Chapter – I

ENVIRONMENTAL IMPACT ASSESSMENT FOR RIVER BASIN

1.1 INTRODUCTION

Environmental Impact Assessment (EIA) is an activity designed to identify and predict the impact on the biogeophysical environment and on man's health and well being of legislative proposals, policies, programmes and projects, operational procedures, to interpret and communicate information about the impacts (Gilpin 1995; Kassim and Simoneit 2001). EIA is an effective and important tool to ensure environmentally sustainable development processes and is a dynamic process where various issues are under review for effective implementation and for strengthening the processes. An overview of the generic and the World Bank EIA processes, various methodologies, issues involved, and steps needed to strengthen the EIA capacity. EIA is the process in which environmental factors are integrated into project planning and decision making so as to achieve ecologically sustainable development. The best practice of EIA processes identifies environmental risks, lessens conflicts by promoting community participation, minimizes adverse environmental effects, informs decision makers and helps lay the base for environmentally sound projects. Benefits of integrating EIA have been observed in all stages of a project from exploration and planning, through construction, operations, decommissioning and beyond site closure. Heer (1977) define, EIA in more precise terms as "an activity that aims at establishing quantitative values for selected parameters which indicate the quality of environment before during and after the proposed activities".

Planning and management of land and water, still present major problems in the industrialized countries, for example in containing urban sprawl, constructing highways and airports, maintaining the quality of lakes and estuaries and preserving wilderness areas (Efford 1975; Fairfax 1978). Many of these problems are associated with the massive and mounting demands for energy and water by industry and a consumer society and are present only in embryonic form in the less developed countries. Perceptions about environmental impacts can be rather different in diverse countries. Where, poverty is widespread and large numbers of people do not have adequate food, shelter, health care and education the lack of development may constitute a greater aggregate degradation to life quality than do the environmental impacts of development. The imperative for development to remedy these defects may be so great that consequent environmental degradation may be tolerated. The pervasive poverty in the underdeveloped nations has been spoken of as the pollution of poverty, while the widespread social and environmental erosion in the developed nations has been characterized in its advanced state as the pollution of affluence. While, it is clear that decisions will and should be made based upon different value judgments concerning the net cost benefit assessments about environmental, economic and social impacts, it is now widely accepted that development can be planned to make best use of environmental resources and to avoid degradation. The process of EIA forms a part of the planning of such environmentally sound development (Caldwell et al 1982). In developing countries, a special challenge is to stimulate development processes at the local level. If such a process can be inaugurated broadly, the fruits of development may reach more of the segments of the population than do the large, centralized schemes. Better adapted development projects and programmes are apt to engender broader public support and cause less undesirable social displacement than a few large centralized projects (Kassim et al 2005).

Developing countries are accepting more responsibility for the environmental impacts that result from their development activities, and many have developed EIA legislation as a management tool for these impacts in the last two decades. EIA is now practiced in more than 100 countries worldwide (Donnelly et al 1998). Today, EIA is firmly established in the planning process in many of these countries (Momtaz 2002). In 1989, the World Bank ruled that EIA should normally be undertaken for major projects by the borrower country under the bank's supervision. The United Nations Environment Programme (UNEP) also made recommendations to member states regarding the establishment of EIA procedures and established goals and principles for EIA. It subsequently issued guidance on EIA in developing countries (UNEP 1988). Despite the existence of good EIA guidelines and legislation, environmental degradation continues to be a major concern in developing countries. In many cases, EIA has not been effective due to legislation, organizational capacity, training, environmental information, participation, diffusion of experience, donor policy, and political will. EIAs have not been able to provided environmental sustainability assurance (ESA) for these countries (Sadler 1999). This failure and the inherent limitations of EIA lead to the consideration of strategic environmental assessment (SEA). It is the proactive assessment of alternatives to proposed in the context of a broader vision, set of goals or objectives to assess the likely outcomes of various means to select the best alternatives to reach desired ends (Noble 2000).

