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INTERNATIONAL WORKSHOP

on

"Fresh Water Related Issues"

with Discussion on 'National River Linking Plan'

Book of Abstracts

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Introduction

We are now in the year of "Fresh Water" and the World Water Day was celebrated just a few days ago on March 22, 2003. A large number of seminars are being held in many places focussing on several aspects of fresh water scenario in the country. Due to the pressures on the fresh water, the political leadership has opted for a grand national river linking plan. The present plan is basically a modification of several earlier version. By opting to go for such a scheme, a pandora's box has been opened and public debate is taking place in many forum. However, most of the time, the discussion assumes strong views without evaluation of proper data base. In this context, we propose to address the issue from purely academic approach without bias so that stakeholder gets an impartial opinion on this important issue facing the nation. Fresh water exploitation involves many related processes and approaches and many presentations highlight these aspects with case studies from different types of water bodies.

A questionnaire has been prepared to address all issues related to the river link plan and will form the basis of round table discussion during the 3 day workshop. Hopefully this academic exercise will be useful for policy makers for arriving at a practicable solution to the vexed problem of making good quality fresh water available to the people of this country. The workshop is being benefited by expertise in many branches of science and social science thereby indicating the integrated nature of understanding required for issues related to water; water in turn is an integral part of environmental science. The organisers hope that the workshop will also be useful as a means of capacity building on issues related to studies on water quality and related aspects of water science.

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Water, Water, what is the Matter

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With an annual rainfall of over 110 cm and river discharges of about 2000 km3 and very large sedimentary basin to account for ground water, we are still at the mercy of water availability- be in urban areas or rural set up. While the mean rainfall over western Europe is just about that of Delhi, the continent there is green throughout the year whereas ours alternates between ever green to ever gray or brown due to problems in spatial and temporal variability and the vagaries of monsoon year to year. The 2002 monsoon was the last straw to drive home the point that is, water scene has reached critical scene in India and we better take a hard look at facts and figures so that a national policy can be in place. Imagine Channai gets around only 75 l/ person/day while the safe limit as per WHO is around 300 l/day for every adult. Most of the major metros ion India face similar problems. While the average per capita availability for the world as a whole is around 8000 m3/ year , for India, it is about a third of this amount. The major cause for the shortage is man-made- due to excess demand in agriculture- about 70% of total demand today as well as expected to be same in the next fifty years. The increasing coverage of land under irrigation, as exemplified by the Cauvery dispute is just an illustration of strong role played by ad hoc land use policies at different scales. Practically every river basin in the south Asia is under different degrees of water stress and water scarcity.Another front causing distress is the quality aspect. There are no agreements between various "standards" and methodologies. Pesticides, metals and large amount of coli bacteria are reported from practically every corner of the country. Well known problem areas such as the arsenic contamination, high fluoride levels are just a few cases of water quality gone out of control due to a number of compounded activities of man.

In fact, water borne diseases make up the bulk of human health problem. One can visualise the entire human body affected by one or other type of contaminant from water we drink or use daily in our life.. Coupled with poor controls on urban and industrial wastes spoiling the show, the water quality requires equally serious attention. Limited conservation measures in urban areas in Delhi by some NGO seems to bear fruit to improve both the quality and levels of ground water. Can this exercise be extended all over given the limitation of land and the pressures on land use.

The urban water supply in the country is bad to worse and all cities have lower per capita availability compared to the rural areas. Rural areas are no heaven either since there are several social divides that make water available only to select few there also. The bottled water controversy only highlights the conflict between the suppliers and users without regard to any common goals. If the problems are attempted to be solved with plans such as river linking network, it opens a pandoras' box that attracts instant debate- some with valid points and some just hypes. May be it is time, the national debate on the river linking should be handled by unbiased academics so that " stakeholders" are given the true pictures and not predetermined notions either for or against such moves. Today Water is certainly more explosive than even petrol. Let us prevent world water war!

In the absence of technology for making "monsoon" behave as we want it, that is uniform in space and time, there needs to be a practicable solution to address issues related to the availability of fresh water so that our future generations can have water for their physical and spiritual needs the same way our ancestors used this precious resource that is the elixir of life!

Mineralogical Studies for Evaluation of Groundwater Quality

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It is well known that during circulation of groundwater through aquifers, its chemical composition undergoes significant modifications because of interaction with rock-forming minerals. Therefore, any evaluation of groundwater quality would remain incomplete unless a detailed inventory of the mineralogy of aquifer materials is taken into consideration. Recent literature contains many case histories where mobilization of toxic elements into groundwater has been traced to minerals present in the aquifer. Important examples are of F from fluorite, apatite and mica in basement rocks and overlying soils; Cr from chromite in ultamafics and As from iron-coated quartz, clay minerals, mica and carbonate concretions in deltaic sediments. This presentation, specifically, focuses on geochemical techniques by which simple water quality parameters in relatively unpolluted terrains have been utilized to decipher the imprint of mineral-water reactions.

Many alluvial aquifers contain carbonate concretions made of cemented sand. Appropriate ion activity products calculated from the concentration of Ca, Mg and CO_3 in the local groundwater usually indicate super-saturation with respect to calcite, aragonite and dolomite which are common constituents of the concretions. Measurement of temperature, pH and bicarbonate-alkalinity in the field allows an estimate of the effective CO_2-pressure in the groundwater. For example, log PCO_2 values in groundwater of the Kanpur-Mainpuri region of Uttar Pradesh range from –2.5 to –1.4 which are much higher than the value of -3.5 in the earth's atmosphere. Such observations support a mechanism of escape of CO_2 gas from the supersaturated waters and consequent precipitation of $CaCO_3$ in pore spaces. In the same waters, the Ca/Mg activity ratio is lower than K_c^2/K_d where K_c and K_d are solubility products of calcite and dolomite. It can be shown that this condition favours dolomitisation of early formed calcite.

A similar calculation of log PCO_2 values in groundwater trickling into limestone caves at Sahasradhara near Dehra Dun gave relatively high values ranging from –1.4 to –1.2. It was concluded, therefore, that calcite and aragonite found in the stalactites had formed due to escape of CO_2 in the caves which were open to the atmosphere.

The relationship between groundwater composition and aquifer mineralogy is more interesting in igneous and metamorphic terrains. This is because weathering of silicate minerals by CO_2-saturated water leaves a residue of clays. The molar ratio of dissolved HCO_3 and SiO_2 is indicative of the types of weathering reactions which control local groundwater quality. Table 1 shows relevant data from two contrasting lithologies.

Table 1: Weathering reactions inferred from bicarbonate-alkalinity and silica concentration in groundwater.

Aquifer	$mHCO_3$ / $mSiO_2$	Weathering
Weathered Basalt, Madhya Pradesh	3.6 to 10.4	Calcic plagioclase to smectite and augite to kaolinite
Weathered Biotite Gneiss, Kerala	0.7 to 1.5	Sodic plagioclase to kaolinite

A more detailed interpretation of groundwater composition through a series of Garrels type "reverse reactions" leads to the reconstruction of the original mineral assemblage which supplied dissolved constituents by weathering. The balance sheet for such a calculation for an open well water in weathered biotite gneiss in Kerala is shown in Table 2.

Table 2: Reconstruction of rock weathering from well water composition. Concentrations in milli-moles/L.

Steps	Na	Ca	Mg	K	HCO_3	SiO_2
Well water	0.087	0.058	0.067	0.032	0.440	0.341
After #1	0.0	0.0	0.067	0.032	0.237	0.167
After #2	0.0	0.0	0.0	0.010	0.080	0.122
After #3	0.0	0.0	0.0	0.0	0.070	0.103

The steps involved are: (1) All Na and Ca are used up in converting kaolinite to plagioclase feldspar, (2) All Mg and appropriate moles of K are used up in converting kaolinite to biotite, (3) The remaining K is used up in converting kaolinite to K-feldspar. The reconstructed mineral assemblage of sodic plagioclase, biotite and K-feldspar is consistent with the local bed rock .The small excess of around 4 mg/L HCO_3 and 6 mg/L SiO_2 may have been acquired from additional sources like rain water and saturation with quartz.

Solute and Sediment Load Observed Through a Decade in the Meltwaters of a Himalayan Glacier

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The Himalayan glaciers give rise to the headwaters of the major Indian rivers that nourish the breadbasket of India, the Indo-Gangetic plains. The melting snow and ice in these glacierised catchments feed these rivers during the crucial premonsoon summer highs. Dokriani glacier is part of the Ganga headwaters and is located in the Uttarkashi District of Uttaranchal extending from *$31^0 49'$ to $31^0 52'$N* latitude and from $78^0 47'$ to $78^0 51'$E longitude. The glacier originates at Draupadi ka Danda and the Janoli peaks and terminates in the snout located about 5 km below at an altitude of 3900 m giving rise to the proglacial stream called Dingad. The ice cover of the glacier is $10km^2$. Three quarters of the glacier ablation area is covered by thick debris. The accumulation area of the glacier is about 2.5 km^2, consisting of two cirque glaciers, one originating on Draupadi ka Danda and the other on Janoli. The equilibrium line is at ~4960m.

Dokriani glacier meltwaters have been monitored through the summer ablation seasons of 1992-1994 and 1999-2001 for their solute and suspended sediment transport. The gauging station was established in the Dingad proglacial stream, 600 m down the glacier portal. Discharge was determined using the area-velocity method and rainfall using a chart recording type rain gauge. Electrical conductivity and TSM measurements were conducted corresponding to the daily minimum and maximum discharge during the field seasons spanning the ablation period. Bicarbonate was estimated in the field itself by potentiometric titration method. Sulphate, Chloride, Calcium, Magnesium, Sodium and Potassium were analyzed in the laboratory. Hourly samples for selected 24 hour time periods were also collected and analyzed for dissolved ions and suspended sediment concentration.

On a diurnal time scale, the suspended sediment transport peaks before the discharge peak, indicating that the sediment transport reacts quickly to increased discharge. On the seasonal scale sediment flux was influenced by the discharge variations. In 1994, about 52% of the total sediment transport occurred in July (ie. 8 x 10^4 tonnes) along with the highest volume of discharge (35% of the total observation period).

Monsoonal rainfall over the glacierised area appears to be an important factor controlling the discharge hydrograph. Monsoonal cloud cover reduces the energy input resulting in subdued ice melt. The pattern of sediment transport is strongly influenced by the monsoonal precipitation between July and mid-September. For example, in 1994 observation period the monsoonal months of July and August accounted for 64% of the discharge, 70% of suspended sediment transport and 74% of the monsoonal rainfall. The prominent peaks in sediment concentration were probably due to slumping of heavily debris laden glacier snout ice during intense monsoon rainfall.

The variations of ionic concentrations in Dokriani glacier melt water during the observation period show the dominance of dilute englacial waters during the late monsoon season. Higher ionic concentrations during the recession flow period resulted from dominance of solute rich subglacial component. Bicarbonate, sulphate and calcium are the dominant ions in the Dokriani glacier meltwaters, suggesting that the meltwater chemistry is dominated by coupled reactions involving sulphide oxidation and carbonate dissolution. High sulphate concentrations and the good relationship between sulphate and suspended sediment concentrations during July and August suggests that the monsoonal rainfall enhances the supraglacial moraine weathering, providing high sulphate content in the meltwater during periods of high discharge. This is substantiated by observed higher sulphate fluxes during high discharges.

Seasonal variations in solute characteristics of supraglacial meltwaters result from varying travel times through surface moraine zones. Spatial variations in EC over the ablation zone reveals that the water draining from surface moraine zones were more chemically enriched. The non-linear inverse relationship of specific conductance of meltwaters with the discharge results from the variable dilution of chemically enriched discharge from subglacial environment by supraglacial meltwaters.

Year to year variations in the solute characteristics of meltwaters is probably due to the instability of glacial drainage system and the variability in the intensity and seasonal distribution of the monsoonal rainfall. The CDR of the Dokriani glacier catchment is 321.6 t $km^{-2}a^{-1}$ (1994), suggesting very high rates of chemical weathering in the southern Himalayan glaciers. A marked increasing trend has been observed during the decade in discharge as well as the chemical and suspended load of the proglacial stream.

Microbiological Aspects of Metal Ion Speciation in Water and Biotechnological Methods to Combat Water Pollution

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Several ore deposits as well as mineral forms under the earth's crust are formed due to biological reactions as attested to by the ubiquitous presence of various types of bacteria, fungi, yeast and algae. It has been well established that there exists a metal-bacteria cycle for almost all metals and microbe-mineral interactions under natural conditions bring about oxidation-reduction, precipitation, dissolution and chelation type reactions. Formation of various forms of minerals such as metal oxides, phosphates and sulphides is a consequence of biogenic reactions and over hundreds of biominerals have been identified. From the view point of biodissolution of minerals in nature, the sulphur cycle in nature is important. Most of the nonferrous metals in the earth's crust occur as their sulphides and in the presence of autotrophic, acidophilic and aerobic bacteria such as *Thiobacillus ferrooxidans* and *Thiobacillus thiooxidans*, acidic waters are generated containing dissolved metal ions such as copper, zinc, arsenic, nickel, cobalt etc. Surface and ground waters in the vicinity of mineral wastes, rock piles, mines or mineralised soils are thus polluted by dissolved metal ions brought about by microbiological reactions.

Examples of such water pollution are indeed numerous; specific ones being the presence of significant concentrations of arsenic, chromium, cadmium, copper and zinc in ground and surface waters. Arsenic speciation through interaction of acidophilic, autotrophic bacteria such *Thiobacillus ferrooxidans* and *Thiobacillus thiooxidans* with arsenopyrite present in soils and rocks in contact with water bodies need be understood in order to develop methods to detoxify polluted water streams. While microorganisms are responsible for acidification and heavy metal dissolution, careful use of certain organisms can help in the mitigation and abatement of metal pollution of water bodies. For example, Sulphate Reducing Bacteria (SRB) such as *Desulfovibrio Spp.* can precipitate out dissolved metals from water as their sulphides and thus detoxify and clean up polluted waters. Use of Sulphate Reducing Bacteria in water purification has now been commercialised. Similarly, microorganisms can also be used to clarify turbid water streams. Biotechnological processes are now available for treatment of polluted water.

In this lecture, microbiological and physicochemical mechanisms involved in metal-microbe interactions are analysed with respect to water pollution. The sulfur cycle as well as different biogenic metal dissolution reactions are illustrated. Potential metal contamination of water bodies through the presence of microorganisms is discussed with examples from industrial and mining sites. The role of various bacteria in metal dissolution is examined with respect to surface and ground water bodies.

Positive and beneficial role of anaerobic heterotrophic bacteria in the removal of dissolved metal ions from polluted water is illustrated in the light of available biotechnological processes. Similarly, technological developments in the rehabilitation of polluted waste water and river bodies are outlined. Various types of available biological routes such as biosorption, bioremediation and bioconversion are illustrated.

Headwater Management: One Key to Self-sustainable Freshwater Resources

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Headwaters are the places where rivers are born and a major resource for freshwater supplies. These lands are the zero to first order catchments on the margins of every river basin. Headwaters are lands where the water flow-lines originate and where many groundwater reserves recharge. When water qualities and yields change in headwaters, the consequences affect the lands downstream. Unfortunately, in the modern era, many processes challenge the quantity and quality of water produced by headwater regions. Although located in the highest and most peripheral parts of a watershed, many headwaters lie in the front-lines of development for agriculture, forest farming, mining, road construction, tourism, nature preservation, hydroelectric power and water supply. Many headwaters also lie on the margins of national and regional socio-economic systems and some contain political boundaries between rival social, cultural and military groups. Traditionally, headwaters were associated with low levels of human occupation and isolation from major industrial and economic processes. Today, many headwaters

experience high rates of population change due to economic development and migration. In some regions, a booming economy is sponsoring economic growth and infrastructural developments that threaten biodiversity, special habitats, valued landscapes and minority cultures. In others, economic and social marginality is leading to emigration and the collapse of local environmental management and socioeconomic systems. Elsewhere, environmental security is threatened by transboundary air pollution and climatic changes.

In developing societies, many headwaters have suffered through colonisation by peasant farmers who have been displaced from better quality agricultural lands. Agricultural modernisation has launched waves of economic migrants into the cultivation of unfamiliar and often unsuitable terrain. In such communities, the struggle for immediate survival has higher priority than any concern for the future or the surrounding environment, even where the skills and resources needed for its management exist. In such cases, the problems of environmental degradation rarely remain in the headwaters. Regions downstream suffer through water and sediment pollution, changes in the hydrological regime, and reduced natural resource supply, which may also lead to social stress and livelihood disruption. This is why the proper management of headwater resources has become one of the most significant modern challenges for environmental management and development.

Case Study 1. Honduras

In Honduras, Central America, the commercialisation of agriculture has caused the displacement of former peasant farmers from the most productive flat-lands and into the cultivation of marginal steeplands. The consequence of this extension has been a reduction in the area of forest and increase in the yield of sediment to adjacent streams. In concert, international and Honduran agencies and ngos have struggled to persuade farmers on these lands to introduce soil conservation measures. Traditionally, these were cross slope barriers. However, these have been less than popular with farmers, mainly because they consume both land and labour, without producing any major benefit in terms of increased production. A test site was set up near Choluteca, S. Honduras, which compared agricultural production and soil losses from two arrays of more than a dozen test plots each, on steeply sloping fields, cropped to traditional maize and beans by local farmers. This confirmed that, on these steep slopes, cross-slope barriers of vetiver grass had relatively little impact on sediment losses from the site. Volumes of sediment trapped upslope of the barriers were largely compensated by increased soil removal immediately downslope, with soil creep being the dominant process involved. They also had little impact on maize, except in very dry conditions, when water stored in sediments trapped above each barrier, permitted increased production. At other times, increased production in crop rows immediately above the barriers was compensated by decreased crop production immediately below.

However, the sustainability of the whole venture has been called into question through the impacts of Hurricane Mitch in October 1998. This intense tropical storm destroyed the test plots and also spawned landslides across many neighbouring hillsides. However, there were few landslides from hillsides that preserved their forest cover. The steepest cultivated slopes were those most seriously affected, with 2-3 metres of soil and weathered disappearing downslope. On the test plot as elsewhere, the lower slopes suffered damage only to the extent that they received landslide sediments from neighbouring fields. Even theoretical estimations of annual soil losses from the agricultural fields and the impact of soil conservation measures upon these show that the volume of sediment moved by this single extreme event was some orders of magnitude greater than that moved during 'normal' conditions. The hurricane–induced landslide destruction demonstrated the limitations of contemporary thinking on environmental management. In retrospect, it could be argued that the impacts of this disaster would have been far less had the forests been preserved and the needs of the peasant farmers catered for in other ways. Instead, the loss of vast tracts of soil and subsoil has reduced the everyday capacity of the affected hillsides to absorb rainfall and moderate runoff. Currently, the attention of soil conservationists has turned to a new approach involving the use of the leguminous, soil-building, cover crop Mucuna, which reputedly can produce up to 100 t.ha. of green manure per hectare.

Case Study 2. Reclamation of the Afon Lwyd, Wales

This second case study concerns the event that first convinced the speaker of the importance of holistic thinking in watershed management and of the special importance of headwaters. The story begins in South Wales, which during the 1970s, was beginning to emerge from a century or so of rampant industrial pollution

dominated by coalmining and steel production, with its culmination in decades of slow, industrial decline. In Cwm Afon Lwyd, the most easterly of the South Wales mining valleys, after almost 400 years, the last headwater last iron/steel foundry had closed, and the last deep mine was reduced to serving as a doorway to coal-seams that actually lay miles to the west, in a completely different drainage basin. Previously, the Afon Lwyd had contested the miserable title of being the most polluted river in Wales. However, with the factories largely closed, the quality of the water in the river began to improve and the river's character began to shift. The yellow pungent slime, which coated each boulder, gradually began to give way to green and fish began to recolonise the stream.

Then, a critical decision was made by the then National Coal Board mining company. The last mine was Big Pit in Blaenavon – literally 'head of the river'. Today it is a national museum of coal-mining, then it was redundant and so there was no longer any need to pump clear its lower galleries. Pumps, which for decades had removed huge volumes of water from the mine workings, were switched off. The year was 1974 and for a couple of years thereafter nothing obvious happened. Then, finally, there was a seriously rainy year, and the water table recovered. In fact, it recovered across a large area of subterranean mine workings, which had been dry for decades, including many that had been back filled with old mine spoils, some dating back the early phases of iron-stone mining in the area. Inevitably, the first flush of water through these spoils became massively enriched with iron. Streams and springs that had been dry and forgotten for generations ran and the colour of their water was bright red. The pollution, of course, completely destroyed the reclamation of the Afon Lwyd, which was seriously polluted for sometime. Of course, after the first flush of iron, water quality, once again began to recover and, by the 1980s, had returned to a pattern of steady improvement.

Of course, the problem still remains. In 1996, as part of a tree planting programme, the author cut a series of trenches into some former surface coal-land. Inadvertently, these trenches breached the naturally-forming water proof clay cap that self-creates on these sites and which keeps the rocks below dry. For a month of two after the trenches were dug, the hillside appeared to bleed, as iron-enriched water drained flushed through the upper layers of the formerly dry mine-spoils. Today, the area is covered with a dense growth of trees and the water it releases is clean.

The case study demonstrates how problems in headwaters affect areas downstream and also the importance of coordinated 'joined-up' thinking required between the multiplicity of land managers that affect headwater areas. One of the platforms of the headwater control movement is that there needs to be coordination between the activities of land users and that it is inappropriate for so much of headwater management to be in the hands of organisations that have a limited interest in the area, whether that be for mining, agriculture, forestry, flood control, tourism, water resource management or whatever.

