Cumec)			59.55	77.35	265.7	297.8	291.7		220.8			
	Temp(°C)			26.7	26.2	28.5	27.5	26.2		27			
	pH			8.5	8.29	8.36	8.34	7.83		8.43			
	Sp.Conductance (micromhos/cm)			474	322	289	430	386		463			
2	Chemical												
	K^+			0.08	0.09	0.05	0.06	0.06		0.05			
	Na^+			1.91	0.98	0.79	1.24	1.12		1.46			
	Ca^{++}			1.44	1.12	0.96	1.36	1.28		1.44			
	Mg^{++}			1.6	0.96	1.2	1.6	1.68		1.84			
	Al^{+++}			0.01	0.012	0.011	0.011	0.011		0.009			
	Fe^{+++}			0.004	0.005	0.005	0.005	0.005		0.004			
	NH_4^+			0.003	0.004	0.004	0.004	0.004		0.002			
	Cationic Total			5.047	3.171	3.02	4.28	4.16		4.805			
	CO_3^{--}			0.9	0	0.23	0.26	0		0.25			
	HCO_3^-			2.51	2.17	1.79	2.67	2.57		3.3			
	Cl^-			1.35	0.73	0.58	0.68	0.58		0.63			
	F^-			0.034	0.029	0.019	0.03	0.039		0.034			
	SO_4^{--}			0.473	0.236	0.287	0.306	0.304		0.374			
	SO_3^{--}			-	-	-	-	-		-			
	NO_3^-			0.183	0.099	0.215	0.348	0.336		0.466			
	NO_2^-			0.002	0.002	0.002	0.002	0.002		0.002			
	PO_4^{---}			0.001	0.002	0.001	0.002	0.002		0.001			
	SiO_3^{--}			0.66	0.66	0.69	0.78	0.87		0.66			
	Anionic Total			6.113	3.928	3.814	5.078	4.703		5.717			
3	Biological and Bacteriological												
	D.O.(mg/l)			6.5	6.1	5.3	6.7	5.3		7			
	B.O.D.(mg/l)			4	2.2	1.4	2.9	1.3		1.7			
	Total Coliform (No. per 10 ml)												
	Faecal Coliform (No. per 10 ml)												
	Total Plate Count (No. per 10 ml)												
	Phytoplankton (No. per ml)												
	Zooplankton (No. per litre)												
4	Trace and Toxic												
	Arsenic (mg/l)												
	Boron (mg/l)			0.31	0.28	0.21	0.212	0.31		0.201			
	Cadmium (mg/l)												
	Chromium (mg/l)			0									
	Copper (mg/l)			0.005	0.01								
	Cyanide (mg/l)												
	Lead (mg/l)												
	Manganese (mg/l)					0							
	Mercury (mg/l)												
	Zinc (mg/l)			0.182									
5	Chemical Indices												
	Hardness number			152	104	108	140	148		164			
	Sodium percentage			37.97	31.11	26.33	34.4	27.05		30.48			
	S.A.R.			1.55	0.96	0.76	1.28	0.92		1.14			
	R.S.C.			0.37	0.09	0	0.13	0		0.27			
	Classification			C2S1	C2S1	C2S1	C2S1	C2S1		C2S1			

S.No.	PARAMETERS	CAUVERY RIVER WATER ANALYSIS URACHIKOTTAI 2003-2004- C.W.C -C000K5											
		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	Physical												
	Q(Cumec)			68.75	38.91	79.63	270.6		282.6				
	Temp(°C)			25.3	26.3	26.5	26.2		26.8				
	pH			8.92	8.53	9.13	8.66		8.79				
	Sp.Conductance (micromhos/cm)			680	456	325	347		355				
2	Chemical												
	K^{+}			0.12	0.12	0.09	0.08		0.07				
	Na^{+}			2.49	1.94	1.13	1.05		1.53				
	Ca^{++}			1.68	1.20	1.20	1.44		1.52				
	Mg^{++}			2.40	1.68	1.04	1.20		0.76				
	Al^{+++}			0.009	0.011	0.008	0.011		0.008				
	Fe^{+++}			0.006	0.005	0.005	0.005		0.004				
	NH_4^{+}			0.002	0.003	0.002	0.002		0.002				
	Cationic Total			6.707	4.959	3.475	3.788		3.894				
	CO_3^{--}			0.35	0.54	0.40	0.28		0.41				
	HCO_3^{-}			2.96	1.69	1.60	1.88		2.28				
	Cl^{-}			1.90	1.32	0.79	0.94		0.84				
	F^{-}			0.068	0.054	0.030	0.005		0.020				