The production of novel chemicals has introduced new environmental hazards and qualms. The addition of large amounts of biodegradable substances to the environment has accelerated the eutrophication of rivers and lakes, where these materials or their metabolites accumulate. Non-biodegradable compounds may be less conspicuous but more dangerous. Some are concentrated as they pass through food chains and endanger the health of man and his domestic animals, as well as that of numerous other species of wildlife. Several crisis episodes attract much attention, but long-term exposure to moderate degrees of pollution may be a more serious threat to human health. Acute or even chronic human toxicity is only one part of the pollution problem; pollutants also have implications for the long-term maintenance of the biosphere. The short term problems are much simpler and are amenable in part to narrowly compartmentalized pragmatic solutions. Long-term effects of pollutants are insidious, chronic and often cumulative. Ecologists must ask what effects these pollutants have on the structure of natural ecosystems and on biological diversity, and what such changes could mean to the long term potential for sustaining life.

A confounding factor is that if the project were not undertaken, the environment would still exhibit: (i) great variability (due to, for instance, variations in weather and climate, natural ecological cycles and successions); (ii) irreversible trends of natural origin (from the eutrophication of rivers for example); (iii) irreversible trends due to a combination of natural and man-induced factors (such as over grazing, salinisation of soils). One of the problems for the environmental impact assessor is to identify the various components of environmental change, due to the interacting influences of man and nature. It also implies no value judgment of whether environmental change is good or bad. However, at some stage in the assessment or the decision making process, such a judgment must be made.

1.2 GLOBAL STATUS OF EIA

EIA is one of the successful policy innovations of the 20th century for environmental conservation. Thirty seven years ago, there was no EIA but today, it is a formal process in many countries and is currently practiced in more than 100 countries (Wood 2003). EIA as a mandatory regulatory procedure originated in the early 1970s, with the implementation of the National Environment Policy Act (NEPA) 1969 in the US. Much of the initial development was in a small number of high income countries, like Canada, Australia, and New Zealand (1973-74). However, there were some developing countries as well, which introduced EIA relatively early-Columbia (1974), Philippines (1978). The EIA process really took off after the mid-1980s. In 1989, the World Bank adopted EIA for major development project, in which borrower country had to undertake the EIA under the Bank's supervision (Table 1.1).

Table 1.1 Evaluation and history of EIA

Year	Development of EIA
Pre-1970	• Project review based on the technical/engineering and economic analysis. • Limited consideration given to environmental consequences.
Early/mid-1970s	• EIA introduced by NEPA in 1970 in US. • Basic principle: Guidelines, procedures including public participation requirement instituted. • Standard methodologies for impact analysis developed (e.g. matrix, checklist and network). • Canada, Australia and New Zealand became first countries to follow NEPA in 1973-1974. Unlike Australia, which legislated EIA, Canada and New Zealand established administrative procedures. • Major public inquires help to shape the process development.
Late 1970 and early 1980s	• More formalised guidance. • Other industrial and developing countries introduced formal EIA requirements (France, 1976; Philippines, 1977) began to use the process informally or experimentally (Netherlands, 1978) or adopted elements, such as impact statements or reports, as part of development applications for planning permission (German states (lander), Ireland). • Use of EA by developing countries (Brazil, Philippines, China, Indonesia) • Strategic Environment Assessment* (SEA), risk analysis included in EA processes**. • Greater emphasis on ecological modeling, prediction and evaluation methods. • Provision for public involvement. • Coordination of EA with land use planning processes.
Mid 1980s to end of decade	• In Europe, EC Directive on EIA establishes basic principle and procedural requirements for all member states. • Increasing efforts to address cumulative effects. • World bank and other leading international aid agencies establish EA requirements. • Spread of EIA process in Asia.
1990s	• Requirement to consider trans-boundary effects under Espoo convention. • Increase use of GIS and other information technologies. • Sustainability principal and global issues receive increased attention. • India also adopted the EIA formally. • Formulation of EA legislation by many developing countries. • Rapid growth in EA training.

Source: International Study of the Effectiveness of Environmental Assessment, final report, Environmental assessment in a changing world, Prepared by Barry Sadler, June 1996.

* Definition of SEA: Policy tool to assess the environmental consequences of development policies, plans and programmes

** Definition of risk assessment: An instrument for estimating the probability of harm occurring from the presence of dangerous conditions or materials at a project site. Risk represents the likelihood and significance of a potential hazard being realized

1.3 GENERALISED PROCESS FLOW SHEET OF THE EIA PROCESS

EIA is the process in which environmental factors are integrated into project planning and decision making so as to achieve ecologically sustainable development. Best practice EIA identifies environmental risks, lessens conflicts by promoting community participation, minimizes adverse environmental effects, informs decision makers and helps lay the base for environmentally sound projects. EIA has been defined by (Jain, Urban and Stacey 1977) in a simple yet convincing way as “a study of probable changes in the various socio-economic and bio-physical characteristics and the environment which may result from a proposed or impending action”.