Headwater Control Movement

The Headwater Control Movement (HCM) was launched in 1989 by an interdisciplinary group of environmental management specialists with a shared concern for the environmental security and socioeconomic welfare of headwater lands and their communities. The movement is founded on the belief that, if the headwaters of a region are in good condition, then they will transmit few problems downstream. Subsequently, the group has devoted itself to developing practical, integrated approaches to the management of headwater regions both in their biophysical and social aspects. It has sought to construct an holistic perspective that includes meeting the needs of headwater communities for better livelihoods that are more self-sustainable in environmental, economic and cultural terms. In sum, its aim is to find approaches that unites the imperatives of environmental conservation, (self-) sustainable development, environmental reconstruction, the empowerment of headwater peoples and the regeneration of livelihoods, through policies and institutions that promote appropriate action.

Headwater regions around the world share many comrnon problems, such as soil, forest and water resource degradation, economic stress and poor, myopic management structures, often dominated by external institutions devoted to the exploitation of a particular resource. The Movement has tried to counter such problems through promoting the exchange or practical knowledge and environmental management experience from work in the different headwater regions in the world. A major vehicle for this work has been the series of international Headwater conferences, organised at 3 yearly intervals. Of course, headwaters are found in flat lands as much as in mountains, but in the International Year of Mountains (IYM2002), the UNU, which has worked on sustainable mountain development for a quarter century, joined hands with the movement to create a 5th international meeting, the first in Africa. However, almost all headwater regions are valued by the outside world as sources of valuable freshwater supplies, this meeting was also devoted to the International Year of Freshwaters 2003.

Policy and Investment in Water Supply in Rural and Urban Sector in India

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Responsibility of providing safe drinking water and sanitation facilities rests with the safe governments and local bodies. The Central Government, besides giving technical assistance, has been supplementing the efforts of state govt. by providing financial assistance through the Centrally sponsored Accelerated Rural Water Supply Programme (ARWSP) since 1977-78. In 1986, the National Drinking Water Mission (known as Rajeev Gandhi drinking water mission) was launched as a part of ARWSP with a view to provide cost effective technology inputs to rural water supply program through an integrated and inter disciplinary approach.

Urban water supply and sanitation have remained an important area of concern and allocation of funds been made since the first five year plan. The plan out lays. For urban water supply and sanitation which was Rs 43 crore in the beginning, increased to Rs 550 crore by the fifth five year plan. The percentage share of the sectors outlays out of the total public sector outlay only showed marginal increase from 1.28 percent to 1.38 percent between the first plan and eighth plan. In the ninth plan, this, however, dramatically improved to 2.17 percent. Urban water supply and sanitation sector in India faces many problems. Many urban water supply and sanitation providers are not financially viable and are unable to maintain services. Without extensive subsidies existing services fall short of full coverage of population and are often of low quality due to insufficient funding of operation and maintenance. The resource as it is currently used is increasingly insufficient and are exploited.

With the massive investment made during the various five year plans by the state and central govt. the results achieved have also been apparently quite impressive. The survey conducted by the state govt. during 1991-1993 and revalidate in 1994 with the help of reputed NGO s and research organizations has given a new dimension to the problem of rural water supply. The survey revealed that a very large number of no- source villages and habitations have emerged to the depletion of water tables, use of improper technologies, malfunctioning of water supply system etc. From the year 1994-1995 habitation approach was adopted instead of village-approach. The national agenda for governance seeks to provide safe water to all habitations within 5 years i.e. by march 2004.

The performance and sustainability of water and sanitation services depends not only on the level of financing of these services but also on the source of such financing. Due to economic liberalization in our country and constrained availability of budgetary resources, new avenues would have been to be identified for mobilizing resources. Keeping this in mind, the focus of water supply and sanitation services would have to be turned from welfare program to public utilities with financial accountability on the part of local service providers. The institutional reforms to boost municipal capacity, commercialization water supply and sanitation providers, and involvement of private sector, will assist in this regard. Private sector participation in the form of service contracts and management contracts should be attempted in appropriate cases. Community participation should be encouraged to run effectively water supply and sanitation schemes. This decade should be treated a Water Supply and sanitation Decade, so as to give more focus on the issues relating to water supply and sanitation.

Some fresh water lakes of Himalaya and their Characteristics

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Many of the lakes of Himalaya are fresh water with or without inflow and out flow. The high altitude lakes are mostly oligotrophic and are fed from snow-melt, precipitation and springs whereas lakes of low altitudes receive water from local rains, through streams, Nalas and springs and some of them approach advance stage of trophic state due to strong impact of anthropogenic influence such as tourist influx, unplanned settlements, land-use and development activities in the catchment area, and disposal of municipal and domestic wastes. Deforestation and removal of plant cover and grazing have accelerated silting thereby making these lakes shallower with luxuriant growth of macrophytes, phytoplankton etc which has led some lakes to shrink and finally to die such as Sanasar Lake, Dal Lake, Khajjihar Lake of Kashmir and H.P. Many large Lesser Himalayan Lakes are fault basin lakes formed due to tectonic activity blocking of the streams/rivers during Holocene period and have main source of water through precipitation and

underground springs. Such lakes are in Kumaun. Himachal Pradesh, Jammu. The Higher Himalayan lakes of Spiti valley, on the other hand, are fed from snow-melt, precipitation and spring water flow. Some of these lakes which have been investigated in detail by the author and his students are briefly review in this paper.

The Nainital in Kumaun, is a famous hill station infested by large number of tourist, and with increasing population in the valley which has now reached about 40,000 inhabitants, has led to deforestation, more and more of land use causing high siltation in the Nainital lake waters (11.5 mm/yr) which in other lakes Bhimtal Naukuchiyatal and Sattal is much less, 4.70, 3.70, and 2.99 mm/yr, respectively because in these areas population is less and anthropogenic impact is very less. The electrical conductivity (E.C) in Nainital Lake is 706 µs/cm whereas in Bhimtal, Naukuchiyatal and Sattal the values are less 181,147 and 119 µs/cm, respectively. The ionic strength in surtace water is 13.1X 10^{-3} mml/l in Nainital and in other lakes it is 3.5 X 10^{-3}, 2.3 X 10^{-3} and 2.0X 10^{-3} mmol/l, respectively. The total dissolved solids in Nainital is 447 mg/l compared to 108, 81,and 62mg/l in other three lakes, respectively. The pH of Nainital waters is relatively low indicating less photosynthesis and inhanced respiration increasing CO_2 in water consequently enhanced Ca^{2+} and HCO_3^- in this lake consistent with Krol limestone lithology (Neo Proterozoic-Proterozoic) in the catchment of Nainital. As the Bhimtal, catchment is comprised of volcanics, metabasites, quartzites etc.; Naukuchiyatal, metavolcanics intercalated with quartzite and phyllite; and Sattal, quartzite with phyllite hence the water chemistry is at variance with each other. The PO_4 content in Nainital is higher showing increasing trend with time leading to eurtrophic conditions in this lake which is not noticed in the other lakes as these lakes are not under the strong cultural influence and maintain their pristine character. The D.O in Nainital Lake is less compared to other lakes particularly in deeper levels, indicating anoxic conditions developing at mud-water interface at depth. The situation becomes aggregated during winters and incidence of fish mortality is also reported. The B.O.D levels is above the acceptable limit of drinking water. The coliform bacteria is reported from this lake. The lake water is therefore not fit for potable purposes. The heavy metals Cu, Zn, Ni, Cr, Mn and Fe are higher in the bed sediments of Nainital compared to other lakes indicating anthropogenic input in the basin.

The Renuka and Rewalsar are the commonly known lakes of Himachal Pradesh, the former is a wetland and is under international Ramsar Convention. The Renuka represents the abandoned course of Giri River. Inlets to the lake are watersheds, rainwater runoff from the catchment and underground seepage. The chemistry of lake water is dominated by carbonate weathering and (Ca+Mg) and (HCO_3^- + SO_4) accounts for about 90% of the cations and anions. The S04 content is almost the same as the HCO_3^-. The high sulphate content in waters is derived from dissolution of pyrite-bearing black shales. The low contribution of (Na+K) to the total cations and the (Ca+Mg) and HCO_3^- tends to indicate that silicate weathering is relatively less significant. The water chemistry data are consistent to limestone, quartzite, shales, siltstone belonging to Krol, Blaini, Infra- Krol rocks. The water is rich in nutrients and support a high biological diversity. Deep water layers are low in Oxygen content and anoxic condition develops during summer. Fishes are in plenty in the lake. The water is used for drinking and agriculture.

Rewalsar is a Siwalik Lake surrounded by middle Siwalik lithology comprising sandstone, silt and shales. Carbonates are scarce but the chemistry of surface and groundwater is dominated by Ca + Mg (81.57 & 78.83 in equivalent basis) to the total cation budget, respectively whereas CO_3+ HCO_3^- (75.92 & 86.96) to the anion budget, respectively. However, Ca^{+2}/ HCO_3^- and Ca^{+2}+Mg^{+2}/ HCO_3^- molar ratio 0.58 & 0.69 in lake waters and 0.48 and 0.60 in groundwater and (Na+K)/T_z^+ ratio 0.18 and that of (Ca+Mg)/T_z^+ 0.81 in surface water and 0.26 and 0.74 in groundwater tends to support silicate source as well. Low abundance of silica (4 to 36 µmol/l) and (Ca+Mg): (Na+K) mol ratio suggest that silicate weathering is less significant. The inconsistency of clay minerals in natural waters of Rewalsar is due to extremely low silica content compared to groundwater and silica uptake and removal by diatoms/planktons in the surface waters and low cation (Na).

The Mansar is another Siwalik lake, one of the largest and deepest fault basin lake in Jammu formed in Holocene. It is non-drainage type and primarily fed from rains and underground spring and thus the depth of water is almost maintained for the whole year. The catchment lithology is lower Siwalik comprising sandstone, shales limestone. The lake water is close to [HCO_3^-] > 3[Ca^{2+}] implying dissolution of carbonate rocks in the basin. The silicate contribution seems to be poor. As the population in the valley is small consequently cultural interference is poor and hence the water is unpolluted and suitable for drinking, agriculture, fish breading and other purposes.

The Higher Himalayan lakes in the Spiti valley have been investigated. The study revealed that the chemistry of waters is consistent to the lithology over which the lakes are situated. The Dankar is located on limestone-dolomite rich Lilang Group of rocks (Triassic), the dissolution of carbonate is the prime source of ionic concentration in this lake. The high (Ca+Mg):HCO_3 6.94 equivalent ratio and very low 0.07 (Na+K):T_z^+ ratio indicates strong carbonate source and low silicate weathering. The lake Thinam, on the other hand, show (Ca+Mg): HCO_3^- 2.09 equivalent ratio and (Na+K):T_z^+ ratio 0.12 which is consistent with the thin intercalation of limestone in Spiti shales (Jurassic) and some contribution from silicate weathering. The lake Gete shows (Ca+Mg):HCO_3 equivalent ratio 5.04 and (Na+K):T_z^+ ratio 0.15 suggesting dissolution of both carbonate and silicate rocks in the basin. This is consistent with the Spiti Shale and Lilang Group of limestone. The very high Sr content 2331 Hg -I in Dankar, 715 µg/l in Gete and 160 µg/l in Thinam further supports consistency of lithology in these lakes and dissolution of carbonates because 90% of Sr is derived from carbonates and silicate rocks contribute very less Sr.

Therefore, these fresh water lakes are deriving there ionic constituents primarily through the weathering of catchment lithology and derivation from aerosol ecyclic salt particularly Cl^- and Na^+ are insignificant as the lakes are far away from the ocean. This is well supported in case of Rewalsar lake by comparing surface and groundwater chemistry. In groundwater Cl^- is much less and Na^+ is 1:3 times higher than the surface waters. The implication has been discussed in the paper.

Towards Sustainability of Ground Water Resources With Reference to Arid to Semiarid Regions of Western India

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Groundwater plays an important role in the overall water resources in most of the arid and semi-arid regions. It is eitherthe main source of water or a complementary source to surface water. It can be renewable or fossil having comparatively longer residence time in the subsurface domain. It is a major component of total water resources, forming an important part of the hydrologic cycle Of the 37Mkm^3 of fresh water esthnated to be present on this planet, about 22% occurs below the land surface in the form of Ground water., Groundwater is an essential and vital resource for living system and economic world, comprises about 97% of the world's liquid fresh water.(Helwey, 1978) which only further high lights the importance of this resource. Any discussion pertaining to water resource particularly in arid to semiarid region is discussion pertaining to Ground water in essence. It is a very large but often not well understood and almost always undervalued resource. Though groundwater is an often unnoticed and unacknowledged cornerstone in the foundation of many regional economic and environmental systems, It is far more reliable and dependable source of supply than surface water and if managed properly may provide potable water of a high quality. Compared to surface water, which is flashy in nature, groundwater offers better insurance against drought because of the long lag between changes in recharge and responses in groundwater levels and well yields (Carter and Howsam, 1994). Ground water based irrigation gives better crop yield in comparison to surface water based irrigated crop (Shah et al., 1999).

However, the groundwater hitherto considered safe and dependable under the subsurface geological domain, now in many parts of the world, is under serious threat. Recent decades have seen not only explosion in global population but also a explosion in both installed pumping capacity as well as potential points of pollution making this resource highly vulnerable. There is global concern towards the increasing scarcity of water. The SCOPE- an international body survey reveals that water scarcity is the second most important global environmental issues next to Climate Change threatening humanity.According to IWMI Indicator of relative water Scarcity, by 2025, 44 percent of the world's population will leave in countries with physical water scarcity and 26 percent will leave in countries with economic scarcity. There has been reduction of about 40 percent in per capita water availability on global basis taking 1970 as baseline. Various agencies and individuals at local, national, regional and global level have forewarned us of worsening water scenario at local, national, regional and Global level mainly due to population explosion, climate change as well as imbalanced competitions among various water user sectors to grab the maximum share and benefit out of the depleting and deteriorating water regime.In view of the growing need and projected water scarcity as well as increasing vuh1erabiiity of the water regime, a big question mark has gradually emerged pertaining to the sustainability of the ground water particularly in arid to semi arid regions of the world.

Throughout the world, regions that have sustainable groundwater balance are shrinking day by day making life more miserable particularly in arid to semi arid regions. Three problems, which dominate groundwater use, are Depletion due to overdraft and climatic warming, Waterlogging and Salinization due mostly to inadequate drainage and insufficient conjunctive use; and Contamination due to agricultural, industrial and other human activities as well as due to geological factors.The issues have been discussed at many national and international forum and quite a number of measures have emerged out of such deliberations. However

the experiences show that only such measures are favored and adopted by the community which are engrained in their cultural fabric and economically viable. One such measures which is receiving renaissance in western India is Rainfall - Runoff Water Harvesting. The people of the western India has survived through many droughts by practicing this techniques. The Scientists may respond by helping the community in identifying the sites for effective realization of this techniques toward sustaining the ground water resources. The author had opportunity to contribute towards targeting sites for RRWH, which was well received by the user agency.

The Impact of Urbanization on Fresh Water Resources

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Fresh water is the key issue because it is the common strand that links population, growth, health, agriculture, industry, ecosystems, climate change and urbanization. The demand for fresh water is growing but in almost all cases the availability of fresh water per person is declining. As population grows there are parts of the world where fresh water per person is reaching a point of criticality. Increasing demands for water are occurring in four key areas, which in aggregate are exerting unsustainable pressure both in developed and developing countries:

- Human needs for safe drinking water and proper sanitation;
- Agriculture needs for expanding production to meet population growth;
- Industrial needs to provide more goods and services for a growing population and
- Environmental needs to protect endangered species, biodiversity and unique areas of special interest

The continuing shifts in population from rural to urban areas coupled with the overall growth in the population of Indian cities are placing enormous pressures on the water environment of many cities. Serious shortages of water are made worse by the degradation of environmental quality resulting from urban development. Many areas in cities lack sewerage and sanitation systems. People health suffers and women as household mangers and water managers in particular are badly affected. The problem is thus that of cities facing increasing difficulties in meeting overall development goals, which are to ensure that people live healthy and productive lives and that the natural environment is protected and enhanced where feasible.

In this paper, an attempt has been made to address the growing water crisis in Chennai, the fourth largest city in India. This city has a population of over 6 million and spread over an area of 1200 km^2 is a chronically water-starved metropolis. One of the principal objectives of this study is to mitigate the environmental impact of urbanization on freshwater and aquatic systems, through an integrated approach to managing urban water resources, taking cognizance of the links between water, urban development and the environment. To be effective a mitigation strategy must be based on a sound understanding of the problem. This requires data collection and analysis to enable:

- Identification of water sources at risk- surface or ground, within the urban area or outside; current and future uses of these sources and their related quality objectives
- Identification of the critical pollutants- physical, chemical and/or biological; conservative/and/or non-conservative; point sources and/or non-point sources
- Identification of the causes and consequences of water depletion

The variation in water quality parameters analyzed in the River Adyar and the adjacent groundwater of Chennai city, showed a similar trend. This indicates the influence of river water quality on the groundwater quality. The river water and groundwater near the shore was found to be more polluted than the upper catchment suggests that the influence on the river water quality in the groundwater is much more in the coastal regions due to the presence of shallow aquifer. The concentration of ions and nutrients was found to be lower in the upper catchment. Extensive use of river water for various purposes and uncontrolled disposal of effluents from the industries have led to an intensely degraded water quality. Drains and sewers carry large amount of pollution away from urbanized areas into the waterways. Along with these pollutants, hospital waste and wastes from commercial institutes also find their way into the drains. This water along with sewage travels from drains into rivers, thereby polluting it to a great extent. Urban development has lead to changes in groundwater quality and quantity. Deterioration of quality can be either directly by allowing pollutants used in urban areas to be leached into groundwater system, or indirectly by changing chemical conditions within an aquifer.

Thus, the freshwater crisis in Chennai is not mainly the result of natural factors such as droughts, floods etc., but has been caused by humans – by increased

pollution of both surface and groundwater, improper water resource management and the shortcomings in the design and implementation of legislation and regulations, which addresses these problems. There is an urgent need for a better and wider understanding of the limits of the resource and for taking effective actions to meet the challenges.

Fresh Water Related Issues: Use of Membrane Process

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The United Nations Environment Programme (UNEP) emphasizes on sustainable management of fresh water resources for India. Urban growth problems including increased industrial activities, intensive farming, overuse of fertilisers and other chemicals in agricultural production are deteriorating fresh water quality and availability to Indian population. In addition inadequate facilities of wastewater treatment (municipal sewage and industrial wastewater) is enhancing this problem. A long-term impact would augment contamination of lakes, rivers and groundwater aquifers. We read almost daily in Indian newspaper about the quality of drinking water in India. According to UN report, water quality in India is rated as 120th among 122 nations surveyed. (Hindustan Times, date 6th March 03).

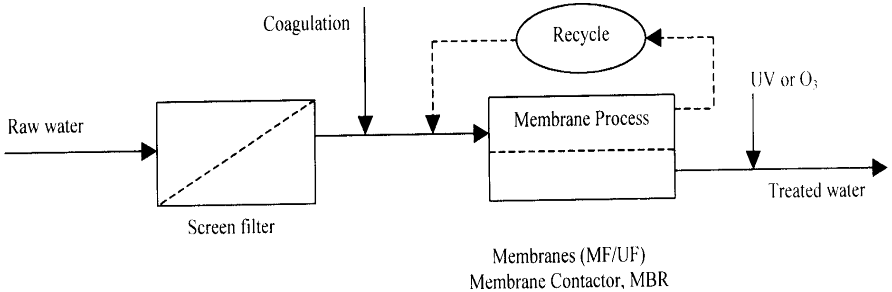
The Government of India formulated the National Water Policy in 1987 in order to provide top priority to drinking water supply and undertook the National River Action Plan to clean up polluted rivers. The national water grid or river-linking plan, an ambitious Rs 5,60,000 crore project, to link 37 major rivers across the country is under consideration. The river-linking project is expected to provide good quality drinking water, enough water for irrigation besides generating a large amount of electricity. This project seems to be a preferred solution for combating recurring droughts and floods in the country. However, there are already many critical comments on the feasibility of such a big project.

Contamination of groundwater with arsenic and fluoride and increasing pollution of surface water with waste from urban areas are major water-quality problems. This requires that policymakers, governments, donors, international organizations, and the research community appreciate the close links between water used for food production and water used for drinking. The growing worldwide scarcity of good-quality fresh water makes it essential to bridge the gap between the different sectors involved in water-resource management.

Rainwater harvesting and rainwater recharging is a possible solution for increasing water resource capacity. Rainwater harvesting can also improve water quality because of water dilution. For the sustainability of water quality and supply water body privatisation and correct water tariff is the best solution for India.

Membrane Process

The membrane processes make use of pressure-driven semi-permeable membrane systems. Membranes are manufactured in a variety of configurations (plane, tubular, spiral wound, hollow fiber etc.), materials (organic/polymer; cellulose acetate, polyamide, polysulfone, polyethylene etc. or inorganic/ceramic; with zirconium, titanium or carbon layer) and in different pore size distributions (with asymmetric or symmetric pores). The selection of a membrane treatment method for a particular drinking water application would depend on the contaminants to be removed, water source, water quality, treated water quality requirements, and installed capacity.



Membrane process for water treatment

In water treatment using a membrane process, pre-treatment is generally advised in order to protect the membranes from plugging effects, fouling and/or scaling, and also to reduce operational and maintenance costs. A disinfectant is commonly applied after membrane treatment in order to protect the water quality. Four main cross flow membrane processes (MF-microfiltration, UF-ultrafiltration, NF-nanofiltration and RO-reverse osmosis) are in use. The selection of a particular type of process or combination of different membrane processes and/or coupling

the membrane process with a biological or physical-chemical process will depend on the size and the type of the substances to be removed from the water. Membrane process is found very successful for its removal capacity of different organic and inorganic substances and, bacteria, viruses and other microorganisms from source water.

Water Quality Management, Pollution and Sustainable Agriculture

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Water is a limiting factor for Crop Production and its efficient use is a major problems for sustainable Agriculture in India both for irrigated and rainfed areas. With growing population, intense urbanisation, rapid industrialization coupled with modernization of Agricultural operations, depletion of natural resources viz. Land and Water is taking place on one hand, degrading the quality of Environment on the other. Growing demand for fresh water supplies by Industry and for urban and civic uses, the prohibitive costs of irrigation development and increasing problems of Soil degradation from poor quality water as well as from poor management practices make Agriculture a poor competitor for its use. All the components of the Strategy for a productive, efficient and sustainable Agriculture are important, but in this paper only integrated management of water resources some case studies from Northern & Southern States along with related Environmental Pollution Problems have been discussed.

