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ENVIRONMENTAL HYDROLOGY

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1.0 INTRODUCTION

The surface of the earth forms a geographical space in which man creates an anthropologeneous living environment by influencing the land directly and indirectly, deliberately and building activities. This is particularly true of continuous build up areas of housing and industries, linear civil engineering structures (railways, roads, bridges, tunnels), public utility networks,waterstructures,etc. Theseactivitiesare complemented by those of agriculture. The effect of such influences becomes evident in terrace cultivation in slopes, strip tillage, felling of forests, etc. Exploitation of minerals and other substances by mining causes, etc. and these often result in very adverse changes.

Many human activities have an impact on water quantity and water quality, and its is useful to look at the interactions between man's activity, the climate, the catchment characteristic and the hydrologic cycle. Man's activities can have a considerable impact on the catchment characteristic and hence on the hydrologic regime. Depending on the nature of this impact, man's activity can be classified into the following categories:

a) Activities leading to changes in the vegetation and land use (deforestation and afforestation, agriculture, drainage of swamps and marsh ridden areas, urbanization etc.).

b) Activities leading to changes to topography and drainage system (construction of various hydraulic structures such as dams, barrages, embankments, polders, terraces and contour plowing).

c) Activities leading to direct and indirect water diversions from or to the rivers the ground water system (surface and ground water abstraction for use outside the area, affluent discharge, artificial ground water recharge, drainage, irrigation etc.).

A climatic change induced by increased concentration of greenhouse gases is possibly the greatest human impact on the inputs of energy and precipitation into the catchment system. Cloud seeding is deliberate attempt to alter inputs-although within certain effects-and emission of sulfur dioxide and other industrially produced gases leads to changes in chemical deposition in a catchment. Many activities influence hydrological regimes by their effect on evaporation and transpiration, of which deforestation is the longest activities also influence both the way water enters the surface and sub-surface soil water storage and movement process. Field drainage, for example, is a deliberate attempt to alter the soil moisture characteristics of a field.

Though all the human activities affect one or more than one components of the hydrologic cycle in small or big way however influence of four activities of man has got great concern on the hydrologic cycle. These are deforestation, urbanisation, use of chemicals i.e. water quality and reservoir impoundments. These impacts operate at different scales: deforestation covers a large area, for example, whilst urbanisation has a greater impact over a more confined area, and river regulation tends to have wide-ranging effects on the flow regimes of large rivers. The studies conducted at the international level by hydrological community have shown tha: although there is a general consensus about the types of changes resulting from a given activity, the actual degree of change is very variable. Not only do the physical and climatic conditions of basins vary but similarly titled impacts can also take many forms. One activity is rarely performed in isolation, and the hydrological characteristics at a basin outlet are an integration of the effects of different activities operating at different scale. For example, afforestation is often preceded by ditching, and field drainage is frequently accompanied by arterial channel modifications and changes in agricultural practices.

Changes in land use and other human influences may lead to very important changes in the hydrological behavior of a particular basin, but variations in behavior between basins are related more to such characteristics as climate and basin topography and geology. Land use and other human influences can therefore be seen 'second order' controls; they become important in explaining variations between basins if topography, geology and climate are relatively constant. The relative importance of all these attributes of a basin must be examined by undertaking regional hydrological investigations.

This complexity of effect and impact has let to the emergence of two main approaches to studying change, namely the use of experimental basins and mathematical simulation of hydrological process, both of which attempt to hold some key attributes constant. Detailed experimental studies of the effects of particular human activities are necessary to understand the processes and dynamics involved and to develop appropriate management responses. However, more attention needs to be directed to the problems of transferring information from experimental sites, with due regard given to the underlying complexities in controls on hydrological processes and responses and the importance of basin scale. Such transfer of results between basins and scales requires an understanding of the reasons for variations in hydrological behavior between basins, and information on the key characteristics of both the study sites and the desired 'target' area.

Based on the studies conducted in the areas of afforestation and deforestation, water quality, environmental impact studies and impact of urbanisation, in the following four sections, an attempt has been made to bring out the thrust areas of research in these four aspects for the country. The attempt has been made to come out with two categories of priorities- Priority-I (short term or immediate) and Priority- II (long term or lower).