The United Nations Environment Programme (UNEP) in 1987 set certain goals and principles of EIA and defined it as an examination, analysis and assessment of planned activities with a view to ensure environmentally sound and sustainable development. The Rio declaration in 1992 has given emphasis to EIA (principle no.17) as a national instrument which shall be undertaken for proposed activities that are likely to have a significant and adverse impact on the environment and are subject to a decision of a competent national authority. In agenda 21, chapter 8 is entirely devoted to integrating environment and development in policy, planning and decision making processes, providing an effective legal and regulatory framework, making effective use of economic instruments and market and other incentives and establishing a system for integrated environmental and economic accounting. The field of EIA was pioneered in the US by formulation of the Natural Environmental Policy Act (NEPA) in 1969. Subsequently, a number of developing and developed countries such as Canada in 1973, Australia and New Zealand in 1974, Japan in 1981, the European community in 1984, The Netherlands in 1986 and the UK in 1988 have enacted similar legislations at different times to conduct EIA. A lot of experiments have been going on throughout the world for the effective application of EIA to ensure environmentally sustainable development (Fig 1.1).

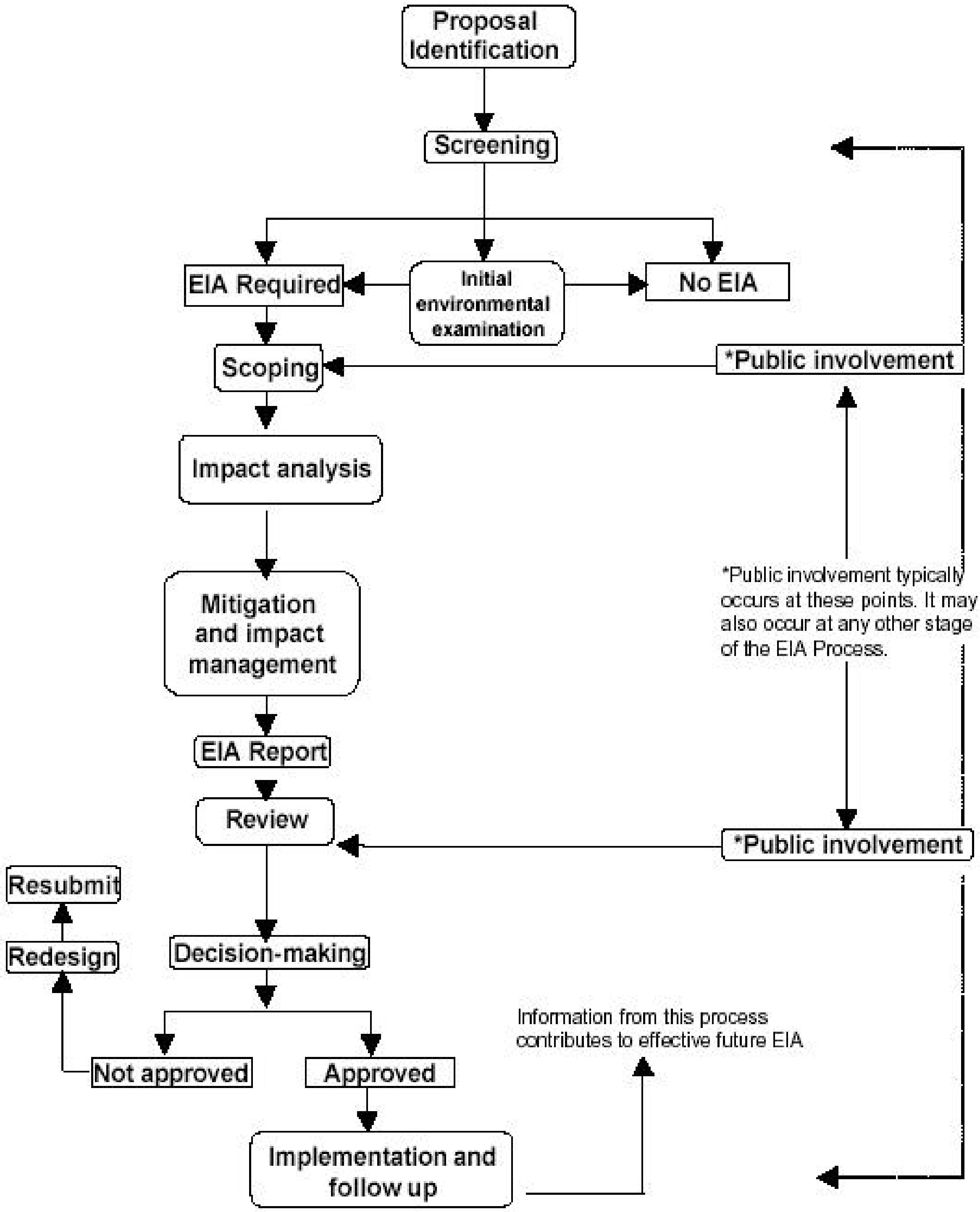

Figure 1.1. Environmental Impact Assessment (EIA) flow chart

(Source: UNEP 2003)

1.4 HISTORY OF EIA IN INDIA

The Indian experience with Environmental Impact Assessment began over 30 years back. It started in 1976-77 when the planning commission asked the Department of Science and Technology to examine the river valley projects from environmental angle. This was subsequently extended to cover those projects, which required approval of the Public Investment Board. Till 1994, environmental clearance from the central government was an administrative decision and lacked the legislative support. On 27 January 1994, the Union Ministry of Environment and Forests (MoEF), Government of India, under the Environmental (protection) Act 1986, promulgated EIA notification making environmental clearance (EC) mandatory for expansion or modernization of any activity or for setting up new projects listed in Schedule 1 of the notification. Since then there have been 12 amendments made in EIA notification of 1994. Today environmental clearance from the central government is required for 32 categories of developmental projects broadly categorized under the following industrial sectors: mining, thermal power plants, river valley, infrastructure (road, highway, ports, harbours and airports) and industries including very small electroplating or foundry units. Although for many other projects, EIA is not needed. Certain activities permissible under the Coastal Regulation Zone Act, 1991 also require similar clearance. Additionally, donor agencies operating in India like the World Bank and the Asian Development Bank (ADB) have a different set of requirements for giving environmental clearance to projects that are funded by them.