	SO_4^{--}			1.170	0.668	0.476	0.371		0.318				
	SO_3^{--}			-	-	-	-		-				
	NO_3^{-}			0.707	0.800	0.058	0.058		0.063				
	NO_2^{-}			0.001	0.001	0.001	0.002		0.001				
	PO_4^{---}			0.001	0.001	0.002	0.001		0.002				
	SiO_3^{--}			0.78	0.62	0.88	0.56		0.74				
	Anionic Total			7.937	5.694	4.237	4.097		4.674				
3	Biological and Bacteriological												
	D.O.(mg/l)			7.6	6.3	5.9	7.1		8				
	B.O.D.(mg/l)			3.7	4.2	2.80	2.7		1.7				
	Total Coliform (No. per 10 ml)												
	Faecal Coliform (No. per 10 ml)												
	Total Plate Count (No. per 10 ml)												
	Phytoplankton (No. per ml)												
	Zooplankton (No. per litre)												
4	Trace and Toxic												
	Arsenic (mg/l)												
	Boron (mg/l)			0.32	0.22	0.21	0.27		0.298				
	Cadmium (mg/l)				6	3			0.09				
	Chromium (mg/l)				0	0	0		2.47				
	Copper (mg/l)				4	3			0				
	Cyanide (mg/l)								0				
	Lead (mg/l)								2.72				
	Manganese (mg/l)				3	0			0				
	Mercury (mg/l)								0.04				
	Zinc (mg/l)				40	23			23				
5	Chemical Indices												
	Hardness number			204	144	112	132		114				
	Sodium percentage			37.22	39.27	32.66	27.85		39.43				
	S.A.R.			1.74	1.62	1.07	0.91		1.43				
	R.S.C.			0.00	0.00	0.00	0.00		0.41				
	Classification			C1S1	C1S1	C1S1	C1S1		C1S1				

S.No.	PARAMETERS	CAUVERY RIVER WATER ANALYSIS URACHIKOTTAI 2004-2005- C.W.C -CODE -CC000K5											
		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	Physical												
	Q(Cumec)		55.28	28.97	454.7	475.4		243.5	258.3			32.27	
	Temp(°C)		27.0	26.5	26.5	26.0		25.0	22.0			25.5	
	pH		8.40	8.59	7.86	8.31		8.64	8.22			8.33	
	Sp.Conductance (micromhos/cm)		862	325	265	308		418	438			457	
2	Chemical												
	K^+		0.13	0.11	0.07	0.07		0.06	0.05			0.07	
	Na^+		3.25	1.17	0.68	1.01		1.22	1.30			1.41	
	Ca^{++}		1.68	1.12	0.88	1.36		1.52	1.52			1.20	
	Mg^{++}		2.72	1.12	1.12	0.80		1.36	1.52			1.84	
	Al^{+++}		-	-	-	-		-	-			-	
	Fe^{+++}		0.004	0.004	0.004	0.003		0.005	0.004			0.004	
	NH_4^+		0.014	0.005	0.004	0.005		0.003	0.002			0.014	
	Cationic Total		7.798	3.529	2.758	3.248		4.168	4.396			4.538	
	CO_3^{--}		0.19	0.19	0.00	0.13		0.06	0.00			0.12	
	HCO_3^-		2.67	1.57	1.43	1.85		2.68	2.55			2.31	
	Cl^-		2.58	0.80	0.47	0.58		0.73	1.10			1.31	
	F^-		0.053	0.022	0.031	0.020		0.028	0.040			0.027	
	SO_4^{--}		1.786	0.365	0.459	0.289		0.353	0.280			0.603	
	SO_3^{--}		-	-	-	-		-	-			-	
	NO_3^-		0.546	0.301	0.205	0.151		0.046	0.065			0.026	
	NO_2^-		0.001	0.001	0.001	0.002		0.001	0.000			0.000	
	PO_4^{---}		0.001	0.001	0.002	0.002		0.001	0.001			0.001	
	SiO_3^{--}		0.67	0.64	0.57	0.70		0.62	0.55			0.82	
	Anionic Total		8.497	3.890	3.168	3.724		4.519	4.586			5.217	
3	Biological and Bacteriological												
	D.O.(mg/l)		7.4	7.1	6			7.5	7.1			6.6	
	B.O.D.(mg/l)		4.4	4.4	1.3			2.7	0.7			3.4	
	Total Coliform (No. per 10 ml)												
	Faecal Coliform (No. per 10 ml)												
	Total Plate Count (No. per 10 ml)												
	Phytoplankton (No. per ml)												
	Zooplankton (No. per litre)												