Fresh Water Quality

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Ground water is a good source of fresh water available on earth. It is an important resource having several inherent advantages over surface water. Its wide distribution, negligible evaporation loss and low risk of contamination are some of the advantages. Hence, in most parts of the world the use of ground water is preferred to surface water. The dependence of ground water is increasing in many regions because of limited surface water resources, non-perennial rivers and frequent failure of monsoons. So the ground water resources are often overexploited to meet the increasing demand and thus the aquifers are heavily stressed. Advancement of human civilization has posed serious questions to the safe use of ground water for drinking. Apart from its depletion due to excessive use, the quality has degraded due to the transport of various organic and inorganic pollutants into the ground water. The socioeconomic growth of region is severely constrained by non-availability of safe drinking water. Man has tried to cope up with this scenario and has rapidly advanced its effect to counteract this malady.

Although India has substantial fresh water resources, yet there is an acute shortage of safe drinking water of acceptable quality, specially in rural areas. Keeping this in view, Government of India constituted Technology Mission for drinking water in 1987. To study the quality of water in Roorkee Township, three samples of ground water were collected from different locations. These samples were analysed for physicochemical parameters and values obtained are depicted in Table 1 along with the values of Indian Standards (IS 10500) for drinking water. The results of analysis show that in case of all the samples the values for different parameters are within the range of values prescribed by Indian Standards and hence water from these locations is suitable for drinking purposes.

Table 1: Physico-chemical analysis of ground water samples

Parameters	Sample 1	Sample 2	Sample 3	IS 10500
Location	CBRI Campus	Bus Stand Station	Railway	———
Source	Tap Water	Hand Pump	Hand Pump	———
pH	8.0	7.13	6.62	6.5-8.5
TDS	300	247	186	500
Total Hardness	500	250	184	300
Chloride	50	9.0	6.0	250
Sulphate	5.0	29.0	31.0	400
Nitrates	1.66	1.98	13.70	20

All values are in mg/l except pH

Groundwater Quality Problems in Sri Lanka

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Sri Lanka being an island in the Indian Ocean, the climate is tropical monsoonal with a marked seasonal rhythm of rainfall. The direction of wind and the physiography control the rain fall and the country can be broadly divided in to two climatic zones; the wet zone where the annual average rain fall is grater than 1900 mm and the dry zone with rain fall less than 1900mm. In Sri Lanka, the only source of fresh water is rainfall, part of which percolates to form groundwater. The contribution of rainfall to the groundwater recharge depends on the rain fall intensity, physiograpy and the underlying geological formations. The amount groundwater recharge is estimated to be varying from 7% to 30% of the rainfall.

Based mainly on geological conditions, the country can be divided in to three hydrogeological regions; *North Western and Northern Sedimentary belt, Coastal belt* and, the *Crystalline basement complex*.

The Northwestern and Northern sedimentary belt covers about 10% of the land area of the country and consists mainly of carstic and faulted Miocene limestone. Overlying this formation are deposits of quaternary alluvial and lagoonal clay, sandy clay and sand. The limestone formations are very good aquifers in terms of transmissivity and specific yields. Electrical conductivity however shows moderate to very high values with saline water deeper down. A narrow discontinuous belt of unconsolidated alluvial, lagoonal and dune sands form the coastal belt of aquifers. These aquifers rarely exceed 20m in thickness and generally form local aquifers mostly along eastern and western coasts. Water table occurs within a few meters from surface and the quality of water is generally good. The crystalline basement complex covers more than 80% of the country and about two third of it within the dry climatic zone. Ground water in the basement complex is found in the secondary porosities such as fracture and joint zones, and in the weathered overburden of the crystalline rocks. At a limited number of locations, well developed inter-connected carstic features in the crystalline limestone has facilitated good groundwater storage and flow. Flowing springs are a distinct feature in association with this rock type. The weathered zone of the crystalline terrain varies in general from very shallow to about 10m depth. Depths down to more than 35m have also been recorded in areas of favorable weathering conditions. In general, it is the lower part of the weathered overburden which is less clayey and is in early stages of weathering, shows the best productive conditions with respect to well yields. The vast majority of the population depends on their water supply through the dug wells constructed in this regolith aquifer.

Water Quality

The underlying geology and climatic conditions affect the quality of groundwater in Sri Lanka. Dissanayaka and Weerasooriya, (1985) classified the groundwater in Sri Lanka into four main water types; 1) calcium type, 2) Magnesium type, 3) Sodium/Potassium type and 4) Non dominant cation types. HCO_3.

In the wet zone, Non dominant cation type, Ca-Bicarbonate and Non dominant anion types of groundwater is common. In contrast, the dry zone has predominantly Na/K type of water is common. In this type of water too Cl sub type is found in many areas. The presence of Cl type in the dry zone could be a result of intense evaporation during common and long drought periods. The effect of underlying geology on water quality is clearly seen in the Jaffna peninsula which is underlain by the sedimentary limestone. Calcium type of water predominates in these areas. Increased salinity is common in areas adjacent to shorelines and saline water intrusions are observed in areas where fresh groundwater is being pumped in high rates. Effect of climate and topography is clearly seen in water quality and probably along regional flow paths. Ca-HCO_3 type in the Wet zone highlands where most of the recharge occurs appears gradually change into Na/K towards the Dry zone lowlands.

Water Quality Problems

The quality of groundwater in most parts of the country is fairly good and constant through out the year. Coastal and sedimentary aquifer regions of the country are densely populated and intensively cultivated. The abstraction of groundwater is largely uncontrolled in these areas and intrusion of saline or brackish water has become significant in certain locations. Excessive use of fertilizer and agrochemicals too contaminates the groundwater with nitrates. Faecal contamination of shallow groundwater is also reported at a number of locations improper disposal of sewage, pit latrines, soakage pits etc. Hard water is a common water quality constrain in limestone areas. In the basement crystalline rock areas, High Iron, Fluoride, and Hardness of water are the commonly observed water quality problems. High nitrate in groundwater has also been observed in the hard rock terrain where population density is high.

Problematic Water Quality Parameters
Nitrate in the groundwater in Sri Lanka

Dissanayake (1988) revealed the risk of pollution of groundwater in Sri Lanka by nitrate in view of nitrogenous fertilizer and human waste matter from septic tanks. With an exception in the Jaffna and Mannar districts, the Maximum nitrate levels of the ground water in different districts of Sri Lanka falls below the WHO allowable limit of 50mg/L. Both in Jaffna and Mannar districts, the agricultural activities are very intensive while population density too is very high in the Jaffna district. Also in the wet zone, nitrate content is comparatively higher in the districts with large cities probably indicating the influence of high population. Although, the agricultural activities are being practiced in to a considerable extent in the dry zone districts, the nitrate levels are comparatively low. This may be explained by the fact that the groundwater table is deeper in the dry zone and therefore, migration of nitrogenous species to the groundwater table may not be effective as in the case of wet zone where water table is much shallower. Country-wise distribution of nitrate in ground water.

Iron in the groundwater in Sri Lanka

The distribution of iron in the groundwater of Sri Lanka. High iron in groundwater is common in the south western part of the country; mostly in the wet zone. Excessive iron in the soil formations and in groundwater affects the rise fields in many areas in the south western region. This region is characterized by considerably thick lateritic residual weathered overburden. Iron is a common constituent in the laterite and excessive leaching associated with high rainfall could enhance the enrichment of iron in the groundwater. Acidic soils in the wet zone can also favor the mobility of iron into the ground water. Unpleasant taste and color of water in many occasions has made water undrinkable. Many water supply schemes based on groundwater sources are therefore using iron removal plats for water purification.

Hardness in the groundwater in Sri Lanka

Total hardness of the groundwater varies over a wide range of concentration. As also indicated earlier, Influence of geology and climatic conditions are well exhibited by the groundwater hardness. Very soft to moderately hard water predominates in the wet zone whereas moderately to very hard groundwater is present in the dry zone. Extremely hard water is found in the Jaffna, Mannar and Mullathiv Distiscts where groundwater occurs mainly in the sedimentary limestone aquifer.

Fluoride in the Groundwater

One main water quality problems in Sri Lanka is the high fluoride content in groundwater, especially in low lying areas of dry zone. Fluoride bearing minerals such as mica, hornblende, apatite etc. are common in the rocks of crystalline basement areas of the country. Levels of fluoride in groundwater in various districts of Sri Lanka correspond well with the incidence of dental caries and dental fluorosis (Dharmagunawardhane and Dissanayake, 1993). Dental health surveys conducted in three districts in the country have correlated the fluoride level in groundwater and dental health of the population between seven and 20 years of age (Table .1)

Table 1: Fluoride concentration in groundwater and related dental health in three districts of Sri Lanka (Seneviratne et. al. 1974)

	Anuradhapura District (dry zone)	Polonnaruwa District (dry zone)	Kandy District (wet zone)
Dental Fluorosis (%)	77.5	56.2	13.0
Dental caries (%)	26.2	26.5	95.9
Fluoride levels (ppm) in groundwater	0.10- 4.70	0.50-13.10	0.02-3.70

Distribution of fluoride in groundwater of Sri Lanka. When comparing the fluoride rich and fluoride poor areas with the climatic, geomorphological and geological factors prevailing in the country, low fluoride concentrations in groundwater are common in the wet zone and high fluoride is common in the dry zone. Physiographycally, high fluoride zones lie within the low plains of the island whereas low- fluoride areas are mostly confined to the central highlands. This situation though possibly caused by many other factors, appeared to be partly explained by the fact that in the elevated wet zone with high rainfall, fluoride is leached from the minerals in rocks and soils whereas in the dry zone plains evaporation and slow groundwater movement tends to increase the fluoride ion concentration.

Pollution Threat to Groundwater

Other than the nitrate problem in groundwater, all other above mentioned problematic water quality parameters are results of the processes of natural

hydrogeochemical environment. The treat to groundwater quality due to anthropogenic activities of the country has also become serious during the last few decades.

These can be classified as:

a) Increasingly widespread use of on-site disposal of unsewered domestic waste.

b) Increased use of fertilizer and pesticides in agriculture, and

c) Uncontrolled onsite discharge of industrial effluents (Lawrence et. al, 1988).

The impact of the above activities is the pollution of aquifers although is a slow process but finally can result in deterioration of groundwater quality. Construction of pit latrines can cause a threat to public groundwater supplies (Foster, 1986). The most immediate threat is the microbiological contamination of groundwater, although the pollution due to nitrate could be a long term one. Most pit latrines in Sri Lanka are water-flush type. This type of latrines can increase the possibility of microbiological contamination of groundwater. The dominant hard rock aquifer systems in the country favor the groundwater flow much faster as fracture flow compared to that of granular aquifers, further increases the risk of groundwater contamination over longer distances.

The use of fertilizer and pesticides in Sri Lanka is increasing rapidly. Those pesticides that are mobile (soluble and only weakly adsorbed) and relatively persistent such as carbamate and thiocarbamate insecticides, are likely to be the most rapidly leached to groundwater. Their persistence in aquifers is likely to be many times greater than in soils (Lawrence and Foster, 1987). In many developing countries, the pesticides that have been banned in the developed countries are often still widely used.

In recent years, groundwater pollution due to various industrial chemicals has received considerable attention. In Sri Lanka, small to medium scale industries such as textiles, metal processing, tanneries and vehicle servicing stations are often widely distributed in urban areas. These industries generate effluents such as solvents and oils that are discharged on to the soils, local water bodies or into shallow pits. Onsite treatment of the effluent is limited. The risk of this effluent penetrating to shallow ground water and usage of such water by the nearby potable-water supply schemes is also high.

Quality of potable ground water is of prime importance in health, particularly in developing countries like Sri Lanka where vast majority of the population depend on untreated groundwater for their water supplies. Naturally occurring chemical parameters in the groundwater in Sri Lanka though not alarmingly high, anthropogenic activities intensify the vulnerability of the groundwater systems in many parts. Improved agricultural and water management practices, improved designs of on-site sanitation systems and safe disposal of industrial wastes must be considered as high priority issues in any groundwater pollution protection measures of the country.

Comprehensive Quantitative and Qualitative Appraisal of Groundwater Resources in Integrated Planning

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Variability in hydrological cycle in the Indian subcontinent has caused severe droughts and floods in space and time resulting in enormous human sufferings and economic losses. With population rise, demand on fresh water has increased manifolds. The deficit in surface water sources has increased the dependency of civilizations on groundwater resources to meet their food, fiber and drinking water demands. Excessive mining of groundwater in arid and semi arid regions has caused imbalance resulting in lowering the water levels and change in hydraulic gradient in some areas. The surface and groundwater resources are also under threat of contamination due to point and non-point sources of pollutants from industries, agricultural sector, municipal solid waste landfills and disposal of large volumes of domestic wastewaters into river and subsurface systems. There are also specific sources of contamination like arsenic, fluoride, nitrate, alkalinity and salinity, which need due attention of water resources planners and managers. Regional scale understanding of hydrological processes may help in quantifying surface runoff and recharge to the geosystem and to estimate sustainable groundwater yield for the area. Hydrogeochemical studies provide a basis for identifying the water types. Major and minor ions concentrations can provide valuable information

related to ongoing reactions in the aquifers. High values of Na^+/Ca^{++} and Br^-/Cl^- ratios indicate that water is derived from rainwater. The identification of fresh water reserves can be carried out with the help of such geochemical studies and delineation of fresh water zones can be done using GIS.

There is very high demand of fresh water for domestic, irrigation and industrial purposes. With increase in population, demand for finite fresh water has to increase with time. Prioritization of demands and optimal allocation of fresh water is necessary. The availability of fresh water in the river basin need to be improved by strengthening the water management or promoting the basin and inter basin transfer of surface water. In India, basin and inter basin transfers of surface waters through major irrigation networks (like Western Yamuna Canal system, Chambal system, Bhakra system, Indira Gandhi Nahar Pariyojna, Mahi project, etc.) are common. Adoption of intensive agriculture without planned irrigation development in such irrigation networks is disturbing the regional water and salt balances in the arid and semi-arid regions. Problems of waterlogging, soil salinity and alkalinity have come up in areas, which lack natural drainage and are underlain by poor quality groundwaters.

On the contrary, decline in the ground water levels has been found due to over exploitation of groundwater resources in the fresh water areas. Different management strategies like optimum pumping, rainwater harvesting, provision of drainage facilities, use of salt tolerant crop varieties, alternate farming and, conjunctive use canal and poor quality waters are necessary. Regional groundwater quality monitoring of aquifer systems including coastal aquifers facing seawater intrusion problem may help in delineating its areal extent of different geochemical species and their concentration levels. Groundwater quality modeling for contaminated aquifer systems is necessary for understanding the transport of chemical species, their reactions and predicting the spatial and temporal changes in groundwater quality in future. There is uncertainty associated in parameter estimation for the solute transport models. A considerable effort is required for data collection, management and interpretation. The suitable geochemical codes for site-specific problems are to be identified, calibrated and validated. The availability of quality data has remained the major problem in such studies. Remedial measures are also needed to rehabilitate the contaminated systems. Comprehensive appraisal of groundwater quantity and quality at local and regional level may help the water planners and mangers to take appropriate measures to tackle these issues.

The Human Impact on Freshwater Ecosystems

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In a world in which nearly every ecosystem seems under stress, freshwater ecosystems—diverse communities found in lakes, rivers and wetlands—may be the most endangered. Freshwater fish are good indicators of water quality. They are subject to a decline in species that has accelerated during the last century as a result of human activity that has destroyed or altered habitats or subjected them to direct pressure from predators.

Aquatic environments have been used since decades as a major repository of anthropogenic wastes. Major rivers are either heavily polluted or drying up because of over-use according to the World Commission on Water for the 21st century. The widespread use of chemicals receives special attention due to industrial and agricultural development whose effluent and waste create a significant health risk by polluting water supplies and sewerage systems apart from soil, air, and food. Among the different types of pollutants typically attributable to human activities, metals, pesticides, persistent organic pollutants, acidification and eutrophication are few of the most ecotoxicologically relevant.

Lesser known effects due to human activities are the overuse of antibiotics which not only lead to more resistant strains of infection, but studies have indicated that antibiotics also may be adversely affecting zooplanktons—tiny organisms that underpin the health of all freshwater ecosystems. Common drugs, ranging from caffeine to anticancer agents, taint freshwater bodies. The pollution is directly related to improper use, either through disposal or through ingestion of medicines. Approximately 80% of drugs taken by humans or animals may be excreted in their biologically active form. Increasing emphasis needs to be given to chronic studies to determine possible genetic, neurobehavioural and immunological hazards, especially for drugs and products.

There are a wide variety of chemicals (both natural and man-made) discharged into the aquatic environment that mimic hormones and in turn may cause disruption in development and/or in wildlife. The most widely known hormone mimics are estrogenic in nature and these are major contaminants in effluents from sewage treatment works. Chemicals such as polychlorinated biphenyls, dioxins, other chlorinated hydrocarbons and surfactants, show the ability to mimic sex hormones.

An increase in the use of fertilizer, the burning of fossil fuels, land clearing and deforestation, lead to an upsurge of N_2. This over fertilization process (eutrophication), is one of the most serious threats to waters where most commercial fish breed. Ozone layer depletion and climate change have resulted in much deeper penetration of UV radiation into lake waters and higher death and disease rates among fish and aquatic plants. This effect is compounded by drought when sulfur compounds in lake sediments oxidize due to falling water levels.

Industrial discharges and agricultural and urban runoff are pervasive stresses. Health concerns associated with environmental contamination by methyl mercury began in 1956 in Minamata, Japan. Studies have demonstrated the importance of atmospheric transport and deposition of particulate mercury as a mechanism for its delivery to remote and pristine ecosystems. Coal fired thermal plants are a major source of Hg emission in all environmental compartments as studies by ITRC have revealed. There are around 2000 tanneries, spread all over the country using chrome in tanning operations discharging massive amount of chromium salt into the wastewaters. Present anthropogenic Pb emissions in inland surface waters due to discharge from industrial effluents have resulted in soil and water contaminations up to several orders of magnitude higher than estimated natural concentrations.

The fact that 60% of the world's population lives within 1 km of surface water means that humans will continue to pose a threat to ecosystem and water quality for the foreseeable future. The affected ecosystem and water quality in turn, threatening both animals up the food chain and humans—thus forming a vicious circle.

Risk evaluation, reduction, and management are major elements of sustainable development. Evaluation and management of risk can be achieved by developing or reinforcing the human, scientific, institutional, legal and information capacity of a country. It is essential that everyone should contribute to capacity building to ensure a fruitful economic future. For risk assessment, reliable data collection over long periods in order to identify hazard, response or dosages in connection with risk characterization is essential. It is only by means of a sound environmental policy and stringent implementation can a country attain growth and stability.

The Occurrences of Drought and ENSO Relationships Over the Dry Zone of Sri Lanka

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Sri Lanka primarily depends on the economy based on agriculture. It has two major climatic zones. The southwestern part of Sri Lanka is wet, while the north and east zones are dry. The variability of rainfall is greater in the dry zone than in the wet zone of Sri Lanka. Rainfall in the dry zone is unreliable, irregular, variable, seasonal, and unevenly distributed. This zone experiences frequent droughts. The occurrence of drought affects significantly not only farming but also other activities such as hydroelectric generation etc. Many studies indicate high probability of teleconnection between the occurrence of drought and ENSO (El Nino Southern Oscillation) events (i.e.Glantz 1987,91, 94, Rasmusson et.al.1982, 83, etc.) The present study focuses on drought occurrence, severity, and their teleconnection with El Nino events over dry zone of Sri Lanka.

Data and Method

Long-term monthly rainfall data collected for 121 years period (1881-2001) for 28 stations in Sri Lanka from the Department of Meteorology, Colombo are used in this study. To identify the tele-connection between El Nino and drought years, Southern Oscillation Index (SOI) data for the same period (1881-2001) collected from the Bureau of Meteorology, Australia. The National Drought Mitigation Center recently introduced the Standardized Precipitation Index (SPI) to monitor drought and flood conditions. SPI computed for different time scales, can provide early warning of drought and help to evaluate drought severity. For these computations, first each year rainfall anomalies are calculated and then anomalies of rainfall for each year is standardized. Drought is then categorized from the normalized rainfall series in accordance with the SPI criteria. Besides, to recognize ENSO events, the SOI data series were standardized and used.

The Drought Occurrences and ENSO Relationships Over the Dry Zone

Generally warm ENSO is associated with a poor monsoon, during an ENSO event, drought can occur virtually anywhere in the world. Based on the

long-term standardized annual rainfall, dry zone drought years have been recognized. Out of 121-year period, 27 years experienced drought. The probability of the occurrence of drought is 0.21. Once in 4 -5 years a drought can be expected in the dry zone area. Besides, 33 percent of the drought occurrences were associated with warm ENSO events. The extreme drought year of1980 and a severe drought year of 1983 obviously coincide with El Nino episodes. The noticeable observation is that out of 27 years drought, half of them occurred during the recent epochs (1961-90, 1971-2000).