1.4.1 Environmental Impact Assessment practices

The notification states that the requirement of EIA can be dispensed with by the impact assessment agency (IAA) which presently is under the MoEF. Environmental appraisal committees constituted by the MoEF for various types of developmental projects include river valleys, multi-purpose irrigation and hydroelectric projects;

atomic power and nuclear fuel projects, mining, industrial, thermal power, tourism/transport, and miscellaneous projects and port and harbour projects. The MoEF has developed guidelines for the preparation of EIA reports along with questionnaires and checklists for the following sectors, namely, industry and mining projects, thermal power projects, river valley projects, rail, road, highway projects, ports and harbours, airports, communication projects, new towns, and parameters for determining ecological fragility. The MoEF amended the EIA notification (S.O.No. 60E) on 10 April 1997 making public hearing mandatory for environmental clearance. The public hearing will be conducted by the state pollution control boards (SPCB) before the proposals are sent to the MoEF for obtaining environmental clearance; and for site-specific projects, it is even before the site clearance applications are forwarded to the MoEF. The MoEF is also in the process of decentralizing the responsibilities of conducting EIA.

In the move, the central government has notified (dated 10 April 1997, no. S.O.319.E) that certain categories of thermal power plants, namely, all capacity cogeneration plants, captive coal and gas/naphtha-based power plants up to 250 MW, coal-based power plants up to 250 MW using conventional technologies, coal-based plants up to 500 MW using fluidized-bed technology, and gas/naphtha based plants up to 500 MW require environmental clearance from the state government. In the case of pithead thermal power plants, the applicant shall intimate the location of the project site to the state government while initiating any investigation and survey. Proposals, where forest land is a part of the project site, need prior forestry clearance before forwarding to the MoEF for environmental clearance. In the environmental clearance process, the documents to be submitted to the MoEF are the project report, the public hearing report, site clearance for site specific projects, a no objection certificate from the state pollution control board, an environmental appraisal questionnaire, the EIA/

environmental management plan (EMP) report, risk analysis for projects involving hazardous substances, and rehabilitation plans if more than 1000 people are likely to be displaced.