4	Trace and Toxic												
	Arsenic (mg/l)												
	Boron (mg/l)		0.281	0.318	0.211	0.207		0.279	0.262			0.198	
	Cadmium (mg/l)												
	Chromium (mg/l)												
	Copper (mg/l)												
	Cyanide (mg/l)												
	Lead (mg/l)												
	Manganese (mg/l)												
	Mercury (mg/l)												
	Zinc (mg/l)												
5	Chemical Indices												
	Hardness number		220	112	88	108		144	152			152	
	Sodium percentage		41.77	33.24	31.09	31.17		29.33	29.61			31.19	
	S.A.R.		2.19										
	R.S.C.		0										
	Classification		C2S1	C2S1	C2S1	C2S1		C2S1	C2S1			C2S1	

	Cauvery river flow data Urachikottai							1999-2000				
Date	Jun	July	Aug	Sep	October	November	December	January	February	March	April	May
1	55.25	30.81	568.23	450.57	48.48	0	379.02	352.6	225.74	56.75	36.9	43.15
2	57.37	88.15	597.14	448.82	0	22.85	286.14	278.84	225.8	53.12	36.67	0
3	59.24	207.99	623.59	450.32	0	289.11	284.36	280.37	226.11	56.75	36.73	0
4	59.21	259.75	610.45	436.39	0	404.67	247.83	281.61	225.97	61.84	28.88	0
5	56.89	141.24	617.9	429.74	0	311.6	230.58	280.37	226.22	45.93	28.37	0
6	56.43	300.21	681.95	426.56	0	268.19	198.7	280.28	95.29	45.19	33.33	0
7	56.21	424.38	700.95	425.87	0	4.39	211.07	95.18	27.1	45.31	36.87	19.37
8	56.04	425.97	700.52	423.11	0	16.4	180.91	0.01	28.57	45.42	36.81	43.66
9	56.24	425.91	700.1	424.64	0	308.76	274.27	0.01	27.75	45.42	36.7	29.45
10	56.24	422.31	703.55	423.7	0	287.05	425.29	0.01	27.72	42.28	36.9	28.4
11	57.91	425.91	769.5	425.09	0	230.95	424.98	0.01	28.37	42.36	44.83	51.34
12	57.68	374.88	781.85	423.17	0	228.85	445	54.49	28.57	42.36	45.53	30.24
13	58.45	338.69	718.42	426.42	217.64	313.58	312.36	72.29	28.12	42.93	45.31	28.4
14	58.13	338.21	639.61	421.27	381.25	341.7	18.83	72.18	27.84	42.33	45.14	28.37
15	58.25	340.17	647.01	420.22	381.08	486.42	0	72.38	28.43	51.73	35	28.37
16	34.43	313.32	697.95	418.1	358.06	502.28	0	72.41	28.15	56.38	55.19	28.37
17	31.4	294.04	700.67	423.42	102.79	494.44	0	72.46	28.4	56.69	45.28	28.4
18	31.57	290.22	582.73	467.76	118.87	547.7	0	192.89	28.43	56.63	59.83	53.49
19	31.77	299.96	509.81	475.1	85.71	565.48	316.07	211.35	44.97	57.37	70.88	70.96
20	31.66	306.3	495.65	477.67	206.57	254.51	358.12	212.2	56.69	36.78	68.75	71.05
21	31.66	307.86	455.73	466.54	121.45	9.26	340.22	211.58	56.58	33.95	62.44	57.91
22	31.4	311.34	455.16	480.5	4.67	0	339.6	212.74	56.52	33.98	56.55	49.7
23	31.4	312.42	453.1	467.59	0	0	336.71	279.46	60	38.26	56.66	56.43
24	31.23	313.55	453.1	431.88	0	500.18	153.11	282.43	57.23	47.63	70.17	58.7
25	31.12	318.79	454.17	428.71	0	863.03	305.39	383.94	43.86	50.94	70.82	70.88
26	31.32	424.38	465.5	421.91	0	526.97	0	425.32	17.7	50.97	70.82	71.95
27	31.46	425.88	474.7	415.66	0	332.13	285.54	424.04	0	50.91	70.4	71.3
28	31.29	425.4	474.7	404.27	0	272.58	367.1	341.81	0	50.74	70.96	71.78
29	31.26	423.59	480.28	331.78	0	361.97	393.66	195.87	32.54	51.17	71.24	71.78
30	30.81	422.79	464.31	247.63	0	264.34	395.67	210.85		38.34	44.03	71.44
31		525.84	450.72		0		397.99	227.13		36.95		72.38