Seasonal Drought Scenario

The monsoon climatic conditions refer to the seasonality of the rainfall. The seasonality is the pre-dominant characteristics in the island's weather and climate. The drought occurrences and its severity are briefly described based on the prevailing four distinct weather seasons and these are:

1) First Inter Monsoon (FIM) Season	-	March - April
2) South West Monsoon (SWM) Season	-	May - September
3) Second Inter Monsoon (SIM) Season	-	October - November
4) North East Monsoon (NEM) Season	-	December – February

During FIM season, the Inter Tropical Convergence zone (ITCZ) lies over or in the vicinity of Sri Lanka and it leads to conventional precipitation throughout the country, however, more than 96 percent dry zone area receives scanty rainfall, which lead to drought. All through out of 121years analytical period 22 years were experienced as drought and its probability of occurrence is 0.18. Out of these drought years 13 events (59 %) was associated with Warm ENSO. The years 1983, 1992 and 1998 ware the extreme droughts as well as warm ENSO years. In SWM season the frequency of occurrence of drought is more than (29 years) other seasons. The occurrence of drought probability is 0.24; once in 4 years a drought can be expected in this season. Severe droughts ware experience in the years of 1899, 1918, 1976 and 2001. An extreme drought was occurred in 1913, which was widespread throughout the county, and it strongly correlated with warm ENSO episode. Positive relationships have been observed between the rainfall and SOI in this SWM season. Out of 29 drought years, 11 occurrences or 38 percent of the drought incidences were associated with Warm ENSO events.

During the SIM and following NEM seasons, dry zone of the country has been dominated strongly by the depression or cyclonic activities, which leads to intense precipitation. In the observed periods, 23 are in drought years, once in 5 years there is a possibility of drought in SIM season. Besides, the SIM season, the drought and warm ENSO associations is notably weak, out of 23 drought years, only two events coincides with warm ENSO, while, high association have been observed with cold ENSO events (more than 75% or 15 occasions). Similar pattern of associations were observed in the equatorial parts of the Eastern Africa during October - December by Ambenje (2000). Besides, 23 drought years occurred during the NEM season. Between these drought years, and warm ENSO events, weak correlation existed. The probability of the drought occurrence is 0.19, thus once in 5-6 years a drought can be expected. Usually ENSO events reach their peak in October to December and gradually dissipate during December to February as they are closely linked with the annual cycle of the Sea Surface Temperatures (SST) of the tropical ocean. Consequently, when the NEM is strong, it has close association with cold ENSO and the vice-visa in the weak monsoon.

A conclusion that can be drawn from the above analysis is that the occurrence of droughts varies not only annually but also seasonally according to monsoon rainfall distribution and its behavior. Generally the dry zone of Sri Lanka receives low rainfall and has high rainfall variability, which results, prolonged drought and the probability of occurrences of drought is more than the high rainfall area (wet zone). Once in 4-5 years a drought could be possible. These general patterns are prominently changing in accordance with seasons. The frequency of drought is larger in the SWM season rather than other seasons. Besides, in the SWM and FIM seasons, below normal rainfall or droughts have strong teleconnection with warm ENSO events and the above normal rainfall has associations with cold ENSO (La-Nina) and vice-versa in the SIM and NEM seasons.

Plan for Integrated Development of Indian Water/Land Resources and Management Thereof

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Since long the author is working on the above topic and desires to keep before the brother colleagues his experience as follows.

His aim was to harness the surplus waters from the basins of the Ganga and the Brahmaputra and divert them to the scarcity region in Peninsula. (Map of conceptual scheme is given at end. It is self-eloquent).

In that effort, as a prime requirement, he was searching for suitable lay out of scheme formed of hydraulic structures. However, every time he used to get bogged down in the host of problems (Like shortage of data, shortage of dam sites in Himalayas, Crossing of Ganga basin, depression paucity of suitable alignment of canal to spread water over peninsula, largeness of hydraulic structures, uneven distribution and somany.

So, he searched for the reason of such episode. He found that he was applying wrongly, the techniques of approach of harnessing of resources, duly developed for mono-basin region to the multibasin region.

So that he used principled approach as below. For the sake of conveniencs, few of them could be quoted. The fabric of nature is supreme. He kept the model of "Tree" before him. He used it for development of layout of the scheme keeping in view the cheaper and easy movement of water in it.

Similarly to translate the above he took help of another principle that is being used in scale model technology for helping human brain to imagine spacially and technically large layout of project in one shot of imagination with facility of slicing it to any small size with due application of factor of model to prototype conformity and so many others.

By this approach , it so happened that limits of application of existing monobasin technology were made known and it was possible to use it correctly and was possible to dovetail its findings with those to multibasin one at proper place and time.

The results were as below:

1) It was possible to develop the plan for integrated water / land resources development and parallel management of them for whole of the India considering it as one piece-apiece.

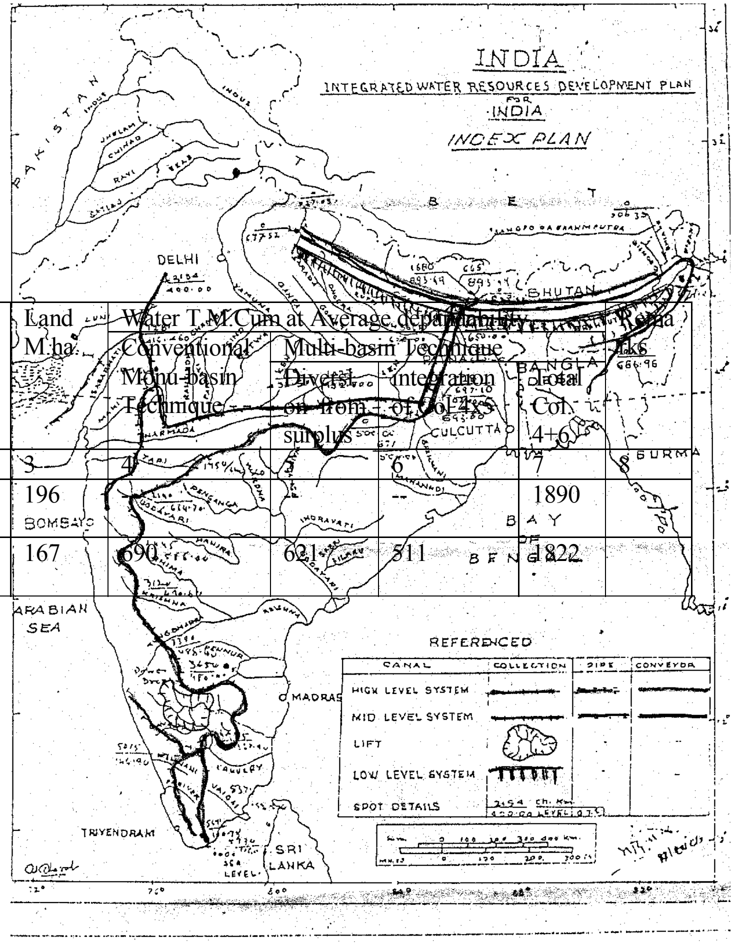
2) All the bogeys were reduced. For example problem of crossing of Ganga basin depression got reduced to the problem of usual cross drainage work which is a normal practice. Here, the technique of inverted syphen was adopted. It avoided costly lifts
3) Hydrologic integration of surplus water resources of catchments with sinks of shortages of water in scarcity land and also promoting of local resources of commands was possible by export / import of water for marginal correction on both sides (catchment- avoid floods, command-avoid drought) through medium of hydraulic structures like tunnels canals etc, for this usual technique, of fill and draw, was modified into moderate and Clear, and was used in catchment side and the former technique was used in command. Because, it was found that those both techniques had their proper application within those region only. This was in sofar as consideration of management at Macro size level was concerned. i.e. supply side.

However, on the other side, for the scale of consideration on the micro level in command area; a model of ultimate development of irriculture was kept in mind and it was of "Phad system" that was sustained for hundreds of years with certain social disciplene behind and drawing full advantage of benefits of irrigation. For that purpose techinque of piped water distribution from field to field was used. (Note - The author has successfully developed that technique in Konkan region of Maharashtra) Accordingly laws and regulations were prepared, and were kept as record.

Now, it is found easier to describe the project as a whole by a map than description (vide map). By this project on more principle was confirmed that " every technology has its life. Until proper data is fed, it gives bold, quick decisions with increasing returns; and it can be said that it is in its ferments of life. However, if it may be taken that dekay has started and at this time new technology should replace.

Indication of the sucess of the whole activities explained above can be seen in the comparative statement of sucess that was attained by using monobasin technology and multibasin technology. From the managemt point of veiw, the project does not involve any element of major lift nor does envisage to divert, any water resources from any basin in the peninsula.

Interim Board Observations from ongoing study. The map and the table give the indications of sucess that the author could achieve by innovations.



Sr. No.	Item Potential	Land M.ha.	Water T.M.Cum at Average dependability				Remarks
			Conventional	Multi-basin Technique			
			Monu-basin Technique	Diversion from surplus	integration of Col 4x5	Total Col. 4+6	
1	2	3	4	5	6	7	8
1	Available	196	--	--	--	1890	
2	Harnessable	167	690	621	511	1822	

Fresh Water Crisis in New Century - Problems in Bengal

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Today, around 3,800 km^3 of fresh water is withdrawn annually from the world's lakes, rivers and aquifers. This is twice the volume extracted 50 years ago. A growing population and a rising level of economic activity both increase human demand for water and water-related services. Development, technological change, income distribution and life-styles all affect the level of water demand.

Despite the massive investment in water resource management and particularly in dams, billions of children, women and men in rural areas lack access to the most basic water and sanitation services. Although problems of access are worst in rural areas, rapid urbanisation is also increasing the demand for water-related services. In 1995, 46% of the world's population lived in urban areas. If current trends persist (and they may accelerate), that figure could reach 60% by the year 2030 and over 70% by 2050.4 Most of this growth will take place in developing countries where an estimated 25 to 50% of urban inhabitants live in impoverished slums and squatter settlements. Lack of access to water in both rural and urban areas is not just a question of supply. It is partly due to inequitable access to existing supplies. Urbanisation implies an increasing concentration on water and energy demand in mega-cities, a switch to different lifestyles and consumption patterns, and a loss of productive agricultural land through urban expansion. It is a widely held view that lack of attention to development in rural areas is fuelling unsustainable forms of urban growth, shifting poverty from rural to urban areas, and contributing to rapidly growing demand for additional services. In heavily populated countries like China, India and Indonesia many question the sustainability of the high rates of urbanisation in mega-cities.

Economic activity and development affect income, income distribution and lifestyles. These in turn affect the demand for water through changes in the level and composition of household consumption in areas such as diet, the use of household appliances and standards of sanitation. How much water is needed for one more person? Although climate and culture influence what constitutes an appropriate level of domestic water consumption, several international agencies and experts have proposed 50 litres per person per day (or just over 18.25 1 a year) as an amount that covers basic human water requirements for drinking,

sanitation, bathing and food preparation. In 1990 over a billion people were below that level." On the other hand households in developed countries and better-off households in developing cities use from 4 to 14 times the Hold of 50 litres per person a day. Drastically lower average figures for domestic consumption in developing countries reflect not only different life styles and lower incomes, but also a huge backlog of unsatisfied demand. The lower average also masks extremely high consumption among better-off urban households and acute deprivation among rural and urban poor.

Water analysts foresee increased competition among water users in meeting the growing demand. They predict that competition will increase among the three largest water users in global terms. Agriculture accounts for about 67% of withdrawals, industry uses 19% and municipal and domestic uses account for 9%. Analysts foresee that these uses will continue to draw from the water needed to sustain natural systems. In dry climates, evaporation from large reservoirs, estimated at close to 5% of total water withdrawals, may also be a significant consumptive use of water." However in India, 9% water is used for drinking 89% for agriculture sector and about 2% for industrial use.

To maintain the growing demand of water in agriculture if major amount of groundwater is utilized, as such in foreseeable future, there will be rapid depletion of ground water availability. In West Bengal, the major demands of existing water supplies lies on ground resources particularly in Gangetic alluvial basin. Though there are surplus water in other river basins, but it is quite difficult to transfer water from one basin to other due to several environmental constrains.

In future, the major emphasis should be given on surface water storage and its rational use particularly in agriculture and also adoption of collection methods for household level rain water harvesting.

Impact of Domestic and Industrial Waste Disposal on Fresh Water Resources

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The continued thirst for modern living, rapid industrialization, urbanization and population explosion in India have led to the over exploitation natural resources and rapid deterioration of their quality in almost every corner of India. Among the various natural resources available in India, fresh water resources (rivers, lakes and groundwater) are under the maximum threat. At present the fresh water resources in India are estimated to be 1880 billion m^3 of annual natural runoff and about 420 billion m^3/year of groundwater [1]. Due to the continuous and rapid increase in the population, haphazard industrialization and unsustainable developmental activities there is a continuous decline in the quality and quantity of fresh water available in India. The current rate of declining of fresh water resources in India is likely to be increased many folds in the coming years due to increased anthropogenic activities.

Impact of Domestic and Industrial Wastes on Fresh water Resources

One of the major factors, which is contributing significantly to the deterioration of quality and quantity of fresh water resources, is the uncontrolled disposal of domestic and industrial wastes.

Today almost all the major rivers in the country are polluted due to discharge of sewage and industrial wastes. For example, river Yamuna during its 48 km of passage through Delhi (2 % of its total length) receives 1700 million liters of domestic and industrial effluents daily accounting for 71 % of its total pollution load [2]. The river once termed as lifeline of northern India has been reduced to a sewer today. The situation with respect to freshwater lakes in no better. The famous Dal lake of Kashmir, lakes of Udaipur, Hussain Sagar of Hyderabad are highly contaminated due to discharge of domestic and industrial effluents.

The unscientific disposal of domestic solid wastes and industrial hazardous wastes has further worsened the situation. The rate of solid waste generation in India varies between 0.2 to 0.5 kg/capita/day amounting to 24 to 39 million tons of solid wastes generation per day [1]. Further a huge quantity of industrial hazardous wastes amounting to more than 4.4 million tons per annum is also generated form various industry sectors [3]. At present major quantities of these wastes are disposed off unscientifically on open land without giving due consideration for environment. These wastes when come in contact with rainwater generate surface runoffs and leachates and contaminate the surface water and ground water resources. A live example of this is the famous case of village Bichhri in Udaipur District of Rajasthan. The two units manufacturing H-Acid (a dye intermediate) at village Bichhri discharged about 2500 tons of hazardous wastes and about 8250 m^3 of untreated effluent on open land in the year 1989 - 1990. The leachate generated from the

waste dumps and the untreated effluent, containing hazardous constituents, percolated the highly porous subsurface strata and migrated along with the groundwater flow towards village Bichhri located downstream of the two units. This resulted in contamination of about 350 hectares of fertile agriculture land and about 60 million m^3 of groundwater [4], which was the only source of drinking and irrigation water for the local villagers. Even after 13 years the quality of groundwater in village Bichhri is unaltered, making life of the people in the area a hell.

There are many similar cases in other parts of the country where the precious fresh water resources have been contaminated by the uncontrolled disposal of such wastes.

Though, there exist the rules and regulations on management of domestic and industrial wastes, their implementation is far below the expectation Thus there is an urgent need to look into these issues and develop suitable mechanism for conservation and protection of these resources.

Hydrochemistry and Ground Water Quality in and Around Muttom, Kanyakumari District, Southern Tamil Nadu

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Water is the most vital resource found on earth. For both biological systems and human societies, water is the major limiting factor of the environment. Out of the total world population, only 20 % gets clean drinking water. The largest available source of drinking water is ground water and once this source is developed, it is necessary to monitor that it is sustainable and no harmful activity takes place in the surrounding area. Ground water is degraded when its quality parameters are changed beyond their natural variation by introduction or removal of certain substances. Hence, the potential of this resource and its quality should be evaluated thoroughly to generate baseline information for the welfare of the society.

A narrow stretch of coastal land (length= ~20 Km) between Midalam and Muttom (N. Lat. 08:07:49 to 08: 14: 00 and E. Long. 77:11:46 to 77:20:38) in the Kanyakumari district of southern Tamil Nadu has been selected for the hydrochemistry and ground water quality studies to generate baseline information for the welfare of the society. This area was selected due to variegated reasons, viz., the occurrence of a dazzling red coloured sand body (a.k.a. 'Teris' meaning sand hills) of considerable extent and thickness; the prevailing semi- arid climate; over-exploitation of groundwater resources; vulnerability of the area to saline water intrusion and the environmental susceptibility of coastal tract between Kolachel and Manavalakurichi (length= ~4 Km) due to the occurrence of several coir retting and manufacturing centers.

In order to assess the spatial and temporal changes in the ground water quality, well sites (N= 12; includes shallow, medium and deep dug wells and bore wells) have been selected and water samples were collected for three seasons, viz., October and December, 2001 and April of 2002. Analytical results show that water is slightly acidic for all the three seasons and it is relatively high during April. However, all the other physico-chemical attributes like turbidity, conductivity, DO, BOD, COD, CO_2, TS, TDS, TSS, NO_3, SO_4, PO_4, Na, K, hardness, Ca, Mg, chloride and salinity are within the permissible limits. The seasonal variation reveal that turbidity, conductivity, Na, K, Cl are relatively higher and DO & BOD are relatively lower during April. Na is the dominant cation for all the seasons followed by Ca, K and Mg, whereas, Cl is the dominant anion followed by SO_4, NO_3 and PO_4. Trace element analysis reveals that Cd (ave.= 0.12 mg/l) and Mn (ave.=0.25mg/l) are above the permissible limits and others like Cu, Pb, Zn, Fe and F fall below the limits.

Bacteriological analysis of select water samples from deep dugwells and borewells shows that they are less contaminated, whereas, the shallow to medium dugwells, particularly the ones near to the Kolachel-Manavalakurichi retting centres record high microbial pollution (over 1600 count/100ml) through out the study period. In accordance with the drinking water quality standards, the water from the shallow to medium wells including the public wells and wells near the Kolachel-Manavalakurichi are not safe to drink and necessary ameliorative steps should be taken to improve the quality.

Impact of Fresh Water Discharge and Dissolved and Suspended Load Relocation from the Brahmaputra Watershed to the Bay of Bengal

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The Brahmaputra river system is one of the primary sources of dissolved and particulate materials entering the coastal Indian Ocean. Having discharge and sediment load of the highest order globally, the Brahmaputra plays a disproportionately important role in transporting materials from terrestrial environments of its Himalayan catchments to the coastal sea of the Bay of Bengal. Both the dissolved and particulate material transfer is seasonally modulated and about 75% and 90% respectively of the total are carried during the southwest monsoon influenced by high flood. Thus the sporadic monsoon pulses of enormous fresh water discharge and suspended load from the Brahmaputra-Ganges are phenomena of significant relevance to the biogeochemistry of the Indian Ocean.

The Indian Ocean is a region of important riverine inputs of N, P, organic carbon and sediment, and a region of important CO_2 exchange between the ocean and the atmosphere. Reported results on the distribution of C-N-P and DO in the deep Indian Ocean suggests that the flux from the Ganges-Brahmaputra may serve as a major nutrient source and oxygen sink. The nature and magnitude of the impact of this monsoon-dependent input on the biological community structure and deep-sea carbon storage would invariably influence the future of the entire ecological and biogeochemical processes of the Indian Ocean.

The Brahmaputra contribute significant amount of DOM to the Bay of Bengal coast through the Bangladesh plains. DOC, which typically comprise 60% or more of TOC load in major world rivers, (Degens et al, 1991) in case of the Brahmaputra, was found to be relatively higher during the monsoon. With predominant contribution of DOM to the total organic matter discharged by the Brahmaputra and the rapid settling of particulate matter from river plumes, it is reasonable to presume that much of the cycling of C, N, and P within the river plume involves DOM. However, the fate of the DOM carried by the Brahmaputra in the ocean margins of Bay of Bengal and its impact on marine food webs will need to be understood and evaluated correctly, particularly keeping in view the reported low primary productivity in the Bay of Bengal.

An adequate understanding of the entire spectrum of transport and transformation process in the Brahmaputra river system is lacking. It is neither clear how the primary productivity of BOB responds to the highly seasonal freshwater and sediment influx. The Brahmaputra- Ganges bring-in new nutrients but at the same time forms a strong stratified layer preventing upwelling of nutrient-rich water from below. Because of high discharge and particulate load, the estuarine processes associated with the Brahmaputra- Ganges take place on the adjacent continental shelf, which influences the magnitude and selectivity of processes that transform, retain or export terrestrial materials.

To investigate the nature of biogeochemical flux coming from the catchments falling within India, water and sediment samples were analysed from 38 locations. Particle size distribution study indicated that after initial mixing from a tributary, the immediate downstream samples represented an unsorted size distribution. However, after complete lateral mixing taking place, the suspended load continued to be increasingly predominated with clay-size materials further downstream. While the particle size distributions were variable with net reduction in size as they moved closer to the river mouth, a corresponding predominance of clay minerals and mica and feldspar were observed suggesting a gradually enhanced amount of alumino-silicates. The average particulate concentrations of Si and Al were determined to be about 32% and 6% respectively. Thus an estimated 18 million tonnes of particulate Si and about 4 million tonnes of particulate Al get injected to the Bay annually from the Brahmaputra catchments alone. The seasonal variations shown by most of the trace metal concentrations were not significant suggesting a consistent trace metal transfer rate to the Bay, only controlled by the mass of the particulates transported. The core samples representing an accumulation over fifty years along the river course also supported a consistency of concentration as none of the cores indicated in-homogenization or remobilization. Positive though limited amount of geo-accumulation of Cu, Pb, Zn, Cr, Mn, Cd near Guwahati city indicated early signature of anthropogenic input. However, these localized anomalies were considered insignificant with respect to total particulate metal flux to the Bay.

Based on average concentrations in the suspended load at the farthest downstream location, the monsoon flux of total organic carbon (TOC) through the Brahmaputra River was estimate to be nearly 15 million tonnes. A decreasing POC concentration with increasing suspended particulate matter was observed resulting from dilution effect linked to high mechanical weathering during monsoon. This was irrespective of a net enrichment of the finer fraction downstream and a corresponding decrease in the quartz-clay ratio. While TDS was relatively low during the monsoon, orthophosphate and silicic acid concentrations were comparable to other large rivers. The dissolved nutrient ratios, indicative of primary production, indicate the intermediate nutrient status for the Brahmaputra River with respect to its contribution to the Indian Ocean in the spectrum from pristine to highly eutrophied drainage systems.