2.0 NEED FOR R & D ACTIVITIES AND PRESENT STATUS

2.1 Afforestation and Deforestation Studies

The influence of forests on their environment forms part of a complex relationship between environment and forest vegetation. Investigators have investigated for past several decades to ascertain the influences of forests on hydrological parameters and water availability. In this direction, forest influences on various hydrological parameters viz. rainfall, interception, infiltration, soil moisture, evapotranspiration, ground water, water yield, soil loss and floods, etc. forms an important area of hydrological studies. A summary of results of studies done in this regard in the country is given in following sections.

2.1.1 Rainfall

Based on the limited studies done in Indian it may be concluded that the result are generally inconclusive in nature, indicating that forests do not affect rainfall on a regional scale. However, in coastal forests the precipitation may be more because of interception and then condensation of fog by forests.

2.1.2 Interception

It can be concluded from the Indian studies that the interception is a function of forest type, density, composition, structure and rainfall amount/intensity. It may be inferred that the average total interception by a dense forest cover (including canopy interception 20 % undergrowth 10 % and litter interception 5%) appears to be around 35%. It has also been observed that the interception is higher from needle leaves trees as compared to broad leaves trees. The interception in forested catchments does not have significant effect during heavy storm (100 mm or so). However, this is important from soil conservation view point.

2.1.3 Infiltration

From various studies it can be inferred that the infiltration rates are relatively more in forested soils as compared to agriculture areas & grasslands. Based on the result of some of the infiltration studies carried out, it could be inferred that infiltration rates from arable crop land and grasslands are nearly 30 to 35% and 40-50% respectively of that from forest lands. However, it is drastically affected due to biotic interferences like forest fires, tampling by cattle, removal of leaf litter, etc. The studies conducted abroad also confirm these results (Molchanov, 1963).

2.1.4 Soil Moisture

In general, it can be concluded that much efforts have not been made to quantify soil-moisture storages under forested lands. However, forested soils have a better soil retention capacity due to improved soil structure because of more humus and organic content.

2.1.5 Evapotranspiration

Studies leading to computation of forest transpiration have indicated that forests generally absorb more radiant energy which is available for transpiration. A limited number of studies done, have indicated that forests have generally high evapotranspiration (ET) requirement as compared to other land uses. The studies conducted in India indicate that forests have higher ET requirements as compared to other land uses. However,more studies are required to be done for systematic computation of ET by forests.

2.1.6 Ground water

The effects of forests on ground water have not been studied on large scale. A limited number of studies done abroad in this regard have indicated non-coherent result.

2.1.7 Water yield

Based on studies reported above it can be inferred that substantial reduction of densities of forest over stories and thinnings (more than 30%) increase water yield and establishment of forest over stories on sparsely vegetated land and/or changing to fast growing species like Eucalyptus decrease water yield. This decrease is more significant in first few years of growth. Besides, the type of land cover, the size of watershed have also important bearing on water yield. Based on various studies, it appears that in small watersheds forests tend to decrease the water yield (i.e. due to decreased surface run-off) while in large watersheds, the sub surface component of total water yield (delayed yield) gets increased.

2.1.8 Soil Loss

From the limited studies, it can be concluded that soil loss is less from dense, well managed forests in comparison to ill managed (denuded) forests. However, soil loss is very less from well managed grass lands. Soil conservation is an effective answer to soil loss problems.

2.1.9 Floods

The occurrence and frequency of floods can not be conclusively linked with deforestation or afforestation in absence of factual data. It is important to note that afforestation measures basically minimise soil loss and reduce sediment load in streams and rivers thus moderating flash floods. The effect of afforestation may be insignificant for large floods.

2.2 Water Quality Studies

2.2.1 River quality

India is a vast country with a total geographical area of 329 million sq. km. India is also fortunate of have numerous rivers, big and small which traverse the land in practically every direction carrying the much needed water through dry and thirsty lands. Though our country's major water resources were relatively free from pollution up to some year back, marked deterioration in water quality has come to the notice in a number of locations. Even the Ganga water, once considered the purest of all and regarded as sacred, is getting polluted by discharge of untreated sewage and industrial wastes. Factories and large industrial establishments situated on the banks of rivers discharge large quantities of untreated effluents and other industrial wastes. Municipal authorities also discharge large quantities of untreated sewerage and sullage which contribute in a large measure to the deterioration of the water quality especially during the dry season.

Drinking water has to meet certain fairly stringent quality standards and water quality is also important for agriculture and industrial uses. The method of classification, to deal with such multiple use situation, is evolved based on the use which demands the highest degree of water quality. The use identified is referred to as the Designated Best Use. The classification scheme based on Designated Best Use has been given by CPCB. Each of these use in-turn leads to pollute water quality. In recent times, on account of the increase in population, urbanization and industrialisation, there is an ever-increasing threat to the quality of waters in rivers, lakes and streams. Unfortunately, the sanctity attached to rivers in the country does not ensure a concern for the maintenance for the purity of water. It will be necessary to review continuously the quality standards to be aimed at in the country's rivers as well as in ground water aquifers, having regard to all the relevant standards.