	Cauvery river flow data Urachikottai							2000-2001				
Date	Jun	July	Aug	Sep	October	November	December	January	February	March	April	May
1	68.41	343.60	429.10	551.80	203.70	583.00	205.60	237.90	0.00	0.00	0.00	0.00
2	55.69	424.40	373.90	499.50	176.50	596.80	246.80	210.20	0.00	0.00	0.00	0.00
3	54.68	406.30	248.80	514.60	185.80	453.70	693.60	200.20	0.00	0.00	0.00	0.00
4	0.00	396.90	238.80	479.80	480.10	444.50	377.70	206.10	0.00	0.00	0.00	0.00
5	0.00	400.50	244.40	591.10	482.80	461.80	346.70	261.80	0.00	0.00	0.00	61.72
6	0.00	439.30	330.50	525.50	580.30	449.10	251.00	316.80	0.00	0.00	0.00	50.44
7	0.00	441.30	236.80	522.80	487.80	456.90	223.50	303.70	0.00	0.00	0.00	38.39
8	0.00	458.70	298.50	549.60	296.90	493.30	221.10	264.70	0.00	0.00	0.00	0.00
9	0.00	400.50	269.40	567.30	960.10	505.50	240.20	275.40	0.00	0.00	0.00	60.94
10	0.00	390.00	275.80	605.60	2632.00	498.70	163.50	359.90	0.00	0.00	0.00	83.43
11	0.00	405.40	260.20	465.90	3720.00	487.80	200.80	352.90	0.00	0.00	0.00	206.20
12	0.00	473.20	275.10	465.90	1275.00	519.20	360.70	357.00	0.00	0.00	0.00	188.00
13	622.50	406.50	320.20	499.20	1720.00	438.20	367.70	272.50	0.00	0.00	0.00	0.00
14	494.90	493.20	293.70	362.90	1536.00	405.30	371.20	287.60	0.00	0.00	0.00	0.00
15	449.10	507.10	337.50	284.30	1483.00	395.10	361.40	260.30	0.00	0.00	0.00	0.00
16	523.20	466.00	396.60	294.30	1009.00	248.50	429.10	277.70	0.00	0.00	0.00	0.00
17	500.70	457.50	396.60	585.70	488.30	256.30	424.50	275.40	0.00	0.00	0.00	0.00
18	453.30	461.80	422.60	561.40	474.50	421.70	466.30	265.70	0.00	0.00	64.08	0.00
19	504.60	517.40	377.80	565.70	286.10	388.90	599.70	260.00	0.00	0.00	53.75	0.00
20	474.20	515.50	388.90	379.40	488.30	215.20	625.80	272.80	0.00	0.00	42.81	28.98
21	511.00	524.70	376.10	370.40	890.30	180.30	894.10	272.10	0.00	0.00	0.00	84.06
22	311.00	526.10	388.00	178.90	1009.00	0.00	571.10	276.30	0.00	0.00	0.00	62.39
23	311.90	483.40	385.10	161.70	957.10	0.00	561.60	270.50	0.00	0.00	0.00	83.46
24	318.70	532.70	359.00	131.00	2524.00	0.00	570.60	278.10	0.00	0.00	0.00	84.39
25	310.00	485.30	362.60	153.60	2573.00	0.00	561.60	274.20	0.00	0.00	0.00	80.27
26	327.50	514.50	366.30	137.70	1373.00	0.00	533.00	222.50	0.00	0.00	0.00	60.87
27	289.70	496.50	164.90	113.10	854.00	0.00	234.50	247.60	0.00	0.00	0.00	88.03
28	303.50	612.80	273.00	96.27	454.10	0.00	0.00	47.52	0.00	0.00	0.00	75.06
29	339.60	692.10	281.20	0.00	400.50	0.00	0.00	0.00		0.00	0.00	81.17
30	323.20	615.70	382.00	431.70	234.50	248.80	0.00	0.00		0.00	0.00	76.22
31		577.30	484.20		601.90		0.00	0.00		0.00		74.62

	Cauvery river flow data Urachikottai							2001-2002				
Date	Jun	July	Aug	Sep	October	November	December	January	February	March	April	May
1	72.80	429.80	196.20	395.00	161.20	293.80	308.70	214.50	359.60	112.00	9.25	81.33
2	81.28	396.00	9.38	369.80	307.30	315.20	318.40	273.20	9.25	111.30	9.25	11.30
3	85.42	428.70	11.65	394.90	273.10	340.30	304.60	260.30	10.60	98.87	8.61	11.30
4	79.83	422.70	62.69	364.00	504.30	397.50	318.20	268.80	9.91	113.60	101.60	69.47