1.5 ISSUES IN THE IMPLEMENTATION OF EIA

A number of issues and constraints that are involved in the process of getting environmental clearance during and after project monitoring and implementation are discussed. Environmental impact assessment is to be introduced as both regulatory and management tool to ensure an environmentally sustainable project. There is a need to strengthen the enforcement mechanism for the implementation of the provisions made in the EIA report and specify the time requirement in each step in the EIA process. It would provide confidence to the operators. There is a need to have clear guidelines for review process which would facilitate the removal of conflicts of interest in the review panel. Representatives from nongovernmental organizations (NGOs) should be included in the review panels. The implementation mechanism needs to be strengthened by using effective regulatory provisions, extending economic incentives, or keeping provisions for environmental guarantee funds which can be used to pay for damages caused or for rehabilitation necessitated by a project. Lack of availability of baseline data increases the cost of preparation of EIA/EMP. In some cases, even though it is available, it is either not in a useful form or reliable. There is a lack of post-project monitoring of environmental conditions to observe the compliance of performance committed in the project report. Most proponents do not submit the required periodic status reports. Lack of institutional mechanism and coordination during the project initiation, decision-making, execution, and implementation processes fail to address and ensure an environmentally-sound development. Therefore, it is imperative to strengthen and ensure the institutional linkages in all stages of the project. A mechanism is needed to ensure that all interested parties are participating in the EIA process including NGOs. There is a need to provide training on the technical aspects of EIA to make participation effective. The social acceptability criteria need to be well defined. The role of state government, regional, and local authorities in the enforcement of EIA needs to be specified. There is an urgent need for training and information dissemination amongst state, regional, local authorities, and NGOs for effective public hearing and implementation of EIA. It is increasingly felt that EIA is often applied to individual projects than to policies, plans, or programmes that inform conceptual and regional development. Environmental assessment of policy, plan, or programme is commonly called strategic environmental assessment. For planning the regional development, it is imperative to take into account the supportive capacity of the resources and the assimilative capacity of the environment.

1.6 IMPORTANCE OF THE STUDY

The river Tamiraparani is one of the perennial rivers flowing in the South India and covers an area of 5869 km^2 and has six major tributaries; Servalar, Manimuthar, Gadana, Chittar, Pachiyar and upper Tamiraparani and together they 1176 Mm^3 to the total yield of the river. The basin receives rainfall 1100mm during the southwest monsoon (June-September) and the northeast monsoon (October-December) and has a perennial flow regulated through eight diversion weirs for irrigation. The bed of the river is made up of igneous and metamorphic rocks in the upper reaches, but turns sandy in the middle and lower reaches. The river has deposited extensive alluvium in the basin used for cultivation. Red soils and a mixture of red and black clay soils are the major soil type found in the basin (IWS 1988). Irrigation occupies 48% of the land used in the basin and utilizes 90% of the water available in the basin. There are a number of natural lakes in the basin that have their own catchments and/or river supply through channels and occupy 6% of the basin area.

This small river basin has been chosen to study the environmental biogeochemical cycles and their flux transformation from the river basin to the adjacent coastal oceans (Bay of Bengal). Ravichandran et al (1996) demonstrated the usefulness of eco-regions within the hydrological context for describing water quality patterns in river basin. So far, no work has been carried out on the environmental impact assessment of the Tamiraparani river basin. Spatial and temporal monitoring of stream quality water has been used as one of the important tools for water quality assessment (Shrestha and Kazama 2007). Hence, there is a need for comprehensive spatial and temporal assessment of water and sediments quality of river basin. The present study focuses on the surface water quality, spatial distribution pattern of trace elements and nutrients, its changes on dissolved loads, pathogenic indicators microbe and pesticide pollution to understand the environmental significance of the river basin. Identification and quantification of influences (natural or anthropogenic inputs) and understanding the contaminant sources is crucial to planning, mitigation, and cleanup process and to establish future management strategies.