Status of river water is assuming great importance in India on account of the gigantic problems being faced by the country like rapid growth of population, increase in standards of living, fast development of river valley projects, increased of water for industrial and urban water supply etc. It is reported that about 70 percent of available water is polluted (CSE,1982). The chief source of pollution is identified to be sewerage constituting 84 to 92 percent of waste water while industrial waste water comprises 8 to 10 percent (Chaudhari, 1982).

2.2.2. Ground water quality

In India numerous studies have been done on the ground water quality. The main agencies which are engaged in these studies are the Central Ground Water Board, State Ground Water Board, Research organisations and Universities. It would be useful to provide a background of the ground water quality problems of the country and also covering the studies which have been conducted. Ground water quality problems can be divided into two parts. Some of these problems are due to natural causes as a result of leaching of various chemical constituent by circulating waters. Other problems which are related to anthropoganic source are mush more harmful for the human health. Various causes of ground water quality problems are listed as under :

a. Natural causes

i. occurrence of high salinity
ii. high concentrations of fluoride
iii. high concentrations of iron and
iv. sea water intrusion.

b. Anthropogenic causes

i. sewage pollution,
ii. industrial pollution
iii. agricultural pollution and
iv. radiological pollution.

Out of these, sea water intrusion could be both due to natural causes as well as anthropogenic causes.

2.2.3 Problematic areas in the country

There is hardly any State in the country which does not have water quality problem in one form or another. Though ground water quality problems due to natural causes are confine to selected areas, degradation of ground water quality as a result of environmental pollution is very extensive and most parts of the country are affected from one or more sources connected with sewage, industrial and agriculture pollution.

It will not be possible to list ground water quality problems of all the parts of the country. Some of major problems in different areas are :

A. Problems associated with natural causes

(i) High Salinity

.ere are large areas in semi-arid and arid belt consisting parts of Rajasthan, southern Punjab, southern Haryana and Gujarat where salinity of ground water moderately to fairly high. There are several places in parts of Rajasthan and southern Haryana where E.C. values of ground water are greater than 10,000 micro siemens/cm making water unpalatable (Handa, 1983). In some of areas such as Kumher and Dig (Rajasthan), Farruknagar and Sultanpur (Haryana), salinity of ground water is so high that salt used to be manufactured by solar evaporation.Even now at Agar-Ka-Rin in western Rajasthan and at Kuda,Kharghoda in Gujarat, salt is being manufactured by solar evaporation from well waters. For drinking purpose, high salinity is one of the major ground water quality problems in these areas. In parts of southern Punjab, U.P., A.P. there are pockets where ground water has E.C.values exceeding 5000 microsiemens/cm.

In the coastal area, water is moderately to highly saline depending upon the extent of sea water intrusion.

(ii) High fluoride

High concentrations of fluoride in ground water are common in some of semi-arid areas of Rajasthan, southern Punjab, southern Haryana. Several areas of Andhra Pradesh have high concentrations of fluoride in ground water (exceeding 5 mg/l). There are number of cases of dental and skeletal fluorosis in these areas. In several parts of Karnataka, Tamil Nadu, U.P.and other areas, fluoride concentrations of ground water are more than the permissible level of 1.5 mg/l.

Apart from salinity, high concentration of fluoride is a serious ground water quality problem in several parts of the country.

(iii) Hign iron

High concentrations of iron in ground water have been found in several areas of high rainfall particularly in north eastern states. In Assam, some of wells have iron content as high as 20 mg/l. In Nadia district of West Bengal, iron concentration of 2-3 mg/l has been reported in ground water at several places (Handa, 1986). In West Bengal, high concentrations of iron in ground water may be due to lowering of redox potential due to presence of organic matter and also at depth, lignite of found which can be associated with high iron content.

(iv) Sea water intrusion

In the coastal areas, ground water salinity problems are there almost in all the areas with varying degrees. These problems are more extensive in the east coast in comparison to west coast probably due to greater ground water development. The coastal alluvial tracts including deltaic tracts of major rivers the Ganga, Mahanadi, Krishna, Godavari, Kaveri have varying degrees of salinity.