5	87.27	430.80	61.34	347.80	426.60	398.50	328.10	278.40	9.25	112.50	78.84	96.89
6	83.51	442.80	350.00	322.10	195.40	455.90	341.60	237.10	8.61	119.70	100.20	80.59
7	90.42	428.60	310.40	341.20	162.10	288.70	366.90	282.60	10.60	116.70	91.04	80.42
8	87.91	463.10	363.00	389.10	148.90	331.30	347.70	300.50	10.60	117.70	78.00	79.97
9	82.67	423.00	392.90	359.60	162.10	8.67	376.20	309.50	10.60	76.62	77.75	77.92
10	96.76	441.10	410.10	334.80	162.70	2.93	372.60	283.70	19.52	69.37	77.83	76.05
11	103.90	465.20	387.50	345.00	147.30	11.65	419.70	299.70	7.99	11.30	76.48	90.25
12	103.00	470.60	394.00	196.30	150.00	1.09	375.60	270.00	10.60	10.60	77.86	85.36
13	197.20	448.20	437.00	193.70	359.60	187.00	375.50	308.00	62.92	10.60	78.58	11.30
14	272.30	459.30	428.70	163.00	366.40	187.00	448.90	380.00	79.46	9.91	94.92	11.30
15	365.50	437.10	422.50	195.20	146.30	285.70	461.40	342.00	108.80	119.90	77.65	11.30
16	445.60	463.10	437.10	171.90	145.00	297.90	455.00	354.40	106.90	9.91	77.81	9.91
17	429.80	466.90	448.20	186.90	142.40	10.87	501.30	377.70	85.36	22.39	78.02	11.30
18	454.10	470.60	451.90	196.20	384.00	17.74	447.00	347.90	110.80	10.60	78.05	11.30
19	455.40	531.30	415.30	248.00	277.60	10.87	277.50	340.00	117.80	107.80	78.10	9.25
20	475.50	573.30	387.00	259.90	374.90	8.67	283.80	350.30	111.80	106.50	77.81	10.60
21	471.90	560.10	342.90	258.50	329.70	208.90	275.40	360.80	115.20	87.23	81.67	11.30
22	464.50	569.20	373.20	253.20	369.10	220.60	132.40	327.10	118.30	81.67	77.12	11.30
23	444.50	571.60	352.80	255.60	379.10	10.87	21.41	345.90	115.50	107.60	77.01	9.91
24	426.20	571.30	376.60	233.40	204.70	11.65	7.40	346.60	117.60	79.86	78.93	10.60
25	424.00	473.60	444.50	170.30	202.60	10.87	5.23	342.40	112.80	83.51	92.97	11.30
26	362.60	485.90	493.60	156.30	359.60	8.67	6.82	325.30	110.40	77.76	89.12	12.03
27	379.30	409.70	437.60	157.80	78.01	290.00	6.82	311.40	112.50	82.33	85.36	10.60
28	361.90	255.00	458.70	141.70	12.45	279.50	6.82	340.40	117.00	80.54	85.36	9.91
29	361.30	200.00	434.90	139.50	11.65	287.20	219.20	353.60		83.51	98.87	9.91
30	364.50	198.10	445.80	162.10	10.87	297.90	5.23	345.90		7.99	80.33	11.30
31		201.20	393.80		204.90		3.03	355.90		9.91		10.60

	Cauvery river flow data Urachikottai							2002-2003				
Date	Jun	July	Aug	Sep	October	November	December	January	February	March	April	May
1	0.00	0.00	59.55	74.78	266.70	38.49	297.80	0.00	220.90	0.00	0.00	0.00
2	0.00	0.00	61.48	77.23	274.60	39.18	292.40	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	60.31	77.07	229.10	46.49	282.90	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	70.27	74.77	268.20	47.66	216.50	0.00	0.00	35.14	0.00	0.00
5	0.00	0.00	60.32	74.98	246.10	0.00	278.20	386.40	0.00	0.00	0.00	0.00
6	0.00	0.00	55.03	75.88	225.80	0.00	291.00	427.30	0.00	34.76	0.00	0.00
7	0.00	20.87	50.79	413.10	236.50	0.00	39.22	382.60	0.00	29.70	27.48	0.00
8	0.00	0.00	56.16	476.60	256.40	0.00	0.00	414.70	0.00	0.00	38.49	0.00
9	0.00	0.00	53.49	472.20	124.90	0.00	0.00	367.40	0.00	31.99	38.23	0.00
10	0.00	0.00	53.80	476.60	171.40	0.00	0.00	0.00	0.00	34.00	38.14	0.00