The outlook for the monsoonal freshwater and particulate input through the Brahmaputra basin in future is that it has the potential to influence the biogeochemistry of the Bay of Bengal as well as that of the entire Indian Ocean, the nature and extent of which is unknown to a large extent as of now. A number

of processes (e.g. aggregation- deaggregation, sorption-desorption, grazing, photo-oxidation, mineralization and settling) may alter the lithogenic and biogenic particles, consequently affecting flux and composition of materials entering the Bay. Pre-depositional decay in the lower floodplains may be as important as post depositional decay processes in the coastal margin.

Bulk fluvial suspended sediment discharge rates of the Brahmaputra are not well constrained. Measurements so far have been made upstream from the river mouth; therefore, quantification of the delivery of particulate materials to the coastal ocean is still uncertain on seasonal and annual time scales due to depositional/ remobilization processes in the lower river and lowland floodplain. The bed load discharge (a potential source of large particulate carbon to the ocean) is even more poorly quantified. Though the present study indicates a net reduction in particle size downstream, little is known about the size fractionation of particulate material actually discharged to the sea, especially during various annual discharge stages, more specifically during the annual flood. Few studies have evaluated the chemical composition (inorganic and organic) of particulate materials entering the oceans from rivers. The current study based on limited sampling could thus provide a base line estimate. To better understand the fate of the particulate constituents, the variability in their riverine concentrations and composition needs to be better constrained. Besides, the age and history of the particles discharged to the ocean are necessary to be known.

On the continental margin, seasonal differences in sediment deposition by the Brahmaputra are thus significant, with deposition rates during monsoon exceeding burial rates by an order of magnitude. The extent and timing of initial deposits and subsequent resuspension/redistribution events, though understood with some qualitative insights, are supported with little quantitative information. Despite the prominence of sediment burial, the shelf environments may potentially liberate quantities of some chemical constituents equivalent to (or even exceeding) the dissolved flux directly from rivers, as a result of diagenetic transformations and subsequent transport in dissolved or colloidal forms. A complex combination of factors such as riverine fluxes, coastal biological activity, the depth and morphology of the continental shelf, wave and tidal energy, and local hydrographic control, when and where particulate materials are dispersed and transformed as well as determination of fractions that are exported from or sequestered on the shelf - all are important for a complete understanding of the fate of the vast freshwater and particulate load coming out of the Brahmaputra-Ganges to the Indian Ocean.

Natural Water Treatment Technique - A Perspective

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On Global water budget, only 0.69% is available as fresh water in the form of rivers, lakes and groundwater. In the present day environment, good quality of water is becoming increasingly scarce. This problem can be tackled in many ways ie., optimized use, waste reduction and reuse of waste water etc. In India most of the sewage is untreated and allowed to drain through rivers, streams, canals, lakes and finally to ocean. Considering this reported fact, less than 8% of population is provided with proper sewage and only less than 4% of the total sewage is treated (UNEP 2000). These scenarios urge us to understand and respond with immediate necessary steps to follow wastewater treatment and re-use. This paper focus on various treatment methods and reuse of domestic and certain industrial wastewater through natural treatment and their working procedures.

The wastewater treatment techniques started in early 1900s and got accelerated in early 70s. During that period the main focuses were on a) removal of suspended solids b) treatment of biodegradable organics and c) elimination of pathogens. In early 1980s the aerobic way of treatment got momentum later with inclusion of chemical methods, which results in of course, lower efficiency. Handling of sludge too was a problem. For that result, the combination of both aerobic and anaerobic method started to play dominant role in waste water treatment system.

Types of methods

Basically the waste water treatment methods are classified as i) physical ii) chemical and iii) biological method. The physical method includes screening, mixing, filtering floatation and advanced systems such as reverse osmosis (RO) etc. The chemical process envisages adsorbtion, precipitation, disinfection and residual properties. The various components of chemical methods includes chemical mixers, primary clarifier and sludge dewatering units. The precise operation of these methods need trained operators, high power, huge dosage of chemicals and the byproduct sludge. Consequently this will add considerable amount of expenses to the operators. On the other hand, conventional biological treatment with mechanical aerators, intensive in power, were proved to be very expensive, though was very efficient. The need for an alternative system which has the high efficiency

of conventional biological treatment, but with low energy input and no/low production of sludge was evident. To achieve this objective a natural method was developed by environmental engineers which is known as Root Zone Treatment (RZT) in other words called as Constructed Wetlands.

Root Zone Treatment techniques

A virtual property of such a system is that it can not be switched off. The operational pattern involves a self regulating dynamics of a specially designed soil eco-system. It encompasses the life interaction of various species of bacteria, fungi, micro organisms, roots of wetland plant (halophytes), filter bed media (sieved sand in the range of 2-5 mm) and water. The halophytes transfer atmospheric oxygen through their root system and create suitable conditions for the growth of aerobic bacteria. Since the process occurs in a complex filter bed, aerobic and anaerobic zone exists side by side including different types of chemical reactions balancing bacterial growth. Once the waste water enters the root zone horizontally or vertically (according to design) the organic pollutants are decomposed biochemically by micro organisms present in the rhizosphere of the halophytes. The filter bed media provide favorable conditions for both bacterial growth as well as sufficient hydraulic loading. Further the aerobic bacteria removes the nitrogen by nitrification as nitrates and anaerobic bacteria converts the nitrates into nitrogen gas by denitrification. The removal of phosphorus is achieved by the redox potential of the soil media. By these combined process, the nutrients (nitrogen and phosphorus), heavy metals, suspended solids, BOD and pathogens are effectively removes to less than $^1/_4$ of the input. The application of reed bed extends to municipal sewage, food processing, textiles, distilleries, oil refineries, tanneries and pharmaceuticals.

The commonly available plant species which are used in these operations are i) arundo donax ii) juncus iii) phragmites australis iv) phragmites karka and) typha latifolia. The application of reed bed in waste water treatments have several advantages which are listed as a) virtually no operational cost b) less maintenance c) no requirement of skilled operators d) better aesthetic value/appearance e) flexibility in operation f) less construction cost and g) continuous operation.

Though the RZT method has several advantages in waste water treatment, the only demerit which come across is it requires larger area for construction when compared to other conventional system. The recent trend in urban development programme, lot of flat owners showing much interest towards a proper effluent treatment system instead of septic tank. In this scenario, RZT will serve the purpose by giving effective treatment as well as aesthetic appearance, at a lower cost and maintenance. The continuous non stop functional features gives this natural treatment system as additional credit with dry and cold period.

Soil Moisture and Seed Priming

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Seed priming/invigoration implies an improvement in seed vigor by any post harvest treatment resulting in improved germinability, greater storability and better field performance than the corresponding untreated (Control) seed. Important seed priming techniques have been described below :-

Hydration – Delydiation (H-D)

In this method, seeds are hydrated in water or solutions of chemicals and kept at room temperature for 2-6 hr. depending upon the material, with occasional stirring. The hydrated seeds are surface dried in the shade for sometime, dried back or original weight either in the sun or in a seed drying cabinet in a current of hot air at 35 + 1^0C. Fungicidal and insecticidal formulations can also be incorporated in the soak water. This method is suitable for cereals.

Moisture Equilibrium – Drying (ME-D)

The seeds are placed in thin layers or trays kept on a raised platform in a closed moisture-saturated chamber at room temperature. After 24-48 hr., depending upon the material and ambient temperature, the seeds are dried back in the usual way. This technique has been recommended for soaking injury prone seeds especially lengumes.

Moist Sand Conditioning – Drying (MSC-D)

The principle of this treatment is similar to the above mentioned moisture equilibrium treatment but easier to practice. There is slow and progressive uptake of moisture, which is desirable. The seed is thoroughly mixed with pre-moistened sand, using in most cases 3 times the amount of air dry sand than seed. The M.C. of sand is adjusted to 5-10%. The quantity of water to be added should be so

adjusted as to get the required hydration effect without initiating the germination process. After mixing the dry sand with the pre-moistened sand, the mixture is kept at room temperature for 16-36 hr. depending on the material and sand moisture content. The seed absorbs moisture from sand, and after incubation, the hybrated seed is separated from sand by sieving and dried back to the original weight.

Osmotic Conditioning

It is a pre-sowing seed treatment, which is based upon the controlled hydration of seeds to a level that permits pre-germinative metabolism to proceed but that prevents actual emergence of the radicle. The most commonly used osomoticum is the polyethylene glycol (PEG) which is non-toxic to seed. PEG (-0.5 to –1.5 MPa) at 10^0C for 1 to 8 days, which results in accelerated germination and improved uniformity may be used.

Matri Conditioning

Priming of seed with moistened solid matrix carriers is termed as matri conditioning, which has proven effective in improving germination, early emergence and sending vigour. The high negative potential of the conditioning medium can be used to regulate the amount of water absorbed by the seed and to achieve moisture equilibrium needed to allow pre-germination process to occur without radicle emergence. Water uptake of imbibing seeds reaches a plateau or lag phase, during which it changes very little until immediately before radicle protrusion. Matri conditioning with solid matrix carriers holds seed at this plateau, in unencumbered by the necessity for aeration, and is ideally suited for the addition of fungicides or other chemicals during the conditioning process. Micro-Cell E, a hydrated synthetic calcium silicate, has been found to be particularly suitable for matri-conditioning. The material generates negligible osmotic potential, however, the high porosity and high water holding capacity of this substance permits the necessary high negative matric potential to develop.

Practical Significance

Improvement of seed quality by physiological treatments is a simple, easy and inexpensive approach to enhance seed performance and agricultural productivity, especially for the resource poor third world countries. Hydration-dehydration followed by dry dressing with Thiram @ 0.25% has been found to be an effective seed priming treatment. The main advantage of seed priming is to enhance the germination percentage, speed of germination, uniformity of seeding emergence under a wide range of field conditions.

Assessment of Himalayan Glaciers for Future Water Needs

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In the United Nation's declared "Year of Fresh Water" it becomes an immediate concern to evaluate the available fresh water resource, which has, of late, become a finite resource. The issues of sustainable development and rational use of this fragile environment is stressed upon by the nation time and again. But a rational and scientific planning for use will be meaningful only when the changing environment is kept in perspective, in a world of all kinds of increasing demands and explosions. Environmentalists, ecologists, glaciologists, hydrologists and the Quaternary scientist have predicted that the change in climate will affect no less than 500 million people directly or indirectly in India. Consumption of water has increased six fold as compared to human population growth in the last century. Availability of fresh water has become a major issue for the coming decades, given the population pressure and requirement. The sources of fresh water for the millions, namely the Himalayan glaciers, are in a phase of depletion due to decrease in glacier ice cover, supposedly related to global warming. Rapid decrease is also going to cause massive hazards related to GLOF and slope failures in the Himalayas and forelands. This recession and decrease in ice cover, in turn, is bound to affect groundwater table within the Himalayas and in the foreground. Drying up of springs across the Himalayan region may be taken as an indicator of the future trend. The depletion in ice cover will adversely change the present granaries of the Gangetic Plains into a desolate landscape. Fresh water source for the exploding urban centers in the north will have to be met from the *perennial rivers* of the north.

The data emanating from the Himalayas suggest that these glaciers have been at least three to five times larger in geographical area not in the distant past. Rapid retreat in snout positions in the second half of last century have caused a concern. These tropical glaciers have been considered to be the most sensitive parameter for estimating approximate global climate change and associated phenomenon. Through the government initiatives and funding, many AWS have been set up in the High Himalayas. The mass balance of the glaciers, which is dependent on both temperature and precipitation, can be worked out from the behavior of present-day glaciers, in order to understand the magnitude of change

through time. Once the trend of depletion is worked out in the backdrop of temporal scale, a planned development and alternative management can be proposed. Any investigation and planning in this regard would require an in-depth study of all aspects of glaciers, micro-characteristics of regions and factors influencing the entire "Himalayan Glacier System". In order to assess the available volume of glacier ice, thus the source of fresh water, and their future existence in terms of present rate of retreat, the important Himalayan glaciers are required to be mapped and brought into a GIS database. Trends in use of water and the source can be monitored regularly and the results brought in to a meaningful use for any futuristic development of the nation.

Drainage congestion in Assam

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It is said that the prosperity of a state or a country depends largely upon the river sources available. Assam, the largest state in the northeast India is rich in river systems. The Brahmaputra and the Barak river system dominate the state of Assam. The Brahmaputra River originates from the Dung glacier, about 100 km southeast of Man-Sarover. It has many tributaries like Kubi-Tsangpo, Chema-Yung, Dung, Maryun-Chu, and Lhasa River etc. Near the peak Namcha Barwa (7,755 m), it takes a sudden turn southward and enters the West Siang district of Arunachal Pradesh by the name Dihang or Siang. Near Sadiya, Disang coming from the north and Lohit from the east joins it. It is formed by the confluence of three rivers of Siang, the Dibang and the Lohit between Kobo and Sadiya. It enters Assam valley and flows westward touching almost every district in the valley till Dhubri, below which it enters Bangladesh. The Brahmaputra is joined by a number of tributaries both from the right bank and the left bank. It has nearly 20 important tributaries in the north bank and 13 in the south bank. The tributaries in the north bank come from a heavy rainfall regime region and pass through the fragile and unstable Himalayan mass with steep slopes. As a result they carry heavier sediments. The major North bank tributaries from east to west are the Subansiri, Bharali, Barnadi, Pagladia, Manas, Ai, and Sonkosh. The most important South bank tributaries are Burhi-Dihing, Disang, Dikhow, Jhanji, Dhansiri, Kopili Digharu, Kulsi, Dudhnoi, Krishnai and Jinijiram.

On the other hand the Barak River is a tributary of the Ganga-Brahmaputra- Meghna system. It is the second most important drainage system in the region. It originates in the upper reaches of Nagaland – Manipur border, about 19 Km east of Mao (25^0 28' N and 96^0 20' E), from the slopes of the mountain ranges. Initially it flows in a southwesterly direction up to Karong and is known as Sangu Lok. Downstream, it takes a harpin bend and flows in a northerly direction. South of Meramei, the Barak turns westwards and resives its tributaries of Kozeri Lok, Majatki Lok and Majakoi nadi. It then turns North- westwards to receive Karuiroi Ki and takes a westward and southwestward course to form the Nagaland-Manipur boundary. It crosses the low hills of Bhubon range and enters the Cachar plains- the flood plains. After flowing through the Cachar plains via Silchar and Badarpur up to Bhanga, it bifurcates into Surma and Kushiara. The Surma enters Bangladesh near Bhanga, while Kushiara continues to flow in Karimganj district and enters Bangladesh thereafter.

Flood and its havoc in the state

Flood affects over three quarters of the plains area of the state. There are evidences of the havoc created by flood even in the Fourteenth century literature. But their current intensity is unprecedented and fast becoming an annual feature destroying crops, properties and many other incomparable things. The flood occurs with monotonous regularity, frequently more than once a year. According to the data available between 1953-1984, floods affected an average of 0.8 Mha each year. The maximum area affected was 3.15 Mha in 1954. The maximum population affected was 5.68million in the 1984. The maximum damage in year-Rs 561.8 million occurred in 1983.The number of people affected per hectare and the amount of damages has been raising steadily.

Causes of flood

- The region's tectonics, geology and climate of the basin have combined to generate high erosion rates and river channel changes, making the valley extremely flood prone. The Brahmaputra and its tributaries bring down enormous quantity of sediments and flows in a highly braided channel characterized by numerous sand bars and islands, including Majuli, the world's largest river island. Most of the channel bars are transient in nature. They get submerged during high flows changing drastically their shape and location.

- Location of the Brahmaputra and the Barak valley, surrounded by the mountains and hills on the three sides, have in more than one way restricted the width of the valleys. For example, in the Brahmaputra valley, the upland areas have been taken up for tree plantations, while the rest of the valley including the flood plains brought under intensive agriculture. This became more widespread with the increase in population as well as due to the need for settling the migrants, which is one of the major problems in Assam. This problem has lead to encroachment into natural areas, which formed an outlet of excess water at the time of high water.
- The water speed of the tributaries of the two major river systems of the state is rapid. They have steep vertical gradient that is compounded by short horizontal distances, before joining the main river in the valley. The speedy flow of water has encouraged the land erosion. The continuous deposition of large quantity of sediments has resulted in rising of the riverbeds and caused consequent reduction in the carrying capacity of the rivers.
- The embankments are also equally responsible for the floods. As major rivers like Brahmaputra and Barak including some of their major tributaries have also been embanked, the rainwater in the valley, which falls outside embankments, accumulates and form stagnant water bodies, particularly near the confluence of the tributaries and the main rivers. Embankments cause drainage congestion because even after the floodwater has receded, water in the surrounding areas does not have an outlet. This has resulted in prolonged flood conditions upstream.
- Apart from river embankments, railway and road embankments also have seriously hampered and changed the drainage pattern in the state. Openings in roads and railways are often inadequate. These roads and railways themselves cause floods.

Assam is one of the states very rich in natural resources, flora and fauna. More than 80% of the total population depends on agriculture. But the floods wash away every year uncountable crops, houses etc including human and animal lives. This havoc has been increasing year after year. It's high time to be concerned about this cruel fact. The government must think about going to the root cause of this increasing evil. For this the hydrological regime and flood pattern require serious concerted studies. It also includes the study on pattern of rainfall as well as study on the impact on ground water level conditions. The other important factor as stated is the population explosion in the state due to increasing infiltration, which to some extent is responsible for floods. Strict rules are required to stop this. Otherwise the huge loss born by the people of Assam can't be compensated and ultimately it affects the economy of the country. In fact, in Assam water resource instead of being an asset has become liability to the people of Assam. Proper scientific management of the water resource of Assam may boost up the state economy to a great extent. The government must give serious attention to solve flood problem of Assam. Moreover, the Government may look into any foreseen ecological and Biogeochemical problem to be caused due to implementation of the proposed National River Linking Project. A nationalize debate should be held before hand for taking up such a mega project.

The Current Practices in Textile Dye Waste Treatment and Future Trends

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With the industrial revolution in the late 18^{th} century, industrial activity has grown rapidly all over the world. Of the various pollutants present in industrial waste water, colour is considered to be very important from the stand point of aesthetic sense and is stated as 'visible pollutant'. Various industries like dye making, textile, pharmaceutical, cosmetic food processing etc, spew out coloured and toxic effluent to the water bodies rendering them murky, dirty and unsuitable for further use. Along with the treatment of these wastewater streams colour removal from these effluents has been the target of many studies in the last few years , not only because of its toxicity but also due to its visibility. The colour and dye bearing waste waters discharged into water streams not only contribute negatively to the aesthetic value but also offers considerable resistance to biodegradation and may upset aquatic life being one of the important recalcitrant, colour persists for long distances in flowing waters, retards photosynthetic activity in streams , inhibits the growth of aquatic biota, decreases recreational value of the streams and has a tendency to chelate metal - ions to sequester metal ion producing microtoxicity to fish and other organisms. Most of the colour bearing waste waters have high COD to BOD ratio and affect the stream water used for drinking purposes. Such coloured waste waters are unfit for recycling without proper treatment. Further, dyes (which impact such intense colours to these water bodies) have also been reported to have toxic effects. The substances are carcinogenic and causes allergy and eye/ skin infections. Dyes often receive the most attentions from researchers interested in textile waste water treatment process because of their colour as well as toxicity of some of the raw materials used to synthesize dyes. Recent estimate indicates that approximately 12% of synthetic textile dyes used each year are lost during manufacture and processing operations and that 20% of these lost dyes enter the environment through effluents that result from the treatment of residual industrial waters. Removal of these colouring substances is of major concern. Moreover this industrial waste water is known biodegradable due to high content of dyestuffs, surfactants and additives which generally are organic compounds of complex structure. Due to low biodegradability of colour causing pollutant physico- chemical methods have been commonly adapted for treatment of colour bearing waste waters.

Status of Three Rift Valley Lakes: Nakuru, Elementaita and Naivasha Kenya

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Lakes and their surrounding watersheds are unique and valuable ecosystems for both people and nature. They are critical "storage tanks" for freshwater. More than 90% of all available liquid surface freshwater is contained in lakes and reservoirs! (Shiklomanov, I. 1993). Lakes provide habitat for bacteria, fungi, algae, plants, plankton, mollusks, crustaceans, insects, fish, amphibians, reptiles, birds and mammals. They support large numbers of threatened species and endemics (species that exist nowhere else in the world).

The Republic of Kenya extends between latitude 4.5^0 N and 4.5^0 S and between longitudes 34^0 E and 42^0 E. A major topographic feature in the country is the north-south trending Rift Valley which was formed through many episodes of faulting and volcanism some 30 million years ago (Cole 1950). There are thirteen lakes in the Kenyan Rift Valley. The lakes are mainly inland (i.e. endorheic) basins which apart from Lake Naivasha (fresh water lake) are sodic and are characterized by extreme physico-chemical environment. The solute levels in these lake are high making them saline. Some of the lakes are critical as waterfaul habitats due to their high community of algae and invertebrates, which they support.

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The current study concentrates on three of the Rift Valley lakes namely, Lakes Nakuru, Elementaita and Naivasha. The three lakes are the remains of a once larger (625km^2) lake which is believed to have dried up (10,000 years ago) due to changes in climatic conditions. The lakes are located in Nakuru District, Rift Valley Province (Kenya). Lake Nakuru at longitude 36^0 05' and latitude 0^0 22'; Lake Elementaita at longitude 36^{0}15' and latitude 0^0 27'; and Lake Naivasha at longitude 36^{0}20' and latitude 0^0 45' Lake Naivasha (145 km^2), has unique characteristics e.g. the only freshwater lake among saline lakes, is located at the highest part of the Kenyan Rift Valley (1890m) above sea level (LNROA 1993). Lake Nakuru (44 km^2) is at (1778m) above sea level and Elementaita (20km^2) lies at 1776 above sea level. Both Lakes Nakuru and Elementaita are shallow with a mean depth of one meter.

Importance of the Lakes

The lakes and the ecosystem within and around them including their catchment areas are of great social, cultural, aesthetic and economic value to Kenya. Lakes Nakuru and Naivasha are recognized as wetlands of international importance (protected under Ramsar convention 1971), Lake Nakuru (1990) and Lake Naivasha (1995), (ENS 2001).