1.7 REVIEW OF LITERATURE

1.7.1 Water Chemistry

Livingstone (1963) was the first to initiate the studies on chemical composition of the inland water of the world. Since then, a lot of important work emerged on the world's biggest rivers: for example Amazon (Gibbs 1967 & 1972; Stallard and Edmond 1983); Mackenzie (Brunskill 1975), Parana (Depetris and Griffin 1968), Meckong (Meybeck and Carbonnel 1975), Ganges-Brahmaputra (Raymahasay 1970; Handa 1972; Abbas and Subramanian 1984; Sarin and Krishnaswamy 1984; Ittekkot and Arain 1986; Sarin et al 1989), Lena (Gordeev and Sidorov 1993), Congo (Gaillardet et al 1995; Dupre et al 1996), Oti river in Ghana (Abdul-Razak et al 2009) and major world rivers (Dupre et al 1999).

After the extensive study on Amazon river Gibbs (1967) concluded that relief is the most important parameter in controlling the chemistry of river water. According to him natural mechanism controlling world surface water chemistry are: a) atmospheric precipitation, both composition and amount; b) rock weathering; c) evaporation and fractional crystallization. For all major world rivers (Mississippi, Ganges, Nile etc.,) rock weathering supplies most of the dissolved salts. Douglas (1973) has determined the rates of chemical denudation in selected small catchments in eastern Australia. Turvey (1975) has studied the water quality in tropical rain forested catchment river. The natural factors that regulate water quality starts with the nature of surface water rocks exposed for interaction with water. While, the geology of the region is very complicated, the lithology can be simplified as composed of soft rocks/sediments in the Himalayan and northern plain region while the southern plateau region in India and Sri Lanka is dominated by hard rocks with a thin belt of soft rocks along the 8000 km coastal belt (Valdiya 1984). All the rivers in general, show high carbonate alkalinity independent of local lithology: rock weathering involving atmospheric CO_2 and minerals in different lithology uniformly release Ca^{2+}, Mg^{2+} and HCO^- to the river water (Berner and Berner 1996). In India, under the National rivers Conservation Program, water quality of all the major rivers is regularly monitored for various physical, chemical, bacteriological and hydrological variables, thus generating large hydro-chemical databases of high complexity, which are often difficult to analyze and interpret for useful outcome (Dixon and Chiswell 1996). Reservoirs play a very important role in the geochemical cycling of elements and influence the chemical composition and material transfer of the river system. It has been observed that the rivers of the Indian subcontinents show pronounced spatial variability in sediment and dissolved load, primarily in response to the lithology, river-bed slope and human interference i.e. deforestation, cultivation, construction of dams and urbanisation (Subramanian 1987 & 1993).

In India, river basin studies were initiated by Raymahasay (1970) followed by Handa (1972) for the Ganges river. Later the chemical transport of individual river basin has been studied by several workers for example Godavari (Biksham and Subramanian 1988), Krishna (Ramesh and Subramanian 1988), Mahanadhi (Chakrapani and Subramanian 1990), Ganges-Brahmaputra (Abbas and Subramanian 1984; Sarin and Krishnaswamy 1984; Sarin et al 1989, Datta and Subramanian 1997); Gomti (Gupta and Subramanian 1994), Cauvery (Ramanathan et al 1994; Venkatesharaju et al 2010), Betwa river (Sarita Verma 2009), Damodar (Chatterjee et al 2010). Sarin et al (1989) reported that the Ganges and Brahmaputra river system together supply 130 million tons yr^{-1} of dissolved solids to the Bay of Bengal, which is nearly 3% of the global river flux to the ocean. It is well known that physical weathering is dominant in Asian rivers but it should also be noted that the solute yield (69 tons km^2 yr^{-1}) of the Indian sub-continent is twice that of global average 35 tons km^2 yr^{-1} (Subramanian 1983). The peninsular rivers, constituting a small part of the great Indian river system are, nevertheless important due to the area they cover and density of population they serve. In this study, a multidisciplinary approach towards the understanding of various processes (natural and anthropogenic) that control the environmental biogeochemistry of the Tamiraparani river basin has an attempted.