The major causes of salinity of ground water in coastal areas can be attributed to:(i) tidal water ingress in upper aquifer, (ii) sea water ingress in lower aquifer, (iii) over exploitation of ground water, and (iv) less natural recharge of ground water.

B. Problems associated with anthropogenic causes

As already pointed, environmental pollution as a result of activities of man has become one of the major causes of degradation of ground water quality. With rapid urbanisation, industrialisation and extensive use of fertilisers, insecticides and inadequate steps taken to check pollution, there has been widespread sewage, industrial and agricultural pollution in several parts of the country. Some of these aspects in brief are discussed as under:

(i) Sewage pollution

There is hardly any town in India which has satisfactory sewage treatment system for its population. Even in metropolitan cities like Delhi entire sewage is not treated and part of its flows to river or is discharged on land where it may seep into ground water system. The position with regard to sewage disposal in other cities is similar to or worse than Delhi.

Though during the process of percolation, sewage looses part of bacteria while passing through the soil and geological materials (natural purification), cases of bacterial pollution of ground water have been reported (Narayan & Rao, 1981). This may to due to direct contamination of well waters or due to cess pools near the well casing and occurrence of small gap between the casing and surrounding wells, resulting in infiltration of contaminated waters.

Number of deaths due to gastro-enteritis in Delhi during 1998 can be linked to sewage pollution of ground water which when withdrawn through hand pumps and used for drinking purposes, resulted in spread of this disease.

(ii) Industrial pollution

In various parts of the country, wherever there is intensification of industries, the process of proper treatment of industrial effluents has lagged far behind the industrial growth. If a river, canal or any other surface course is available, the industries in most of the cases discharge their effluents in surface waters without proper treatment. Alternately, the effluents are discharged through unlined channels on land or depressions near the industrial units. Though some of constituents present in effluents may be absorbed by soil and unsaturated zone, this capacity is not limited. After passage of time, the toxic constituents percolate into ground water and may damage the entire aquifer system.

The number of industries that can cause damage to ground water quality is substantial. However, the ground water in vicinity of the following industries should be monitored regularly in check the adverse effects of effluents:(1) sewage, (2) breweries and distilleries, (3) soaps and detergents, (4) dairy and meat, (5) fertilisers and agricultural chemicals, (6) pharmaceuticals, (7) textile and rayon, (8) paper and allied products, (9) chemicals, (10) pharmaceuticals and refineries, (11) paints, varnishes and enamels, (12) steel and foundries, (15) electroplating, (14) explosives, (15) mining, (16) wood preservation, (17) photo films, (18) nuclear fuel processing, (19) rubber and tyres and (20) food processing.

Studies carried out by Kakkar et. al. (1981), Kakar et. al. (1983) indicate extensive damage to the ground water quality from effluents of electroplating wastes. High concentrations of cyanide (to the extent of 2 mg/l) and hexavalent chromium (to the extent of 12.8 mg/l) have been observed in ground water of Ludhiana, Punjab. Handa (1986) has reported chromium to the extent of 2 mg/l in ground water Varanasi and 21 mg/l) in Kanpur area of U.P in north Arcot, along the Palar river, effluents from tanning industries are reported to have polluted shallow ground water (Sriniwas et al. 1984).

These are just few examples of ground water pollution from industrial effluents. As pointed out earlier, there are large number of places in the country where ground water quality has been adversely affected due to industrial pollution.

(iii) Agricultural pollution

With the advent of green revolution, fertiliser consumption in the country grown several times. The consumption of N, P and K fertilisers in 1951-52 was 45, 11, 8 thousand tonnes, respectively, which in the year 1982-83, rose to 4362,1420, 735 thousand tonnes respectively. Large number of cattle in the rural areas also generate wastes. Agricultural activities in the rural areas which include application barn yard manure to soils, leakage from composting pits, increase in use of fertilisers and insecticide and at time unscientific management of crops, fertilisers and soil water may result in ground water pollutions. The efficiency of N-fertilisers in India is about 30% for paddy (party being lost by volatilization-microbial decomposition) and about 50% for wheat. For potassium and phosphatic fertilisers, the efficiency is around 50% and 15-20%, respectively (Handa, 1986).

Apart from high concentrations of nitrate in ground water given in aforementioned tables, in some of big cities such as Delhi, Nagpur, Hyderabad, high nitrate levels in ground water have been reported (Kakkar, 1985; Gupta, 1981).