Lake Naivasha supports an outstanding horticulture and floriculture sector that generates much of the needed job opportunities as well as foreign exchange for Kenya. It also supports a thriving fishery, geothermal power generation, livestock farming and a growing tourism sector (LNRA 1993). The lake is rich in biodiversity, as over 350 species of birds have been recorded. Lake Nakuru is Internationally recognized because of the number of flamingos in the lake (can hold 1.6 million at the peak period). Over 450 species of birds have also been identified in the area. Lake Elementaita has no conservation status but its adjoining areas are used for large-scale livestock farming and small-scale subsistence agriculture. A few flamingos plus a number of species of birds have been sighted in the lake area.

Major Threats to the Lakes

Due to rapid urbanization and other activities in the surrounding area, the lakes have been subjected to increasing environmental pressure and the environmental conditions of the lakes and their basins have been deteriorating. This is evidenced by deaths of tens of thousands of flamingos in Lake Nakuru since the 1990's (35000 (1993), 15000 (1995) and about 30000 (2000), (SAPS 2001, 2002)). Increased phytoplankton biomass in Lake Naivasha has also been

reported (Harper and Mavuti 1990). The major threats to the lakes include:

- Pollution by agricultural chemicals such as fertilizers, pesticides and herbicides as well as industrial and domestic effluents.
- Heavy metals have been identified by Veterinary pathologists in Kenya as the leading cause of massive deaths of flamingos in Lake Nakuru.
- Sedimentation and siltation as a result of erosion and deforestation in the catchment areas.
- Increased water abstraction from feeder rivers, which reduces the amount of recharge to the lakes. Abstraction of water directly from Lake Naivasha for irrigation purposes.
- Encroachment into the riparian land due to demand for land for agriculture, grazing, residential and tourist hotels and facilities has led to Intensified cultivation and the removal of fringing swamps especially in Lake Naivasha.

Water Chemistry

Analysis carried out on the water of the three lakes indicate that Lakes Nakuru and Elementaita are highly alkaline in nature (pH 9.9 Elementaita and 10.3 Nakuru) unlike Lakes Naivasha which is alkaline with a pH 8.6. The high pH values in the rift valley lakes can be explained fundamentally by the natural process of weathering in the study area, (Yurechi 1982 and Nanyaro 1984). Contribution of photosynthetic activities, which utilizes CO_2 thereby shifting the equilibrium towards the alkaline side in the lakes, cannot be overlooked.

Electrical conductivity (EC) ranged between 39300-54800 mS/cm in Lakes Nakuru and Elementaita and 250-350 mS/cm in Lake Naivasha. The high EC in Lakes Nakuru and Elementaita indicates high concentration of dissolved ions in the two lakes.

Dissolved oxygen ranges between 6.25-17.9 mg/l in Lake Nakuru, 6.7-10.5 mg/l in Lake Naivasha. Supersaturation in most sampling sites in Lake Nakuru, was observed due to photosynthetic activity in the surface waters of the lake. High concentration of *Spirulina p enrichment lantensis* in the lake has been reported (SAPS2002).

Fluoride content in the Rift Valley lakes was high. It ranges between 18-39 mg/l in Lake Nakuru, 2-25 mg/l in Lake Naivasha and 9.65 mg/l (mean) in Lake Elementaita. High fluoride content in the Kenya waters has been reported (Barkish, 1974, Jones *et.al.* 1970, Clerke 1990). The major source of fluoride entering into the hydrological system in Kenya can be traced to volcanic activity associated with rift valley formation and chemical weathering of volcanic rocks (Yuretich 1982, Nanyaro et al 1984). The volcanic rocks of the Rift system are predominantly alkaline rocks rich in Sodium and Fluoride. The rocks are richer in fluoride than analogous rocks in other regions of the world (Gachiri and Davies, 1993, Williams 1982). Evaporative concentrations, have also been reported to be responsible for the extremely high fluoride concentrations found in Kenyan lakes (Eugster, 1970; Jones *et al*. 1977; Nanyaro *at al*. 1984 and Clarke *et al.* 1990). Evaporative mechanism in the rift valley lakes is reported to be so effective that the fluoride concentration is several orders of magnitude higher than the normal groundwater and rivers waters. Considerable amounts of fluoride are also discharged direct into hydrological system in the form of waste waters and other wastes resulting from mining and ore-processing operations at the Kenyan Fluospar Mine in the Kerio Valley in Western Kenya.

Sodium is the major cation while Chloride and Bicarbonate are the major anions contributing almost equal in percent proportion. Silicate weathering is the major contributing factor to the bicarbonate content in the Rift Valley lakes. The relatively high (Na+K)/TZ+ ratio and the low equivalent ratio of (Ca+Mg)/(Na+K) indicate that dissolved ions contribute significantly to the weathering of aluminosilicate mineral in the Rift Valley Lakes.

The observed chemical data of the lakes was used to predict the mineral assemblages in the carbonate and silicate systems. Dolomite and aragonite seems to be the possible mineral in equilibrium with the lakes. Silicate system indicate that the water chemistry of Lake Naivasha is in the range of stability field of kaolinite while the water chemistry of lakes Nakuru and Elementaita is in the range of stability of Albite, Quartz and Chlorite.

Metal attenuation and sulfur biogeochemistry in a wetland receiving mine drainage - contaminated groundwater

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Wetland are generally dominated by reducing condition along with a high organic content. In systems where dissolved sulfate is present, these sediments are capable of retaining a high metal mass by either adsorption or by metal sulfide precipitation. Because of their large meta1 retention capacity. the use of natural and engineered wetlands for the treatment of metal contaminated waters has received increasing attention in recent years.

Down-gradient from the abandoned Rudolfsgruvan nickel mine in Dalarna, Sweden, mine drainage - contaminated groundwater discharges to the wetland Kambamyran. The wetland is a transitional minerotrophic fen, and has received discharges of contaminated groundwater for at least 50 years. In general groundwater discharging to the wetland is acidic (pH ~ 4), with elevated sulfate (~ 350 mg L-l) and metal concentrations (~ 3 mg L-l Cu, ~ 3 mg L-l Zn, < 0.1 mg L-l Fe). Field investigations have been conducted in 1998 and 2002 in an effort to identify the major sinks for metals in the wetland, and to investigate the relative importance of sulfur transformations on metal mobility.

Field sampling was conducted in September, 2002. Sediment cores were collected from the wetland using a 5 x 50 cm steel peat coring device, at several points along a transect extending from the suspected area of contaminant plume discharge to the wetland. In order to avoid the oxidation of aqueous hydrogen sulfide and solid phase sulfides present in the material, all sample handling was performed in a nitrogen-filled glovebag. In the field and under a N2 atmosphere, most cores were cut into 5 - l 5 cm sections, avoiding material that came into contact with the metal walls of the coring device. Pore-water was pressed from the core samples by squeezing in 60 ml syringes. Pore water pH and redox potential were measured in the field. In the laboratory, sulfur and metal speciation in the peat samples was investigated using the techniques listed in Table l.

The results of the current study indicate that microbial sulfate reduction is occurring in the wetland sediments, since H2S is detected. Gas chromatography indicates the presence of H2S in the gas phase as well, which is expected. No other gaseous phases were detected, such as methanethiol and dimethylsulfide that might be produced in such as system. The result show that sulfurs, in the form of acid volatile sulfides (AVS) and elemental sulfur (S^0), accumulates in the solid phase. Indeed, elemental sulfur concentrations generally exceed AVS concentrations. The analytical results for sulfate ester - bound sulfur and total sulfur are not yet available (work in progress), but it is possible that sulfate esters comprise another significant sink for sulfur in this system.

The metals Cu, Ni, and Zn accumulate as sulfide minerals, and there is no indication that adsorption provides more than a minor, short - term sink for these metals. The precipitation of the metal sulfides along the groundwater flow-path into the wetland occurs in the order of thermodynamic stability, and supports

Table 1: Compounds analyzed in this study, and methodology.

Compound	Analytical Method
Dissolved sulfur species	
Hydrogen sulfide, thiosulfate, sulfite	polarography
Sulfate	ion chromatography
Gas - phase sulfur species e.g. hydrogen sulfide, methane thiol	gas chromatography with a pulsed flame photometric detector
Dissolved metals	ICP - OES
Solid - phase sulfur species:	
Acid volatile sulfides (AVS)	Distillation in 6M HC1
Elemental sulfur	Extraction with acetone, distillation with $CrCl_2$
Pyrite	Distillation with $CrCl_2$
Sulfate esters	Distillation with formic acid + hydroiodic acid
Carbon - bound sulfur	Residual fraction
Solid-phase associated metals	Determined on AVS fraction - bound metals and total metal concentrations, by ICP - OES

the conclusion that metal sulfide precipitation is the dominant mechanism for metal accumulation near the groundwater- wetland interface. However, the estimated rate of metal sulfide accumulation is relatively low and much less than the rate of sulfate reduction in engineered systems such as reactive barriers.

The accumulation of sulfur in non - AVS fractions (e.g. elemental sulfur) is significant in that these fractions do not contribute to metal retention. Engineered wetlands for groundwater and surface water remediation in mining environments are often designed to remove dissolved heavy metals by metal sulfide precipitation. However, if sulfur is primarily retained in elemental sulfur or organosulfur compounds, these sulfur - immobilization processes must be considered when dimensioning engineered wetlands.

Water and Development

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Prior to independence, the country suffered time and again by droughts leading to famines and starvation. The poor suffered the most. Mainly failure of the monsoon or deficient rains leading to crop-failure and sometimes, intensive rains causing floods and destruction of standing crops caused perpetual these distress. Quite so the remedy lay in developing our water resources to provide assured irrigation so as to overcome the vagaries of the nature.

Population growth and high living standards have increased the demand for food and water. This has exerted additional pressure on our natural resources including environmental degradation. Alleviating poverty is equally essential. If sustainable development is to be meaningful such development must be based on an appropriate understanding of the environment.

Poverty alleviation has been one of the main objectives of our development planning. Government has been a key player in the development of water resources of the country. There are many success stories and some failures too About 83% of the developed water resources of the country are presently used for irrigation that has contributed to significant agricultural growth.

Water Requirements

Demand for water is rising and is estimated to have risen six to seven times from 1900 to 2001, more than the rate of population growth. It is a rise, which seems likely to accelerate in to the future, because the population is expected to reach 1.3 billion by the year 2025 AD and 1.6 billion by 2050 AD. A tentative study indicates that total annual requirement of fresh water for various sectors in the country will be about 1093 b.cu.m by 2025 AD. This fresh water requirements by 2025 AD will be almost at par with exploitable water resources including both surface and ground water. Thereafter additional supply will be necessary or else scarcity conditions would prevail in majority of our river basins.

For recharging depleted ground water aquifers, arresting deterioratin9 ground water quality including salinity ingress initiatives are being undertaken in several parts of the country through programmes of roof-top water harvesting, artificial recharge and rain water harvesting structures to restore the depleting quantity and quality of ground water.

Water Losses

Unfortunately, much of the water abstracted from surface and groundwater sources for human activities is used very inefficiently. In irrigation, for example. more than 60 per cent of the water seeps from the channels of the distribution systems and is lost by evaporation. To make matters worse, seepage causes water logging and salinization in irrigated lands, resulting in significant reductions in crop yield. Many industrial processes use water inefficiently and fail to make savings through techniques such as recycling.

Losses also occur in the public water supply distribution systems, particularly where the water mains are old and are not well maintained. Leakage of 50 per cent or more of the water is not uncommon and there are losses due to illegal connections as well. There are also losses from the sewers, which carry away the wastewater, which can cause serious pollution problems.

Water Pollution

Streams and rivers are now being used as convenient places to dump wastes. When the world's population was small and industry and agriculture were primitive, this posed no problems. But conditions have changed as cities swell and industry and agriculture demands increase. Today water pollution comes from many different sources, often in large volumes. Some of is in the forms of untreated sewage, industrial discharges, leakage from oil storage tanks, mine drainage and leaching from mine waste, and drainage from the residues of agricultural fertilizers and pesticides. Water pollution varies in severity from one region to the other depending on the density of urban development, agricultural and industrial practices and the presence or absence of systems for collecting and treating waste waters.

Fresh Water Equity: Kerala's Vanishing Dream?

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Kerala (Area = 38,863 Km^2; Population = 35 Million) is endowed with a total of 44 (41 west flowing and 3 east flowing – all tributaries of Cauvery) minor and medium rivers (Rao, 1972). Among these only 5 (>2000 Km^2 of basin area) fall under the medium category. Sahyadris (a.k.a. Western Gahts) form the eastern border, where as the Laccadive sea shoreline (length = 560 Km) demarcates the western border. Despite the relatively heavy rain fall (annual av.= 400 cm) in the state (SW and NE monsoons combined), geomorphology and subsurface geology dictate a very low residence time for the surface and phreatic water. The annual runoff of Kerala's rivers is estimated at 70,323 Mm^3 out of which 42,722 Mm^3 is utilizable (Anonymous, 1974).

Land surface slopes relatively steeply. Narrowest tract in north, has only a width of 11 Km., but widest portion attains a width of 124 Km. Axial length is only 546 Km. Highland region (>75.0 m a.m.s.l.; area= 21777 Km^2) is dominantly covered by Pre-Cambrian gneissic rocks (Hornblende or garnetiferrous-Biotite-gneisses, Khondalites) and Charnockite. Dominant cover rock in the midland (7.5 m – 75.0 m. a.m.s.l.; area = 13476 Km^2) is mostly laterite – a derivative of the crystallines. But coastal land (<7.5 m. a.m.s.l.; extent = 3610 Km^2) is covered by Tertiary sedimentary rocks capped by laterite except regions of coastal alluvial mantle molded into a complex set of beach ridges of at least 4 different generations.

When gneisses and charnockite cover an area of 27955 Km^2; laterite spreads only over 5116 Km^2, followed by recent alluvium (area = 4672 Km2) and lastly by Laterite capped sedimentary sequence of Tertiary age (area = 1120 Km^2). This resulted in a variety of hydro-geological conditions in the state. Laterite and alluvium (though less dominant), in the low- and most of the mid-land tract possess exceedingly commendable water bearing properties and recharge characteristics. With the exception of charnockite, due to vast spread and sheared nature, high ground water potential and resource manifests in the gneisses.

Access to satellite imageries (especially the LANDSAT) provided a synoptic view of the surface lithological cover as well as the gross structural make up of the basement. Subsequent, litho-structural analysis of rock suites revealed the relation between the lineaments and certain leading shear zones (e.g. Bavani and Achankovil shear zones). Data gathered on lineament sets (e.g., multiple generations, differing attitudes, varying extents as well as control on the geometry of the drainage net or disposition of the ridges), added newer dimensions to knowledge base of the practicing hydrogeologist. The dominant chemical weathering process characteristic of tropical environment adequately enlarged these discontinuities in otherwise massive rock, facilitating discharge and recharge.

Role of topographic lows falling along or coinciding with some of the major or minor lineaments (= now mostly stream courses or part of the stream net) in recharging the phreatic reservoir gained acceptance. The CGWB and SGWD have promptly and adequately recognized the role of the lineaments as major conduits of recharge and/or discharge. The lineaments, identified to range between a few tens of meters to several tens of meters in width, are important conduits or "free ways" of water flow like other planar structures.

Cumulative length of the major lineaments mapped from satellite imageries (the LANDSAT) is placed at 1824 Km. (or let say 1800 Km.). It has been possible to identify two sets based on their orientation in plan view, viz., a minor NE-SW set (498 Km. or say 500 Km.) and a major NW-SE set (1325 or let us say 1300 Km.). This 1800 Km. long zone (i.e., a slab of 100 m wide and 100 m. depth of high porosity and permeability), in comparison with the rocks bounding it, is an excellent phreatic aquifer. Assuming a porosity of say 30%, then ideally total volume of water borne in this slab of rock, at any point in time, will be (1800 Km. x 0.1 Km. x0.1Km. x 0.3) 5.5 $Km.^3$, or 5.5×10^9 M^3 (subject only to rainfall and gradient of land and water table). GW is always in dynamic state. The estimate is only a ceiling value, but the actual figure will be far lower. Further, this estimate does not take into account odds like through flow and loss, lack of optimal annual recharge (a factor determined purely by rain fall). It will be fair then to assume that the GW sources in Kerala will not be entirely support the water needs of population, leave alone other sectors like manufacturing and service industry and farming sector.

An estimate of domestic water need, for a teeming population of 30 million Keralites, is also on the rise in comparison with the past decades. Water equity for all policy shall then mean an annual supply or availability of 4.38×10^{11} liters (30×10^6 x 365 x40 lit.) or 4.38×10^8 M^3.Vast majority population depends on ground water (GW) sources to meet domestic needs. In certain regions Industrial needs are also filled by the GW. Only a small percentage is covered by public water distribution system linked to reservoirs and dams and GW reserves, where rain is the main source of replenishment. An order of magnitude difference between the demand and GW availability on further refinement is bound to increase.

Only by economizing, the use of available water and/or by application of new technologies of conservation, that the 40 lit/day/person slogan could be realized and maintained. Only if Kerala is also brought under the scheme of "Linking of Indian Rivers", a perennial flow in the stream net is possible (otherwise a seasonal flow only), and hence a greater degree of recharge into the aquifer systems.

Short term climatic impacts on the dissolved nutrient distribution and budgeting in smaller water sheds – case study from Achankovil river basin, Kerala

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Water in rivers contains many dissolved nutrients, depending on the geological conditions, atmospheric inputs and climate. These materials define the waters chemical characteristics. Chemical river water quality is a function of the chemical load applied to the river, water temperatures and the volume of flow. A changing climate also may alter the chemical weathering processes. It has been reported that substantial in crease in base cation weathering rates when temperature and precipitation increased. Warmer and drier conditions promote minerilisation of C, N and P and thus increase the potential supply to the river system water quality however also will be affected by stream flow volumes, affecting both concentrations and total loads. In order to get insight into the short term climatic impacts on the dissolved nutrients in the river water and their budget a detailed study has been carried out here.

Several studies have focussed on the transport of nutrient material within the rivers and streams in order to establish biogeochemical budget due to weathering / denudation of catchment areas (Stallard & Edmond 1998, Meybeck, 1998; Lasaga et al. 1994; Stallard, 1995). Most of the work in India was done on large rivers like Ganges (Abbas and Subramanian, 1984, Dutta & Subramanian ,1997),Brahamaputra (Chandhan Mahantha, 1998) , Godavari (Biksham and Subramanian, 1984), Krishna, (Ramesh,1985), Cauvery (Ramanathan et al 1996) . But little is known about the transport of terrestrial nutrient material by smaller rivers, which are having homogenous lithology, smaller drainage basin area with partial anthropogenic signature over it. So the biogeochemical studies of smaller rivers are more appealing and important to exactly estimate the material transport and to develop any meaningful model for effective and reliable budgeting of material transport to ocean. Recent estimates show that the small rivers with basin area < 10,000 sq.kms, could be a major source of terrestrial material to the ocean and the estimates of river inputs to the oceans based on data from the major rivers alone may lead to serious underestimation of the fluxes (Milliman & Syvitskt, 1992).

The Western Ghats form a well-defined physiographic feature along the West Coast of India. It stretches for a distance of about 1600 km from Tapi Valley to Cape-Camorin, running parallel to the West Coast. This hill range plays an important role in regulating the climate of India. The main rivers of Kerala, Tamilnadu, Karnataka, Andhra Pradesh, Goa and Maharastra states rises from its various stretches.

The nutrient chemistry, distribution, load and their rate of transport in the Achankovil River is poorly understood. The goal of our research was to study the nutrient chemistry, distribution, and climatic impact on nutrient distribution that causes seasonal variation of nutrient export (budgeting) from Achankovil River to Vembanad Lake. The climate induced seasonal variations and its impact on the nutrient distribution and validation of the biogeochemical budgeting of non-conservative nutrient fluxes are the major focus of this paper.

The river basin is dominated by SW monsoon and in smaller percentage by NW monsoon. Average monthly discharge of each year (out of 11yrs) shows an increasing trend with fluctuation in the last few years until 2000 indicating the possible climatic change in the river basin. Similarly the average monthly temperature shows the increasing trend in the river basin in recent times. . In the year 2002 (study period), the average yearly rainfall shows an increasing trend in the monsoon periods , whereas the average yearly temperature is not showing much variation.

In order to get an insight into the short-term climatic changes in the basin monthly temperature and rainfall data's for the eleven-year period (1989-2001) has been computed . The temperature from March to June is relatively high and the trend shows an overall decrease in temperature in the last decade by around 2 ^{0}C in this river basin. . The temperature is decreasing over the last ten years, but the discharge shows an increasing trends . Discharge increases by 180 cumecs over this ten year period (80-100% increase). The river is subjected to seasonal and year to year variation in temperature and discharge that is due to short term climatic variability. The river warming and cooling will have +ve and –ve impact on aquatic species which are tolerating these changes. The temporal changes within

a given year are the result of complex interaction between the characteristics of the river itself. In general it is observed that the average summer temperature of the river during this ten year period shows overall increase even though the overall temperature shows the decreasing trend, because of that less water flow (discharge) occur during summer. The temperature variation showing different trend in summer in comparison to the overall yearly trend. These variations may be due to change in forest cover which influences the river temperature and discharge trend. The substantial increase in the discharge of 80 to 100% in the past ten year period are due to the increasing precipitation and lesser evopotranspiration in the river system .The impact due to rise in temperature is lower in summer in comparison to overall temperature induced climatic change. If the warming is decreasing within this ten-year period the relatively lower temperature in the river is expected to reoccur in the future and enhance the higher discharge in the river. These climatic variations certainly have to have a major impact in the river nutrient distribution in the long term. Since there is a lack of long term data on nutrients we have generated data for three seasons and analysed their variation with respect to the local climatic conditions.