1.7.2 Organochlorine pesticides

1, 1, 1-trichloro-2, 2-bis (p-chlorophenyl) ethane (DDT) was first synthesized in 1874 in Germany. Paul Müller in the late 1930s Rogan and Chen (2005) described its insecticidal properties. Commercial sales began in 1945 and DDT became widely used in agriculture to control insects (Turusov et al 2002). However, Rachel Carson’s Silent Spring, which was published in September 1962, described the environmental damages of DDT and later catalyzed public and governmental concern about it (Murray 2002). As a result of further studies, DDT was banned in the USA and other countries in the

1970s. These bans were largely based on ecological considerations (Turusov et al 2002). In India, the first report of poisoning due to pesticides was from Kerala in 1958, where over 100 people died after consuming wheat flour contaminated with parathion6. This prompted the special committee on harmful effects of pesticides constituted by the ICAR to focus further attention on the problem (Wadhwani and Lall 1972). Significant amounts of HCB can be found in water in rivers, lakes and seas, and generally, river concentrations > estuary concentrations > lake concentrations > sea concentrations. Levels of HCB in rivers in remote areas are low, with values of 0.5 – 20 pg l^{-1} reported in New Zealand (Herrmann 1987) and 3-14 pg l^{-1} reported in Northern Ontario rivers (McCrea et al 1984).

The DDT and HCH residues measured in several rivers of South India. Neither study found significant changes in DDT residue concentrations in water of the river Vellar, Kaveri and Coleroon or in the Pichavaram mangrove wetland based on seasonal changes, wet or dry season or summer, pre-, post- or monsoon season. However, there was a significant increase in mean Σ-HCH levels during the wet season for the Vellar river and the Pichavaram mangroves (Ramesh et al 1990a) and among premonsoon season for the rivers Kaveri and Coleroon (Rajendran and Subramanian 1997). The increase in Σ-HCH concentrations corresponding with the time of increased agricultural use of the pesticide and the absence of a similar pattern of ΣDDT strongly suggests that farmers for pest control are not employing DDT nor is it being excessively employed in public health programs in South India. OCPs including DDT, hexachlorocyclohexanes (technical HCH), lindane, dieldrin and aldrin were all imported and applied to farmland. These OCPs have produced its share of pesticide poisoning and wider environmental contamination, especially in the agricultural sector (Boonyaratumanond et al 2002). These persistent organic compounds such as HCH isomers, DDT and its metabolites are the predominant chemical contaminants found along the Indian coast

(Sarkar et al 2008) and were reported in major rivers (Rajendran and Subramanian 1997; Zhou et al 2006; Leong et al 2007; Imo et al 2007; Ma et al 2007; Kannel et al 2007; Poolpak et al 2008; Doong et al 2008; Kaushik et al 2008; Malik et al 2009 and Bulut et al 2010). India is one of the major producer and consumer of Organochlorine pesticides, particularly dichlorodiphenyltrichloroethane (DDT) and hexachlorocyclohexanes (HCHs) for agriculture and public health programs. Even in the 1990s more than 70% of the gross tonnage of pesticides used in agricultural applications in India consisted of formulations which are banned or severely restricted in the east and west (Gupta 1989; Shetty 2001 and Subramanian et al 2007). Several researchers (Agarwal et al 1986; Ramesh et al 1990; Rehana et al 1995; Rajendran and Subramanian 1997 & 1999; James 2000; Malik et al 2009 and Begum 2009) report the pesticide pollution and their impact on Indian rivers.

1.7.3 Pathogenic indicator organisms

Pathogenic indicators are used to determine the presence of disease causing organisms originating from fecal pollution. Indicators such as Total Coliform (TC), Fecal Coliform (FC) and Fecal *Streptococcus* (FS) are used because of the laborious technique and equally expensive equipment required isolating pathogenic bacteria and viruses from water. Lin et al (1974) were investigated bacterial assessment of Spoon river water quality. By using fecal coliform to fecal streptococcus ratios to sort out fecal pollution origins, it was evident that a concern must be expressed not only for municipal wastewater effluents to the receiving stream, but also for non-point sources of pollution in assessing the bacterial quality of a stream. Ambient water quality regulations make use of bacterial indicators because the density of an indicator in the water can be quantitatively linked potential human health risks (Cabelli 1983). The United States Public Health Services (USPHS) first based coliform indicator criteria on studies that the agency conducted in the 1940's and early 1950's. In the 1960's the

USPHS adopted the fecal coliform standard by using a fixed ratio (18%) of fecal coliform to total coliform bacteria (USEPA 1986).