11	0.00	0.00	53.79	469.80	0.00	0.00	117.70	0.00	0.00	27.94	38.27	0.00
12	0.00	0.00	54.18	498.00	0.00	105.20	116.00	0.00	0.00	24.69	0.00	0.00
13	0.00	0.00	53.39	501.20	0.00	272.50	72.60	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	54.43	497.80	0.00	279.50	73.11	0.00	0.00	0.00	0.00	0.00
15	0.00	59.97	57.68	459.20	148.70	293.80	85.41	0.00	0.00	0.00	0.00	0.00
16	0.00	59.85	55.31	393.00	173.80	252.10	76.63	0.00	0.00	0.00	0.00	0.00
17	0.00	59.87	57.25	415.50	183.20	261.90	94.82	0.00	264.00	0.00	0.00	0.00
18	0.00	50.37	60.35	387.50	165.10	299.40	75.86	0.00	248.20	0.00	0.00	0.00
19	0.00	49.81	53.83	387.80	170.10	304.50	75.22	0.00	241.70	0.00	0.00	0.00
20	0.00	0.00	57.38	386.30	82.66	286.30	74.31	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	58.45	321.90	46.41	274.90	491.10	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	58.39	350.80	47.90	279.00	478.30	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	67.76	301.20	45.66	287.80	473.80	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	76.60	284.00	33.70	321.90	481.30	0.00	0.00	0.00	0.00	0.00
25	0.00	59.54	77.88	371.60	161.80	57.58	322.40	0.00	0.00	25.41	0.00	0.00
26	0.00	59.46	76.44	329.90	169.20	295.30	428.20	0.00	0.00	39.44	0.00	0.00
27	0.00	59.19	77.87	229.50	192.70	289.70	421.10	0.00	0.00	38.49	0.00	0.00
28	0.00	53.79	71.28	291.30	159.70	258.90	392.10	226.60	0.00	37.89	0.00	0.00
29	0.00	59.67	76.36	261.90	83.12	252.40	38.62	263.50		37.64	0.00	0.00
30	0.00	60.84	75.96	244.40	223.40	264.20	0.00	242.50		47.20	0.00	0.00
31		67.51	76.44		44.29		0.00	256.00		39.18		0.00

	Cauvery river flow data Urachikottai					2003--2004					
Date	Jun	July	Aug	Sep	October	November	December	January	February	March	April	May
1	0.00	0.00	68.73	39.37	83.09	275.70	0.00	282.40	0.00	0.00	0.00	0.00
2	0.00	0.00	69.22	0.00	55.19	385.10	0.00	296.60	0.00	0.00	0.00	0.00
3	0.00	0.00	67.65	0.00	0.00	418.50	0.00	274.00	0.00	0.00	0.00	70.73
4	0.00	0.00	69.86	0.00	0.00	412.60	0.00	298.00	0.00	0.00	0.00	75.59
5	0.00	30.49	86.38	0.00	0.00	424.30	0.00	272.20	0.00	0.00	0.00	58.47
6	0.00	32.54	85.11	0.00	0.00	429.30	0.00	0.00	0.00	0.00	0.00	62.95
7	0.00	29.82	46.58	0.00	0.00	411.50	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	479.40	317.40	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	522.00	155.30	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	559.30	43.44	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	533.20	147.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	543.50	150.40	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	580.90	214.20	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	478.20	240.30	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	317.40	89.63	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	299.00	93.49	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	274.60	91.04	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	452.10	91.52	35.71	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	167.30	85.58	176.70	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	178.10	89.61	181.40	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	193.10	89.28	151.30	0.00	251.00	0.00	0.00	0.00