The river water is alkaline in nature. EC and TDS shows seasonal variation. Monsoon season shows dilution effects over the dissolved solids. Dissolved oxygen is very high during monsoon season. Bicarbonate is the major ions followed by Cl, H_4SiO_4, Na, SO_4, NO_3, and PO_4. Silicate weathering plays a major role in contributing the dissolved ions to the river system. Nutrients are contributed mainly by weathering process and by anthropogenic source. Correlation analysis also shows the role of weathering and anthropogenic activities control on the water chemistry.

The river system in the upstream to downstream acts as sources for the DIP and DIN. Within the river system they behave in contrast to each other due to the differential weathering of the drainage rock, microclimatic changes and the runoff from the human sources. So the system seems to be a source and may be sink at the end (lakes region) for these two nutrients in a given short period with rapid changes. In general here the river input of DIN and DIP is higher . This will support and compensate decomposition with in the system. It shows that de-nitrification is found to be higher than nitrogen fixation. So these rivers are apparently the net producers of organic material. Hence their concentrations in two seasons were not varied too much and it also indicates the rivers higher current assimilative capacity.

Importance of Freshwater to the Coastal Environment

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Estuary is an integral part of the coastal environment. It is the outfall region of the river, making the transitional zone between the fluvial and marine environs.

In India, the coastal population density has been quite high since many centuries and the metropolitan cities like Mumbai, Kolkata and Chennai are developed around the estuaries. Even at the time of the Harappan civilization, exploitation of estuarine and riverine resources was intensive; for instance the Indus delta (Mohan-jo-daro area), the Ganga-Brahmaputra delta and the harbours in Bengal and South India where active Graeco-Roman sea trade flourished.

Estuaries have been the focal point of the maritime studies and activities. As they are semi-enclosed they provide natural harbour for trade and commerce. They are also effective nutrient traps and provide a vital source of natural resources to man and are used for commercial, industrial and recreational purposes. Biodiversity in this ecosystem is very impressive. They are serving as the best settling places for clams and oysters. They also act as nursery ground for a variety of shrimps and finfishes.

India has a coastline of 7500 km with an exclusive economic zone of 2.015 x 10^6 km^2 which is 61% of the land area. The country has 14 major, 44 medium and 162 minor rivers with a total catchment area of 3.12 x 10^6 km^2, discharging 1645 km^2 of freshwater every year to the seas around the country. The important major rivers are Ganga, Mahanadi, Godavari, Krishna and Kaveri on the east coast and Narmada and Tapti on the west coast. These seven rivers drain a catchment area of 1.83 x 10^6 km^2 and discharge 812 km^3 of freshwater transporting 1194 x 10^6 t of silt to the marine waters every year (Zingde, 1989).

Mangrove plants are growing luxuriantly along the river deltas where the major rivers are mixing with sea. In recent years the rate of freshwater discharge is very much reduced due to dam and barricade construction and other man made activities in the upland area as a result many of the freshwater liking species are disappeared. Due to the poor discharge of freshwater in Tamil Nadu, the plant species occurring along the estuaries are very much reduced and the species like

Sonneratia sp. and *Kandelia* sp. are disappeared and only few *Xylocarpus* sp. are available. Also the freshwater inflow in estuaries are necessary for seed germination and establishment of mangrove seedlings and brings enormous amount of nutrients to the coastal environs thereby the productivity of the area is increased. Such a dynamic environment provides many ecological niches for diverse biota. The health status and the biological diversity of the Indian estuarine ecosystem are deteriorating day by day through man-made activities and dumping of enormous quantities of sewage into the estuary has drastically reduced the population of the fishes. It has also caused considerable ecological imbalance and resulted in large-scale disappearance of their flora and fauna and ultimately it affects the coastal fisheries. So it is necessary to allow some amount of freshwater in to the coastal system and this will enhance the biodiversity.

Cauvery Problem

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The Cauvery Basin, is an interstate river system with a drainage area of 87,900 sq. km flowing through Kerala (3.3%), Karnataka (41.2%), Tamil Nadu (55.4%) and Pondicherry (<0.1%) states. The main river has a length of 800 km with 40% of it in Karnataka, 52% in Tamil Nadu and 8% common to both the states. Within southern India, it is only smaller than the Godavari, the Mahanadi and the Krishna. The river rises in Coorg of Western Ghats at an elevation of 1341 m, flows in a general easterly direction to join the Bay of Bengal in Tamil Nadu.

Irrigation has been in vogue for centuries in the Cauvery basin through minor irrigation reservoirs known as tanks and weirs locally known as anicuts. The most important work across the Cauvery is the Grand Anicut in the Cauvery delta of Tamil Nadu, reputed to have been built by the Great Chola Kings in the first century A.D. As time passed, improvements were made to improve its irrigation capabilities, of which those made in 1830 are most important. The Upper Anicut was constructed by Sir Arthur Cotton across the north branch of the river in Tamil Nadu in 1839 and further improved as the Mettur dam just to stabilise the command area under the lower anicut.

But for these structures, the major portion of the Cauvery waters particularly in Karnataka state couldn't be utilised until the beginning of the 20'h century for want of technological advances in the construction of large storage reservoirs across rivers. After entering into an agreement with the then Madras Presidency in 1924 in sharing of the Cauvery water between the riparian states, the first major breakthrough took place with the construction of the Krishnanasagara dam near Mysore to irrigate over 50,000 hectares in Mysore and Mandya districtsw The net land under irrigation utilising the surface waters in the Cauvery basin now is around 1.2 million hectares, with 73% belonging to Tamil Nadu and 27% to Karnataka. Despite covering over 41% of the drainage area, Karnataka had to be satisfied with a lower share of Cauvery water owing to the need to honour the established rights in regard to the existing irrigation in the Cauvery delta.

Agreements between Karnataka and Tamil Nadu in sharing Cauvery Waters

The utilisation of water by the riparian states is governed by the Agreements of 1892 and 1924 between the erstwhile Government of Madras Presidency and the former Princely State of Mysore. According to the 1892 agreement, the Mysore Government had to obtain the prior consent of Madras for taking up new irrigation projects, to ensure that those works would not affect irrigation of the existing projects in the Madras Presidency. It was also agreed that any disputes as to the interpretation, operation and implementation of the Agreement would be settled by arbitration within themselves or through mediation by the Government of India. The agreement of 1924 was necessitated for Kamataka to get green signal for the construction of the Krishnarajasagar dam. The Government of India has constituted a tribunal to settle disputes arising among the riparian states.

Present State of the Problem

There were disputes between Karnataka and Tamil Nadu on several occasions in the past whenever there was deficiency of rainfall in the catchment areas of the Cauvery basin. The most recent of this happened only last year. The rainfall was so meagre that the reservoirs in Karnataka couldn't be filled to meet even the water requirements of the Karnataka farmers. There was a big uproar in Tamil Nadu for release of what little water that accumulated in the Karnataka reservoirs to save their standing crop in the Cauvery delta. The matter went up to the level of the Supreme Court of India, which directed the Karnataka to release some water to Tamil Nadu. There was a virtual water war with Karnataka farmers forcing the State Government to defy the orders of the Supreme Court and the tribunal. Regional passions rose so high that even intellectuals from various walks of life divided themselves on regional lines.

Comparison between Agreements in Sharing Cauvery and Farakka waters

Farakka barrage was constructed to divert flows of the Ganga River to the Hoogly River so that there will be enough water in the Calcutta Port during summer. This had led to a dispute between India and Bangladesh, which was amicably settled by the treaty of 1996. The whole draft of the treaty was so well prepared that there were no further disputes between India and Bangladesh on this account. A mechanism was evolved to indicate the measures to be taken by India to ensure adequate Ganga waters arriving at Farakka but also to evolve the exact sharing mechanism under varying flow conditions, including distress conditions. Unfortunately, similar care was not taken in the draft of the Cauvery tribunal in the sharing of the Cauvery waters by Karnataka and Tamil Nadu particularly during distress periods. The Cauvery problem can be solved amicably if only the Central Government convenes the Cauvery Tribunal once again to spell out an exact sharing mechanism without any ambiguity binding by the riparian states under varying rainfall and runoff conditions.

Interlinking of Rivers as a Solution to the Cauvery Problem

The Cauvery problem made right-thinking people including the Supreme Court of India to go in for the interlinking of rivers so that the surplus water from the north Indian rivers could be pumped into the south Indian rivers including the Cauvery. As most of Karnataka is at a high elevation, there is little possibility for any such water to be obtained by any part of Karnataka. The state however can get indirect benefits such as obtaining a greater share of water from the rivers such as Cauvery flowing within the state. The types of problems such as the one Karnataka faced from Tamil Nadu this year to part with some of its legitimate share of Cauvery water in the name of "distress sharing" will be eliminated with assured water coming through inter-basin transfer of river waters. These benefits can however come only after the successful execution of the interlinking of the rivers, which might take place after several decades.**An Interim Solution to the Cauvery Problem**One way to tackle the Cauvery problem before additional water could be actually imported to the Cauvery River through the interlinking of rivers is by developing the groundwater flowing beneath the river bed as base flow or underflow and presently getting lost to the Bay of Bengal. The Central Ground Water Board (CGWB) has estimated the quantum of groundwater lost in this away to be around one half of the replenishable groundwater resources of the Cauvery river basin of over 14 km3 a year. By large-scale pumping of this groundwater into the riverbed through a large number of high-yielding wells of proper design selected on a foolproof basis all along its course, it would be possible not only to ensure adequate flows in the river but also make available much-needed water to the farmers during distress years.

Baseflow Analysis

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This paper describes a simple technique for baseflow separation from continuous daily stream flow records. The technique employ the smoothed minima algorithm, which has been widely for baseflow separation. Also, it describes the possible application of baseflow in the context of water resources management.

Baseflow is an important genetic component of a streamflow hydrograph, which comes from groundwater and/or shallow subsurface storages. Through most of the dry season of the year, the streamflow discharge is composed entirely of baseflow. During a wet season, discharge is made up of baseflow and quickflow. The latter represents the direct catchment response to rainfall events. Baseflow may be characterized by its hydrogrpah, which is derived from the total stream flow hydrograph by various baseflow separation techniques. A variety of event-based separation methods are available, which focus on separating baseflow from a flood hydrograph and are eventually aimed at the estimation of surface runoff component of a flood.

There are various types of baseflow separation techniques are designed to generate a baseflow hydrograph for a long-term period – a year, several years or for the entire period of observations. These techniques normally make use of a filtering procedure of some kind, which allows a streamflow time series to be disintegrated into quickflow and baseflow. Perhaps, the most well known techniques of this type are the UK "smoothed minima" method (FREND, 1989) and "recursive digital filter" (Nathan and McMahon, 1990) although other methods to separate baseflow on a continuous basins have reported (Smakhtin and Hughes, 1993). Continuous baseflow separation techniques do not normally attempt to simulate baseflow conditions for a particular flood event, nor are they always appropriate for the identification of the origin of baseflow. These methods are rather aimed at the derivation of objective quantitative indices related to the long-term baseflow response of a catchment (baseflow index (BFI) – the ratio of baseflow to total stream flow) and at the estimation of continuous time series, which specifically characterised baseflow regime.

Baseflow may be separated from either daily or monthly stream flow time series. Traditionally, most of the continuous separation techniques dealt with the

separation of baseflow from more detailed daily stream flow records. The continuous baseflow time series may be useful for the development of cathcment management strategies, the establishment of relationships between aquatic organisms and their environment, the estimation of small to medium water supplies, water quality and salinity management, the estimation of groundwater recharge, etc. This paper describes one of the simple techniques for continuous baseflow separation from daily flow time series and discuss the possible application of this technique in the context of water resources management.

Base Flow Separation Method

In the present study, a procedure suggested in low flow studies report (Gustard et.al., 1992) to estimate the Base Flow Index using the mean daily discharge data is used.

The BFI can be thought of as measuring the proportion of the river runoff that derives from stored sources. A computer program is applied to smooth and to separate the recorded or observed flow hydrogrpah from which the index in calculated as the ratio of the flow under the separated hydrograph to the flow under the total hydrograph. The procedure for calculating the BFI is as follows

1. Divide the mean daily flow data into non-overlapping blocks of five days and calculate the minimum for each of the block and they may be called as Q1, Q2, Q3,…….Qn
2. Consider in turn (Q1,Q2,Q3), (Q2,Q3,Q4), (Qi-1, Qi, Qi+1) etc. In each case if 0.9 times central value is less than other values, then the central value is an ordinate for the base flow line. This procedure is continued till all the data are analysed to provide a derived set of base flow ordinates QB1, QB2, QB3,……. QBn which will have different time periods between them.
3. By linear interpolation between each Qbi values as found above, daily value of QB1 to QBn are estimated
4. If QBi is greater than Qi then QBi is made equal to Qi
5. The volume beneath the base flow line thus separated VB is calculated between the first and last points QB1 to QBn.
6. The volume beneath the recorded mean daily flow Qi and Qn is calculated as VA for the period QB1 to QBn.
7. The base flow index is derived as the ratio of VB and VA.

The baseflow separated using the method described and the relationship with the total observed flow are shown in the Figure 1 and Figure.2. Also, the BFI computed for the different years and its variation are shown in Figure.3.

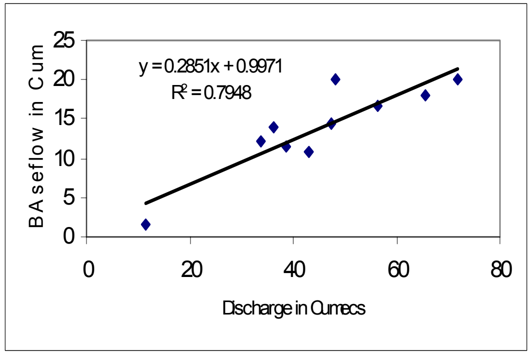

Figure 1: Yearly variation of baseflow with total flow

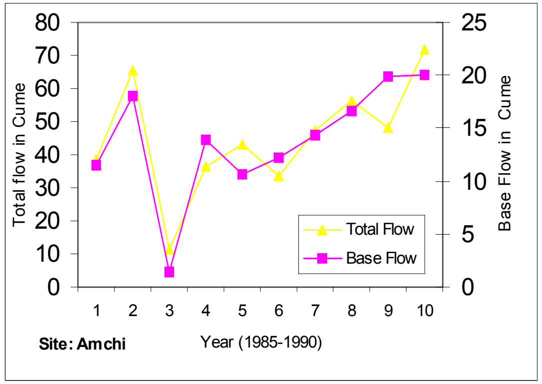

Figure 2: Relationship of total discharge with baseflow

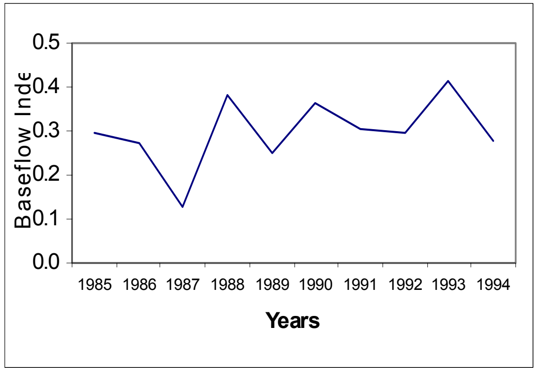

Figure 3: Yearly variation of BFI

Possible Applications of Continuous Base flow in the Context of Water Resource Management

The major problem in the management of rivers has been how to balance the tradeoffs between instream (e.g. auqatic life, and recreation) and out-of stream (e.g, reservoir regulation) uses. Management problems normally exacerbate during low-flow periods and with on-going water resources development resulting in gradual reduction of flow available for instream uses.

There are number of studies carried out to analyse the possible environmental effects caused by instream flow reduction. Such reduction may lead to increased sedimentation that changes the morphology of the stream channel and flood plain. Changes in stream morphology may potentially affect the distribution and abundance of stream biota. Stream flow reduction can also aggravate the effects of water pollution.

The components of a flow regime which are considered important for the estimation of Instream flow requirements include low flows, small increase in flow and small and medium loods. Large floods, which cannot be managed, are normally ignored. The instream flow assessment process has the following objectives :

1. To establish low-flow and high-flow discharges for ecological river maintenance for each of the 12 months of the year. Additional information that describes the required duration of high-glow events and the severity of low-flows is often also included
2. To determine minimum flow requirements during drought years. These are also determined as a sent of month-by-month daily flow rates and are viewed as the flows which could prevent the irreversible damage to the river system during extreme droughts
3. To estimate the total water volume, which will be required to maintain the desired ecological state of the river after the water resource development has been implemented.

The process requires the description of natural flow regime and the stream flow time-series data with daily time resolution. Instream flow requirements are estimated at several different sites below the proposed impoundment or other water resource development. The estimation of IFR is an information consuming process where the hydrological information is a basic need and at the same time a primary component for final recommendations. The recent development related to the IFR estimation includes the work by Hughes et al., (1997) where the technique to convert tabulated monthly IFR values into continuous daily modified flow time series has been suggested. Further, he has suggested to use this technique to estimate the assurance levels. This has opened the way to implement the ecological flow recommendations within the context of a water resource plan or management of the river.

Understanding of low-flow processes and reliable low-flow information will attract more focus from the side of integrated and environmentally sustainable catchment management. In the context of such management, low flows should rather be viewed as a dynamic concept and not described by just one single low-flow characteristic. The preference should therefore be given to the time series of flows, from which the variety of low flow indices may be extracted to satisfy different management and engineering purposes. Alternatively, more emphasis should be placed on the application of condensed information general measures of catchment flow response.

Fresh Water

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Water, a wonderful commodity provided by nature is essential for life on Earth. As far as the Indian subcontinent is concerned, this is the wettest place on the planet. Despite of the availability of plenty of fresh water resources an average annual precipitation of over 4,000 km^3 or 110 cm and a total river flow around 1,880 km^3, 7 million hectares of various types of lakes, pounds, reservoirs and a potential renewable ground water resources of about 431,423 million m^3 (431km^3) - the problem of fresh water for drinking and irrigation purposes is turning into a major crisis. Growing population, urbanization with its modern lifer style industrialization, expansion of cultivated land, deforestation, discardment of ground and riverine water resources have compounded the water crisis. The future is even darker. The present annual requirement of water for our country for various users such as agriculture, domestic, industrial energy and other miscellaneous purposes is around 634km^3 and is expected more than double in the next 50 years. Thus 'water' is going to be the most volatile political issue in the coming future.

There are two processes of over coming the crisis - water conservation and water management. Water management is concerned with the efficient use of

water, which is based on related technologies and consciousness on the part of users. However, the present paper focuses on water conservation through water harvesting by means of micro/tiny projects, which is viable and highly sustainable. A point in the case is the research done by Michael Evenari, an Israeli scientist. He had found ancient towns in the middle of the Nagev desert which got only 100 mm rain every year. Not only did they have their own drinking water systems but surplus for agriculture too. This research showed that a small catchment managed to hold more water than the larger ones 3,000 micro catchments of 0.1 hectares each give five time more water than one catchment of 300 hectares. Similar researches in India have established even more encouraging prospects. According to the CSE, on an average each Indian village can harvest about 3.75 billions litres of water every year which can fulfil its most of the requirements. In this context the paper also proposes to study the 'Pani Roko Abhiyan' in Madhya Pradesh as a ground level campaign towards water conservation / harvesting by applying traditional techniques in a scientific way. The campaign launched with state-people collaboration to overcome water crisis may be a very practical, cost effective (economical), environment friendly and socially viable and a sustainable alternative to mega projects.

Some Aspects of Sustainable Development of Ground Water in India

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Ground water and surface water are social goods as far as everyone's right of access and availability for meeting basic drinking water needs are concerned. However, they are also economic goods and the beneficiary must pay the price or at least a subsidized price for them. Ground water development, however, takes place mainly through private funds on private lands and a strict legislative control on pumping is difficult to implement even in the over-exploited watersheds. Legislative control is further impeded by the lack of knowledge about the dynamics of this hidden resource, flowing through an inhomogeneous and anisotropic porous media. Moreover, this dynamics is highly variable, heavily dependent on local conditions and is often not reflected in the data-sets collected by the government departments (Moench, 2001). However, if mismanaged, the ground water can cause reduction in food production, environmental degradation and hardships to many of the world's poorest people. The issue of sustainable development is, therefore, as much social as technical, i.e., the technical solutions which have to be socially acceptable.

In consideration of the above facts, the ground water policy for the future should have the following tenets for achieving sustainable development:

1. Economical and efficient use of ground water: It is only in recent years that the limitations of ground water, as a resource. are being recognized. Irrigation being the biggest use of ground water, efficient irrigation methods must be adopted. Irrigation is a consumptive use and most of the water supplied to the crops is 1ost from the system. As against this, ground water use for domestic purpose is mostly a non-consumptive use, because almost 70 to 80 % of domestic water supply is back into the system as wastewater.
2. Watershed development through soil and water conservation programs: Recharge augmentation and rainwater harvesting have to be promoted simultaneously with ground water development projects so as to minimize the impact of increased pumpage on ground water outflow from a sub-basin.
3. Conjunctive use of surface water and ground water: In monsoon climate, when the rainfall is restricted to a few months of the year, surface water storages must be created at suitable places so as to augment recharge in post-monsoon months. Excess water in irrigation canals during the rainy season should be pumped and stored in reservoirs in out-of-command areas or charged into dug wells in these areas.
4. Prevention of pollution of surface water and ground water: Quality of surface water and ground water is going to be a major problem in future. If surface water gets polluted, the average residence time of water in a river is only a few weeks, till the river meets the sea. Average residence time of ground water in an aquifer is about 1,400 years. Scientific land-use-planning, especially in the vicinity of cities and megacities, is virtually absent in our country. There are too many political and non-technical influences in land use planning. This results in industrial development taking place in the catchment areas of reservoirs supplying drinking water to megacities or on the recharge areas of prominent aquifers.
5. Irrigation of food crops giving more calories per cubic metre of water: In a country overloaded with population, the prime importance should be given to

promoting crops which give more calories per unit of water consumed.