Bacteria show an affinity for inorganic particle surfaces, and the role of chemical factors such as the pH and ionic strength of the solution (Walker et al 1989; Mills et al 1994; Yee et al 2000), cell factors such as hydrophobicity (Gannon et al 1991a) and the mineralogy and surface properties of the particles (Scholl et al 1990) all influence the adsorption process. Microbiological impairment of water may be assessed by monitoring, usually for the presence of indicator bacteria such as fecal coliforms, *E. coli* or *fecal enterococci*. These microorganisms are associated with fecal material from humans and other warm blooded animals and their presence in water may also signal the presence of enteric pathogens. Specific pathogen monitoring may also be used to assess impairment of water. The USEPA has published a protocol for developing pathogen TMDLs that provides guidance for this process. Pathogen levels of surface water are sun light sensitive and are related to many other factors including temperature, salinity, moisture, soil condition, water body condition and encystations (USEPA 2001).

Indicator organisms are used as diffuse pollution indicator, as well. Maul and Cooper (2000) used *enterococci* and fecal coliform bacteria concentrations to assess the variability of water quality in an agricultural field during wet weather. Aitken (2003) investigated the potential risk of fecal contamination due to diffuse pollution on river catchments and coastal bathing water using indicator organisms. Indicator organisms are often used as a tool to identify the contaminant sources. Whitlock et al (2002) used fecal coliform to identify the contaminant sources in an urban watershed. The presence of *Escherichia coli*, a more common microbial constituent used for water quality examination indicates fecal contamination, since *E. coli* is the subset of fecal coliform. Fecal streptococci are also often used as an indicator. Pathogen levels in surface water are regulated in many countries to guarantee water quality for recreational use, drinking water supply, and aquatic life protection. United Nation Environmental Program (UNEP) and World Health Organization (WHO) have established criteria for coliform concentration for primary contact recreation purposes. Fecal coliform concentration of geometric mean of at least 5 samples should be less than 100/100 ml for 50% and less than 1000/100 ml for 90%. The U.S. EPA requires *E. coli* density to be less than 126/100 ml for fresh water for a logarithmic average for a period of 30 days of at least 5 samples (USEPA 1999).

The most frequently used microbial indicators of water quality are Total Coliforms (TC), Fecal Coliforms (FC) and Fecal *Streptococci* (FS); all considered indicators of recent fecal contamination (Godfree et al 1997). Fecal contamination of water is considered a human health risk, and there has always been a great deal of concern regarding the level of coliform bacterial counts in water. To establish a relationship between the concentrations of fecal indicators and the risk of illness upon using contaminated water, many epidemiological studies has been conducted (McBride et al 1998; Van Asperen et al 1998; Zamxaka et al 2004). Unsanitary means of disposing human waste and faecal droppings from livestock are routes through which faecal matter may enter aquatic systems. Faecal matter degrades water quality due to the possible introduction of pathogens, nutrients and organic matter (Vinneras et al 2003; Langergraber and Muellergger 2005; Vikaskumar et al 2007). To minimize health risk, it is often required to undertake regular monitoring of indicator parameters in aquatic systems (Kong et al 2002; McLellan and Salmore 2003; Noble et al 2003; Shah et al 2007). Such assessment studies are useful not only for evaluating health risk, but also for determining the course of action that may be required to solve the problem (Parveen et al 2001; Ahmed et al 2007; Graves et al 2007). Assessments on the water quality parameters are coliform including the bacterial abundance from a point source of river.

1.8 GENERAL OBJECTIVES

The river basin represents a dynamic area with complex human and natural factors affecting and altering their physical structure and chemical composition to a large extent. In contrast to the great quantity of published data on large Indian rivers, only limited studies (Ravichandran et al 1996) have been conducted on a small river Tamiraparani river basin. With these aspects in view, a detailed investigation of a small sized river basin has been taken up with the following objectives.

- To assess the spatial and temporal variations of major ions and nutrients in water and its controlling factors.
- To assess the impact of natural and anthropogenic activities on nutrient biogeochemistry in the river basin.
- To assess the levels and spatial and temporal distributions of organochlorine pesticides (OCPs) in water and sediment and discuss their contamination profiles and possible sources of certain important OCPs from agriculture.
- To enumerate the pathogen indicator organism in water quality management and understand the concentration range of pathogen indicator organisms in the surface water.
- To suggest an optimal land use plan using the Geographic Information System (GIS) and broadcast overall impacts in the river basin.

By virtue of complex natural process that occurs in a river basin, a multidisciplinary effort is necessary to understand the ongoing environmental changes and this research work is a step ahead in this direction.