There has been some advance in the country of using the water quality models for assessing and forecasting the water quality in the water bodies of the country specially in the rivers. Mostly these attempts have been made in the research and educational organisations. These attempts have been made at the National Environmental Engineering Institute, National Institute of Hydrology, Indian Institute of Technology at Bombay and Delhi, University of Roorkee, Central Pollution Control Board, Ganga Project Directorate, Central Water Commission, etc.

2.3 Effects of River Impoundments

Small scale reservoir development has a locally significant impact on hydrological characteristics, but the consequences of large scale developments on major rivers are much more wide-ranging. Indeed few of the world's largest rivers can be said to remain in their 'natural' state, making it difficult, incidentally, to find suitably unaffected large catchments for the study of the effects of human activities at different spatial scales.

Most studies in India concentrate on the effects of reservoir impoundments on charges in flow regime. These changes are frequently deliberate, although as distance downstream increase may be regarded as being inadvertent or unanticipated. Reservoir development may influence a wider area than just the catchment containing the reservoir, as some schemes involve the diversion of water from other catchments. The precise impacts of impoundments depend on the reservoir size and purpose, design criteria and operating rules, but several areas of impact can be identified. Reservoir impoundments may lead to reduced annual yields not just in catchments from where water is diverted but also in the reservoired catchments themselves, due to evaporation from the reservoir. This will obviously be greater in areas with higher potential evaporation, and may be relatively greater for small reservoirs with shallower depths. Impoundments may also change the seasonal distribution of flows.

The influence of reservoirs on low flows is determined by the design of the release structure - for small reservoirs - or operating rules for the release of 'compensation flows'. These rules are an attempted to satisfy the demands downstream habitats and users, but are often often based on limited knowledge out-of-date information on water users.

More subtly, (and inadvertently) reservoir impoundments may affect local micro climate. The ecological effects of changes in flow regimes downstream of reservoirs have been increasingly studied in recent years, but it is difficult to separate the effects of changes in flow regime from changes in the temperature or chemical composition of the released water. Water in a reservoir tends to become stratified into layers, with the coldest, densest and most chemically-rich water at the bottom. The release of this water may have significant effects on downstream ecosystems, as indicated in several of the reviews to climatic variations and summer flows are cooler.

Economic development in most countries is anchored in the wise exploitation of the renewable natural resource base i.e. soil, water, vegetation, animals, nutrients, solar energy and the ecosystem in which these elements are linked. Development of water as a resource, has been realized only recently and all efforts should be focused on the exponential exploitation of this vital resource. However, while cruising towards this goal it should be always kept in mind that the environmental balance is a delicately poised systems which is greatly dependent on the human interference with the nature. Our water resources development projects have social and environmental implications besides economic implications. Because of non-uniform distribution of rainfall, both spatially and temporally, limited availability if potential sites and pollution problems in mid stream and downstream segments of many rivers, water resources development projects, i.e. building of reservoirs are essential for industrialisation and economic growth of the country. In the recent years there has been a growing concern about the environmental effects of the development activities in general and water resources in particular specially in developing countries. In this regard environmental impact assessment (EIA) has become a generally accepted instrument for decision making. The purpose of the EIA is to determine the potential environmental effects of a proposed developmental activity in a form that permits a logical and rational decision to be made. Attempts can be made to reduce potential adverse impacts through identification of possible alternative sites and/or processes. The results of the assessment can be found in a document called 'Environmental Impact Statement (EIS)'. This document shall contain a discussion of beneficial and adverse impacts considered to be relevant to the project, plan or policy. The present paper attempts to demonstrate a step wise procedure for environmental impact assessment related to large scale water resources development projects. Assessment means analysis and evaluation of impacts. Analysis aims at identification of actions and possible effects, measurement of possible effects and predictions of likely effects. Evaluation of impacts covers determination of the significance or worth of likely effects to the affected parties of ecosystem's productivity. Predictions have to be presented in form useful to decision makers.

Before determining ecological impacts it is important to understand the pattern of fluctuations of ecosystem variables. The project planner must identify the parameters representing the variation before determining whether a predicted or projected change in the ecosystem variable represents a significant departure from the normal range of variation. Main techniques for impact identification are: Checklist Method, Overlay Method, Matrix Method, Network Method, Energetic Method, Environmental Evaluation System (EES).