6. Use of aquifers having marginal quality of ground water: Salt-tolerant varieties of crops should be developed so that some of the brackish water aquifers could be put to use. Artificial recharge of good quality water during rainy season, into brackish aquifers should be encouraged. The recharged water could be regained for use in summer season.
7. Creating a public awareness about the true economic value of water: The ultimate end-user is the public. Audio & Visual programs over radio and TV should cover topics related to water resources.
8. Involvement of women in management of irrigation and of village drinking water supply from wells and bores: Women by their nature are better managers of scarce resources. They appreciate the value of water and avoid wastage.
9. Pumpage control in over-exploited watersheds, only through village councils: Recharge augmentation is a positive way, while pumpage control is a negative way of management. In extreme cases, when pumpage control is to be observed in a watershed, the best way of monitoring is at the level of village council.
10. Alternative use of ground water should be planned: In extreme cases of aquifer over-exploitation, a shift in economy from its base in ground water irrigated agriculture to advanced non-irrigated or rainfed farming and to industries requiring much less amount of water, may be necessary. When several alternative uses are competing for a scarce resource, the use which gives more contribution to the GDP per one cu.m. of water is often the preferred use.
11. Building bridges of understanding and cooperative action between various stakeholders in water resources: In recent years, organizations, like World Bank, World Water Council, and Global Water Partnership, are promoting greater involvement of the stakeholders in water management. The motto is "Making water everyone's business" or better still, "Making water everybody's concern". NGOs are playing an active role in bringing together various stakeholders, holding dialogues and solving water-related problem.

Policy on Fresh Water

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The Strategic Issue: Demand Management, Asset, Creation or Both?

Large-scale asset creation and centrally managed recourse systems are not the only way to solve water supply problems. It is possible in many cases to solve such problems not by making more water available but to look at current usage and see if it can be improved in terms of both distribution and application. In other cases, supply can be augmented with the use of local, socially-controlled and environmentally friendly approaches.

There is a profound difference between satisfying demand and managing it, especially as unmanaged demand generally continues to expand. Supply driven approaches intended to satisfy uncontrolled demand and which result in ever expanding withdrawals of badly managed, poorly allocated and otherwise wastefully used water simply means that that there is less of it left for future use, and that the reducing balance is ever more difficult and costly to access. An approach which instead, manages and fairly adjudicates demand, has immense economic advantages in that sunk cost assets become more productive as does the water itself; water sector goods and services become more equitably accessible; and, their benefits-in-use are better distributed, including those that conserve environmental stream flows.

The Generic Issues introduced briefly9 in the following sections are profoundly relevant to this fundamental and pivotal issue. A review of them may suggest alternative solutions to India's current water supply difficulties that could reduce the need for massive new investments in capital infrastructure and vast amounts of new energy while reducing any social disruption and environmental compromise.

Economic Issues

The Energy and Water Supply Dilemma

The Proposed Project will require a huge increase in installed power generating capacity, yet the Indian power sector is already in a perilous state, barley able to meet even the artificially reduced demand in the country. Widely acknowledged problems include the following:

- difficulties in establishing meaningful power tariffs limit cost recovery and hence sustainable operation and maintenance;

- installed capacity lags behind demand and existing plant is prone to breakdowns leading to frequent power outages;
- small farmers dependent on power to irrigate for irrigation frequently lose some or all of their crops for which in many cases they have borrowed money to growth
- unreliable power is a principle constraint on the productivity of water, which as will be seen in the next section is a pivotal issue in the context of this concept note.

Yet, the pumping requirements of The Proposed Project are likely to double the country's power requirement. It must be asked therefore whether it is reasonable to satisfy demand for one resource - namely water - by doubling the demand for another resource, in this case energy? And this question is particularly relevant because it can be shown that the most significant constraint on the productivity of water, and one of the biggest constraints on its availability is unreliable power. It is logically flawed therefore to assume that problems of water availability (if indeed that is the real problem - the next sub-section refers) can be solved by means of an approach which assumes that installed capacity can be installed and maintained.

The Productivity of Water

The more productive water is, the less of it is needed to facilitate, maintain or even increase economic growth, and usually, since the productivity water is directly related to its spatial and sectoral distribution, high water productivity is normally associated with poverty alleviation and hence less environmental stress. An important question here then concerns the present levels of water productivity in India. Are current withdrawals used as productively as possible and are the benefits-in-use equitably / distributed in India?

The productivity of water depends on how much it is used and has little to do with how efficiently it is used (at least not in terms of application efficiency). Some of the most productive water in the world is that used in the Egyptian irrigation sector.

Although application efficiencies are extremely low at around 30%, the wise and sustainable re-use in one location of water wasted in another results in extremely high production efficiencies which have been estimated to be as high as 230%.

Furthermore, re-use of water not only spread its benefits-in-use rather than concentrating wealth, it also reduces its management costs per unit of production. This results in both poverty alleviation and economic growth.

The Indian water sector is currently characterized by grossly under-productive water. Poor management and deteriorating assets mean that water seldom achieves even 50% of its intended productivity; this greatly increases its unit cost of delivery while reducing access to its benefits-in-use as well as causing water logging and associated disease.

The National Water policy actually states that:

"There is an urgent need of paradigm shift in the emphasis on the management of water resources rector. From the present emphasis on the creation and expansion of water resources infrastructure for diverse, there is now a need to give greater emphasis on the improvement of the performance of the existing water resources facilities....."

Existing water resource facilities represent sunk cost assets, improving their performance is likely to represent the least cost approach and produce rapid and major benefits.

What scope is there for this, how soon could the benefits be realized and how significant would they be in social, environmental and economic terms?

The productivity of water also depends on how it is used. To use large quantities of water to produce a thirsty, low yielding, low value crops is less beneficial than using half as much to produce a frugal, high yielding, high value crop. Planning for this requires however, knowledge of comparative advantage, the mobilization of which may require a shift from one sector to another. It also requires a sensitivity to perceived food security needs at the household (at least in the short to medium term) and it must be admitted that it often requires systems of decision making that place equity and efficiency above political and other "traditional" expediencies.

Increasing the economic productivity of water by allocating it to a higher value use is quite an easy step. However, unless the benefits are equitably distributed economic growth is achieved by incurring the costs of wealth concentration and further poverty. Customary users of waters must in some way benefit from its reallocation. This requires that their customary rights are recognized and rewarded in some way.

What then is the nature of India's water use comparative advantage in any given location and can it be mobilized without compromising household food security and in a way that allocates the benefits in an equitable and transparent fashion? What infrastructure is necessary to increase the productivity of existing withdrawals and are they more cost effective than new facilities?

Concept paper on status of River Yamuna and options for restoring its Natural water Quality

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The Yamuna River traverses a length of 50 k.m. in Delhi, out of which about 28 k.m. length is upstream of Wzirabad, while the balance 22 k.m. stretch is between Wazirabad and Okhla. The river bed covers an area of 9700 hectares. 6100 is upstream of Wazirabad. 1600 hectares comprises the riverbed where the land is under water during the monsoon months. Therefore, about 2000 hectares (9700 – (6100) = 2000) is, in theory, availability for development on its banks.

The river Yamuna while entering Delhi (Palla) is relatively clean with the dissolved Oxygen (DO) level ranging from 5.2 mg/l to 7.8 mg/l and the Biological Oxygen Demand (BOD) level ranging from 1 mg/l to 3 mg/l against the prescribed levels of 5 mg/l and 3 mg/l of DO and BDO respectively for river water category B. After the Okhla industrial zone, the river water quality deteriorates excessively with no DO level. The Coliform count also increases to 3,47,00,000/100 ml against the referred standard of 5000/100 ml. The water quality of Yamuna at Okhla after meeting the Shahdara drain does not even meet one permissible parameter.

The main reasons for pollution for the river are as under:-

No perennial flow

There is no perennial fresh water flow in the river below Wazirabad barrage and down stream along its 22 kms stretch upto Okhla barrage. This is because the entire river flow is ponded upstream of wazirabad for meeting the drinking water requirement of Delhi. Thus there is no dilution capacity in the river beyond Wazirabad.

Discharge of industrial and domestic effluent

On the other hand, nearly 3000 Mld of effluents containing sewage and industrial wastes are discharged into the river in partially treated and partially untreated condition.

Domestic sewage

62,000 odd Jhuggies are located on the embankment of the river and also by the banks of the storm water drains. Due to lack of sanitation facilities, the people living in these clusters use the open for defecation. Domestic waste generated from these areas ultimately finds its way through the open surface drains into the river Yamuna.

Towards a cleaner Yamuna

To restore the natural quality of river Yamuna, various developmental activities have been initiated by the Central and State Govt. agencies, which includes Rejuvenation of river Yamuna. The role of Delhi Jal Board, MCD, DDA, Department of Environment and other related agencies for restoring the natural quality of river Yamuna and various options shall be elaborated while discussing this concept paper.

Water Conservation

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Water Resources Conservation in a Sustainable way is a necessity and no one cannot deny the utmost importance related to various issues related to water and policy makers cannot simply formulate policies which are on papers and are not doable. A concerted and coordinated action plan has to be there to achieve this. As the crisis approaches and as water resources becomes scarcer, the risk of conflict over them will become greater. After 2025 AD climate change could also make conditions such that precipitation amounts decreases in the major food producing regions and evaporation rates increase. The bulk of the increase in food production has to come from irrigated lands, this in turn will require more money to be spend on long distance water transfer, dams and the like, should the resources be available. The increasing size and number of cities will create a much bigger pollution load unless sanitation systems are provided.

The climatological whims in the form of erratic monsoon, poses a threat for the water conservation in different areas of India and globally. It has been inferred by the TIGER project that "Solar Maximum " has definitely some influence on the hydrological cycle including water conservation. This problem can be effectively tackled by the countrywide mega plan of linking of various rivers. Since the interlinking of the rivers will be a possible future solution, we have attempted the water conservation through rainwater harvesting in different parts of the country namely Delhi, Rajasthan and Gujarat. One case study of JNU is being discussed in this session.

In urban areas, dependence on ground water is high, resulting in deterioration of ground water resource qualitatively as well as quantitatively. This necessitates repleshishment of ground water reservoirs through artificial recharge by rainwater harvesting, which involves including collecting, storing and conserving

local surface runoff. Jawaharlal Nehru University (J.N.U.) has initiated the pilot project within the New Campus an its surrounding areas. In J.N.U. and its surrounding areas comprising of 5 microwatersheds, 0.46 Million Cubic Meters (MCM) storm water was going waste which could be stored in purpose-built structures and ultimately recharge the depleted aquifers. Three check dams were constructed on rivulets and sixteen piezometers were established to monitor the impact of artificial recharge on ground water regime. The storage capacity of 49,000 Cubic Meters was created in these dams and 343,000 Cubic Meters water had already recharged to the aquifer during last seven years. Substantial rise in water level has been observed. Besides increase in water level quality of ground water has also improved. Apart from sustainable qualitative-quantitative improvement of the aquifer vegetation cover has also increased within the JNU campus. Analysis in Geographical Information Systems has been done to prepare land suitability map in a part of J.N.U. new campus. Vegetation canopy was reduced in this campus due to urbanization and development of brick kilns in Masoodpur area. Water level was gone down drastically due to overexploitation and imposed poor infiltration. Three check dams were constructed within campus, which has recharged the aquifer. Multispectral and multitemporal data from SPOT, IRS- 1A, IRS- 1B and IRS -1C when integrated with Geological, Geomorphologic, Hydrogeological and magnetic data, have potentiality for identification of suitable areas for construction of check dams. It was computed that 45,000 cubic meters of water was recharged to the shallow and deep aquifers every year. The rise in water level was noticed between 5.26 and 11.33 in the piezometers in less than two years. The check dams are creating water bodies, which the master plan says, " should be developed to act as major lung spaces and to attract migratory birds and for improving the micro-climate." The total area under dense and sparse vegetation canopy cover has increased 25% and 46% respectively. Eco-conservation map of the area have been prepared based on geological map, ground water prospect map, groundwater quality map, resistively map, magnetic anomaly map, geochemical map and soil map.

Out of a total area of approximately 5 squire kilometer 112.5 squire meter is characterized as dense vegetation over weathered shallow buried pediment which is ideally suited for regeneration through protection and gap plantation and about 4.57 squire kilometer would need considerable new plantation out of which 3500 squire meter is characterized as weathered shallow buried pediment, and about 470 squire meter of rocky ridge and 600 squire metre of fallow flat area. Some species selected for roadside planting are Prosopis cineraria(Khejri), for shallow buried pediment Acacia leucophloea (safed kikar), Acacia senegal (kumta) Cordia rothii (gondi), etc.,. Suitable plants for sandy soil near Check dam sites are Salvadora persica (Pilu), Boswellia serrata (salai) etc. Suitable draught resistant plant wold is Acacia modesta (phulanhi). Fast growing plants in Buried pediment plain (Deep) are suitable for Zizyphus nummularia (Kokanber). Appreciable improvement in groundwater quality in JNU campus has also been observed after the artificial recharge through rainwater harvesting.

National River Linking Project – An Absurd Economic and Ecological Proposition

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On 127th birth anniversary of Sardar Vallabhbhai Patel the Supreme Court asked the Government of India to complete the project for interlinking the rivers within ten years (by 2012). The dramatic order from a three judge Bench has provided a tremendous boost to the concept of inter-basin transfer of river waters from surplus Himalayan rivers basin to deficit peninsular rivers. The interim order of the Court came in the context of a public interest litigation filed by Ranjit Kumar, amicus curae. The idea of networking rivers was originally mooted by Sir Arthur Cotton more than a century ago. The proposal was revived in post independent India by Dr. K.L.Rao who was then the Union Irrigation Minister. The proposal was examined in detail by a high level National Commission on Integrated Water Resources Development Plan which did not find it promising. The court order has set in motion a fresh attempt at implementing the proposal.

A Task Force of Experts has been set up by the government on the project. The Prime Minister nominated experts for the task force on March 2 and with this the task force is well set to work on the preparation of Action Plan-1 giving an outline and time schedules for the completion of feasibility studies, detailed project reports, draw up implementation schedule, estimate costs, benefits and advantages of the project. Tentatively, project is estimated to cost Rs.5,60,00 crore (at 2002 prices) and it is expected that 31st December 2006 will be the deadline for completions of detailed project reports and for starting the implementation of the project.

Legal Issues

Water is a State subject as it figures as item 56 in List 2 (State list) of Indian Constitution: "Water, that is to say, water supplies, irrigation and canals, drainage and embankments, water storage and water power subject to the provisions of entry 56 of List 1". Entry 56 of List 1 stipulates that "Regulation and development of inter-State rivers and river valleys to the extent to which regulation under the control of the Union is declared by Parliament by law to be expedient in the public interest". The Bench said that if legislation is made under 56 of List 1, there would be no need for consultations with States for implementing the interlinking project.

The Perceived Benefits of the Project

When the inter-linking is completed, India will have a national water grid similar to railways and national highways networks and power grid. It is expected to irrigate additional 150 million hectares of land and generate 3500 mega watts of electricity. The interlinking project will not only bring more drinking and irrigation water, it would add to the country's power generation capacity, shift some goods traffic off roads onto the navigable rivers and thus reduce some pollution and help control floods and droughts.

The Perceived Costs:

A. Financial Aspects

The project is estimated to cost Rs. 5,60,000 crores at (2002 prices). Going by India's track record in completion of mega infrastructure projects, the super giga project of interlinking the major rivers appears to be too ambitious to be completed in the short time of ten years. The government has been striving hard to monitor and ensure timely completion of projects costing merely Rs.100 Crore. Major stumbling blocks to its timely execution are the acquisition of land and resettlement and rehabilitation of displaced people. These may lead to time and cost over runs and increase the costs substantially. Such a huge amount cannot obviously be met from budgetary resources of the Central government. Funds from many rural development programs and other developmental programs and social welfare programs will have to be transferred to canal excavation work. Government may have to float bonds and borrow from foreign multilateral lending agencies. The apprehension here is that benefits from the project will start accruing only after it is completed and becomes operational. This may lead to much suffering and political unrest in the interim period which could be even half a century. During this long period the industrial development agenda will take a back seat.

Another set of costs have to be carefully examined. These are the recurring costs of managing the grid, desilting of the canals network and energy costs of uplifting water at several points. The nature of these costs has always been misunderstood and underestimated in the past.

B. Environmental Implications

Linking of rivers is a disastrous idea from environmental point of view. Sir Arthur Cotton and Dr.K.L. Rao were eminent engineers but scientific knowledge itself was not yet aware of the environmental consequences. The drying up of the Aral Sea in the former Soviet Union, the facts that Colorado river in US no longer reaches the sea and only 10 percent of the Nile goes to the Mediterranean and their ecological consequences have been well documented. The ecological consequences of the drying up of Sabarmati river are also known back at home. Several Himalayan rivers may considerably reduce or even stop drainage into the ocean after the project is implemented. Networking of rivers would mean flow of pollutants from higher gradients to cause distress in other areas too. Bigger catchment areas, which would result from the project, would lead to greater loss of water.

C. Adverse Effects on Poorer Sections

The river-linking project will definitely have adverse economic impact on the poor. The irrigation will go the rich farmers everywhere. Poor farmers will be facing the twin problem of reduction in rainfall and ground water resources and increased cost of irrigation.

D. Alternatives are available

The schemes of decentralized water management of water resources by harvesting of rainwater by local communities which have been envisioned, operated and tested by several NGOs over the last few decades (notable among them being the Centre for Science and Environment) offer an economically viable and ecologically sound alternative. The Alwar experiment tapped the rainfall of their local region (less than 200 mm). The impounded the same into thousands of village ponds, used it for agriculture and allied operations and got the ground water recharged as a bonus. Accumulated ground water helped revive dead rivers which in turn yielded immense ecological benefit. Simultaneous implementation of large number of such small local water harvesting projects all over the country under the coordination of a Central authority and budgetary support would yield spectacular results not only for water management but in terms of ecological sustainability. This scheme would not only leave central resources free for other developmental activity but would also have the advantage of not locking up scarce investment funds in projects of long gestation periods. The poor will benefit enormously from this alternative. The Task Force must carry out an in depth analysis of this alternative.

Occurrence and Utilisation of Fresh Groundwater in the Mewat Region of Gurgaon District, Haryana

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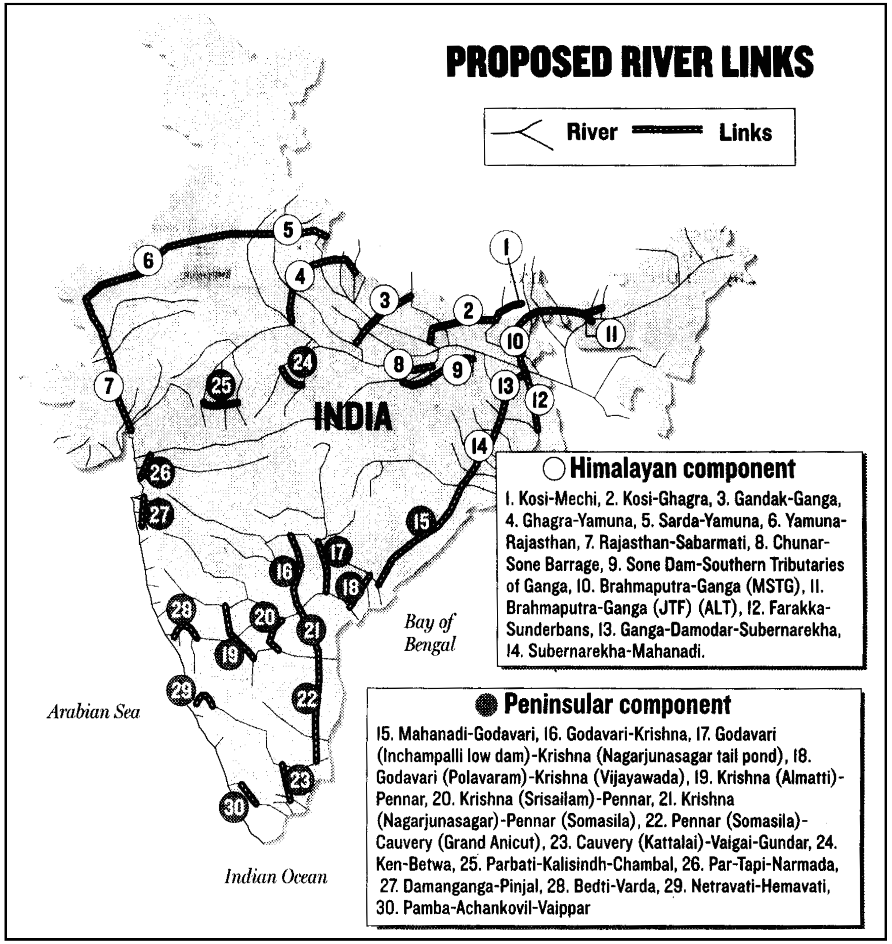
Mewat Region covers Sohna, Nuh, Nagina and Ferozepur Jhirka blocks of Gurgaon district, Haryana on Delhi-Alwar road adjoining to the Aravalli hills. In this area there is severe problem of drinking water. Fresh Groundwater is found at the foothills of the Aravalli ranges. Through deep tubwell this water is used for drinking as well as for irrigation. Many bore wells are dug by the government agencies to provide safe drinking water to the villagers and Nuh Town. Water salinity increases away from the ridges and groundwater is completely saline in alluvial plain.

Water quality, depth of groundwater and trend in water use have been analysed from the data collected through limited field survey and from departments of Harayna government. The geomorphic units and landuse characteristics have been identified by digital and visual analysis of the satellite imagery.

The groundwater levels have been declining. Many of the swallow wells have been dried up and water is extracted by deep tubwells from a depth of over 100m. More and more industries are coming up in this region and groundwater is further exploited for industrial use. The industries also pump the used water into the ground. This would affect water quality of groundwater. If appropriate checks are not implemented for conservation of fresh water in these foothills zones certainly the fresh water will be deteriorated and fresh water sources may also dry up.

Investigation is going on to study the trend in water use, land utilisation and industrial development in the area and their impact on groundwater resources.



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