22	37.56	0.00	0.00	0.00	172.30	88.78	165.60	0.00	216.60	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	40.81	32.54	144.90	0.00	229.90	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	40.78	0.00	382.10	0.00	146.20	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	39.33	0.00	347.70	0.00	86.03	0.00	0.00	0.00
26	0.00	0.00	0.00	91.55	37.56	0.00	352.10	0.00	60.26	0.00	0.00	0.00
27	0.00	0.00	0.00	84.80	39.92	0.00	350.60	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	76.78	224.70	0.00	286.10	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	84.38	224.70	0.00	248.30	0.00	0.00	0.00	0.00	0.00
30	0.00	0.00	0.00	85.31	305.40	0.00	313.50	0.00		0.00	0.00	0.00
31		68.15	41.89		306.50		292.80	0.00		0.00		0.00

	Cauvery river flow data Urachikottai						2004-2005				
Date	Jun	July	Aug	Sep	October	November	December	January	February	March	April	May
1	0.00	55.34	48.53	454.20	0.00	0.00	243.40	258.50	0.00	0.00	32.28	36.98
2	0.00	57.57	28.97	445.20	168.00	0.00	237.50	259.00	0.00	0.00	33.45	0.00
3	0.00	57.71	0.00	459.00	122.80	0.00	248.70	171.80	0.00	39.17	31.80	0.00
4	0.00	60.41	0.00	463.20	111.00	0.00	238.90	259.00	0.00	36.98	31.54	0.00
5	0.00	24.84	0.00	475.20	139.20	0.00	222.90	358.80	0.00	35.35	33.75	0.00
6	0.00	0.00	0.00	374.70	381.50	0.00	232.50	351.40	0.00	47.38	30.61	0.00
7	0.00	0.00	0.00	315.90	382.50	0.00	246.50	391.60	0.00	32.53	33.56	0.00
8	0.00	0.00	0.00	307.90	396.00	0.00	344.30	355.80	0.00	0.00	0.00	32.80
9	0.00	0.00	0.00	320.30	417.30	0.00	357.80	351.40	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	309.40	449.20	0.00	352.90	352.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	308.50	434.10	0.00	357.90	353.30	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	354.70	480.70	0.00	358.80	349.10	0.00	0.00	0.00	0.00
13	0.00	0.00	348.10	368.10	486.10	0.00	361.70	285.40	0.00	0.00	0.00	0.00
14	0.00	0.00	328.30	338.30	437.50	0.00	359.10	288.10	0.00	0.00	0.00	0.00
15	0.00	0.00	344.80	303.30	475.70	0.00	248.30	303.80	0.00	0.00	0.00	0.00
16	0.00	0.00	322.70	354.70	380.40	0.00	230.30	308.40	0.00	0.00	0.00	0.00
17	0.00	0.00	331.30	153.80	399.00	0.00	316.90	255.70	0.00	0.00	0.00	0.00
18	0.00	0.00	392.10	187.80	320.20	0.00	308.80	269.70	0.00	0.00	0.00	0.00
19	0.00	0.00	541.00	106.50	319.30	0.00	294.80	262.80	0.00	0.00	33.07	0.00
20	0.00	0.00	564.90	306.50	260.80	0.00	230.90	281.30	0.00	0.00	0.00	0.00
21	0.00	0.00	580.60	306.50	258.00	0.00	296.00	255.90	0.00	0.00	31.98	0.00
22	0.00	0.00	525.20	303.30	195.40	195.80	294.70	293.40	0.00	0.00	31.80	0.00
23	0.00	0.00	479.40	308.60	193.30	183.10	251.90	401.40	0.00	0.00	0.00	0.00
24	0.00	362.00	547.80	311.90	35.27	186.00	263.30	296.00	0.00	34.68	31.80	0.00
25	0.00	494.20	432.30	375.20	0.00	243.00	298.20	287.90	0.00	35.91	31.59	0.00
26	0.00	355.70	340.90	306.50	0.00	156.10	265.40	237.60	0.00	34.46	31.06	0.00