In india very few studies have been conducted on the use of these methods for actual case studies. The details of the procedures can be found in literature (Lohani, 1982; Bhatia & Abbasi 1983; Bhatia & Sikka, 1986; Bhatia & Lohani, 1987 & 1991). However, these methods have been sparingly used in India and no concrete case studies are available which use one/combination of these methodologies. In India a number of attempts have been made to qualitatively assess the positive and negative impacts of water resources project (WRPs) and conclusions have been drawn highlighting the weightage of positive aspects on negative aspects (Sarma, 1985; Maudgal, 1985; Karajagi, 1985; Mistry & Purohit, 1985; Varshney, 1985; Bhargava, 1989; Gururaj Rau, 1989 etc.). Moudgal (1982,1985,& 1986) has worked on the guidelines for conducting environmental impact studies and has made excellent contributions in the area.

2.4 Urbanisation

Of all indirect human influences on hydrological characteristics, urbanisation has perhaps the most dramatic and rapid impact. The general effect of urbanisation are well known, and are basically due to the replacement of the natural drainage network with a denser, more efficient and permanent network and the covering of large areas of the catchment with impermeable surfaces.

Hardly any systematic studies have been conducted in India and most studies at the international level have been made of the impact of urbanisation on flood peaks (reflecting the need for design techniques under such circumstances), and all show that urbanisation increases flood peaks and reduces lag times. It may also increase the relative frequency of summer floods: previously summer rainfall would have had to fill soil storage before producing floods. As ever, the precise effect of urbanisation of flood peaks depends on the characteristics of the basin. Greater effects are noticed when a previously permeable and slowly respond basin is developed.

Urbanisation tends to reduce minimum flows and ground water levels because rainfall is removed quickly from the basin. However, the return of water abstracted for domestic or industrial use and leakage from water mains has in some areas led to increasing low flows and ground water levels (emphasising the importance of understanding the nature of the human impact as well as the original basin).

The dramatic effects of construction works associated with urbanisation on sediment loads have shown the very significant increases in sediment yield during urbanisation. Once construction is completed, however, sediment yields reduce considerably due to the protective effects of the impermeable surfaces.

Practically all studies worldwide have also shown that water quality changes in and downstream of urban and industrial areas. This is due both to the washing of pollutants from the catchment surface, particularly roads, during rainstorms and the discharge of polluted waste water. Not only are nitrates and other chemicals higher in urban areas, but pollutants with a more long-term impact, such as heavy metals, are also common.

The relatively straightforward effect of urbanisation is reflected in the development of many operational computer models for urban water quantity and quality management, and arises because the changes in a catchment due to urban development are so large. It is significant that the only land use variable with any influence on the variability in flood characteristics is the extent of urbanisation.

3.0 THRUST AREAS

Based on the presentation above, review of literature, recommendations made at various conferences and seminars, the following priority areas can be identified:

3.1 Priority 1 :

1. Identification of sources of pollution and monitoring of hazardous substances, biological degradation in water bodies.
2. Impact of insecticides, pesticides and fertilizers on water quality
3. Water quality modelling.
4. Influence of afforestation and deforestation on hydrological parameters.
5. Representative basin studies.
6. Environmental impact assessment of existing major water resources projects.
7. Impact of urbanisation on hydrological characteristics of a basin.
8. Hydrological processes in the humid tropics environment.

3.2. Priority II :

1. Measurement and prediction of bio-monitoring indicators.
2. Water quality standards for various uses and uniformity in water quality standard for each use.
3. Reuse and recycling of waste water.
4. Determination of infiltration capacities of different soils by different types and densities of forest covers.
5. Development of generalised, computer based, quantitative methodologies for EIA studies preferably with different scenario and data availability.
6. Land use, erosion and sedimentation - their consequences and control.
7. Preservation and restoration of rivers and wetlands.
8. Resolution of water conflicts.

4.0 RECOMMENDATIONS

Once the priority areas of research in environmental hydrology have been identified, it would be appropriate to put forth some notes of caution as well as think of line of action for achieving the intended objectives.

First of all it shall be made very clear that the priorities which are derived are not the priorities for the whole gambit of environmental engineering and those identified are closely related to hydrology only. Secondly, now a days it is a fashion to talk and write about environmental issues, hence scientific and research organisations have a very critical and important role to play. Thirdly, all the issues which are identified in the paper are directly affecting the common man and hence they shall be dealt with great care and selflessly. Fourthly, the issues relating to environmental hydrology are conflicting and very less understood issues and hence they shall be treated with great caution and without hurting the feelings of other groups. The fifth point which shall be kept in mind is the role of media in giving wrong or just picture of these issues as well as importance of publicity. The next aspect is backing up of theory with solid, concrete and quantitative results.

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