27	0.00	271.30	429.90	256.10	0.00	303.10	267.40	179.60	0.00	35.91	0.00	0.00
28	0.00	115.40	435.70	193.40	0.00	261.20	173.50	166.40	0.00	34.82	0.00	0.00
29	0.00	112.00	456.50	0.00	74.77	288.40	162.50	0.00		34.20	31.09	24.40
30	50.04	249.40	459.10	0.00	0.00	275.40	166.70	0.00		34.49	0.00	0.00
31		196.20	454.60		0.00		170.30	0.00		33.48		0.00

	Cauvery river flow data Urachikottai							2005-2006				
Date	Jun	July	Aug	Sep	October	November	December	January	February	March	April	May
1	25.23	25.43	339.74	606.82	537.85	423.70	291.66	340.22	0.00	0.00	56.69	56.55
2	25.17	25.54	337.62	749.66	432.08	1110.01	283.96	340.28	0.00	0.00	56.66	56.75
3	25.09	25.37	283.93	892.09	424.38	2278.52	283.34	294.27	23.50	0.00	56.58	56.75
4	25.29	25.46	272.38	715.65	505.88	1892.17	319.72	283.14	28.34	28.37	56.60	56.58
5	25.15	25.46	155.65	799.07	509.56	1441.37	524.54	283.39	28.26	27.75	56.58	56.69
6	25.03	25.34	510.61	1065.44	509.90	1609.91	516.78	207.08	28.29	27.69	56.60	56.63
7	25.03	25.40	509.61	895.68	508.99	797.03	404.64	169.76	28.29	28.23	56.69	56.60
8	25.57	25.40	509.39	738.95	509.70	633.95	359.88	169.76	28.29	28.15	56.63	56.63
9	24.86	25.60	509.90	509.69	479.34	464.73	340.14	169.81	28.32	28.29	56.60	56.72
10	24.98	25.32	509.78	509.98	366.05	507.55	255.05	172.42	28.26	28.32	56.60	56.66
11	24.86	25.43	456.49	509.95	339.52	473.88	293.59	169.70	28.37	28.29	56.55	50.97
12	26.14	25.40	425.01	508.71	340.08	377.26	284.61	170.10	28.26	28.17	56.60	56.55
13	24.69	25.40	424.04	508.54	257.23	377.80	283.65	169.59	28.23	28.29	56.55	56.69
14	26.22	25.37	424.72	509.95	133.48	341.70	409.00	169.93	28.23	28.23	56.66	56.72
15	24.69	25.43	424.75	509.25	84.92	401.30	355.71	170.07	28.32	28.12	56.66	56.75
16	24.66	25.51	424.72	593.63	275.75	377.69	274.25	169.73	28.26	28.12	56.63	56.69
17	24.98	25.43	424.47	920.38	339.20	293.08	239.98	169.93	28.26	28.32	56.63	56.60
18	24.95	25.37	424.63	888.29	339.71	283.25	244.29	169.67	28.32	43.66	56.60	56.72
19	24.89	25.48	427.80	695.52	437.66	283.05	240.83	169.98	28.37	56.63	56.58	43.69
20	25.00	25.48	509.36	509.36	626.28	417.56	256.38	169.98	28.23	56.60	43.64	42.62
21	26.42	25.40	392.50	564.01	684.30	271.78	236.02	154.27	28.23	56.58	42.39	42.45
22	25.32	25.46	508.79	651.14	794.17	123.29	164.86	141.64	28.29	56.60	29.45	42.42
23	25.37	25.37	509.26	649.3	712.84	389.41	151.21	141.41	28.29	56.63	28.32	42.45
24	25.48	25.40	509.70	651.4	2749.77	621.44	171.32	141.58	28.29	56.69	28.32	55.53
25	25.34	25.54	509.84	650.07	6011.13	629.17	162.62	126.32	28.29	56.69	54.28	56.80
26	25.46	25.51	509.50	651.17	3599.26	692.17	167.32	113.61	28.34	56.66	56.58	56.58
27	25.46	37.97	509.47	650.47	2848.56	466.52	250.91	113.15	0.00	56.63	56.63	56.60
28	25.34	318.45	431.52	651.06	1804.42	510.09	200.62	113.38	0.00	56.63	56.63	56.60
29	25.48	339.54	424.72	651.63	1395.27	374.37	338.84	51.90		56.66	56.60	56.63
30	25.37	339.54	432.71	651	1082.57	448.62	340.73	0.00		56.55	56.63	56.66
31		339.69	750.25		786.52		339.52	0.00		56.60		56.66

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