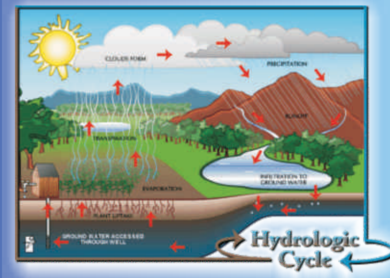
Issue 8, July 2014

Hydrology for People™



Newsletter of National Institute of Hydrology, Roorkee (India)

From Director's Desk

Water is the most important and perishable asset of our planet. On a global scale, we have only 0.75 percent accessible fresh water of the total water resources available on the earth. Our global economy, agricultural production, industrial growth, socio-economic structures, governance mechanisms and everyday life depends on this finite and vulnerable resource. In most parts of the world, including India, the water resources are under stress due to growing imbalance between the mounting demand for water and shrinking water reserve. In our country, the water table is falling due to intense ground water use, thus hampering our quest for the sustainable development. With increased prospects of feeding increased population in 2050, the industrial, individual and agricultural demand is expected to escalate dramatically. Also, the climate change is becoming a more and more important issue for growing water scarcity. This calls for awareness that water is very scarce and valuable natural resource and that we need to initiate innovative technological and management changes. Thus, we have to go for a 'blue revolution' to achieve food security and prevent a serious water crisis in the future.

National Institute of Hydrology has been conducting the research in the field of hydrology and water resources, over the last three decades. Many purpose driven studies and strategic projects were carried out to solve the various need based problems touching almost every sphere of water resources development. With growing interest of managing water resources under the constant threat of climate change, the Institute is gearing-up to conquer the challenges and fulfill the needs of the country via demand driven strategic studies. The Institute is also pro-actively contributing to the knowledge dissemination, mass awareness and capacity building programmes.

R D Singh

Editorial

The document 'The future we want', produced based on the Rio+20 Earth Summit in 2012, demonstrate a shift in the international community towards developing countries in 'the South', contributing more leadership in charting the world's path to sustainable development and green growth. The summit also heralded a variety of new processes to create a post-2015 framework for sustainable development, supported by a new generation of indicators and targets to measure progress and achievement. Developing countries have taken on leading roles in these initiatives, thereby claiming more ownership in the decision-making processes that affect their development paths in an ever more connected world.

Water security is a complex challenge (especially in the developing countries) and is increasingly perceived to be facilitated by the process of integrated water resources management (IWRM). Measuring performance, convening the players and growing our knowledge, with new skills, tools and capacities, are keys for success. A landmark study called 'Asian Water Development Outlook 2013', published by the Asian Development Bank and the Asia–Pacific Water Forum, sets out that increasing national water security requires simultaneous investments and good governance for five key dimensions: household water security, economic water security, urban water security, environmental water security (healthy rivers) and resilience to water-related disasters.

Under the NDA Government, river development, inter-linking of rivers and Ganga cleaning will also be the major focus areas of the reconstituted Ministry of Water Resources, River Development and Ganga Rejuvenation. The National Institute of Hydrology is playing a key role in this national endeavour by providing research inputs in all major activities of the Ministry.

Publication of this newsletter is an attempt to rejuvenate the knowledge dissemination efforts of the Institute, with a flavour of 'connecting to the people'. The intent is to take the research findings to the community so that they are incited to develop interest in the scientific developments taking place in the country. This is the time to make information related with water reach all nooks of the country. And, NIH fraternity is zestful enough to do its bit in this endeavour.

Response to the previous issues has been encouraging. Your suggestions and feedback are welcome, and will help us in improving future issues!

V C Goyal

About National Institute of Hydrology

The National Institute of Hydrology (NIH), established in 1978 as an autonomous organization under Ministry of Water Resources (Government of India), is a premier R&D institute in the country to undertake, aid, promote and coordinate basic, applied and strategic research on all aspects of hydrology and water resources development. The Institute has its headquarters at Roorkee (Uttarakhand). To carry out field related research covering different regions of the country, the Institute has four Regional Centers located at Belgaum, Jammu, Kakinada and Bhopal, and two Centres for Flood Management Studies at Guwahati and Patna in Hydrology, Water Quality, Soil Water, Remote Sensing & GIS Applications, Groundwater Modelling and Hydrological Instrumentation.

The Institute acts as a centre of excellence for the transfer of technology, human resources development and institutional development in specialized areas of hydrology, and conducts user defined, demand-driven research through collaboration with relevant national and international organizations. The Institute vigorously pursues capacity development activities by organizing training programmes for field engineers, scientists, researchers and NGOs. NIH has so far completed more than 150 sponsored research and consultancy projects- the sponsors included Indian Army, PSUs, Planning Commission, National Productivity Council, State Government Departments, and central ministries of Science & Technology, Environment & Forests, Agriculture, Rural Development, etc. The Institute has undertaken a number of internationally funded projects, including those from UNDP, USAID, UNESCO, The World Bank, The Netherlands, Sweden and European Union. The Institute is presently participating in the World Bank funded Hydrology Project Phase-II.

Some of the significant contributions of NIH include studies for solution of real-life problems related to augmentation of water supply and water management in cities, glacier contribution in streamflow of Himalayan rivers for hydro-electric power projects, watershed development, water quality management plan for lakes, watershed development, storm water drainage network in cities, flood inundation mapping and flood risk zoning, and water quality assessment in major cities. The Institute is actively pursuing the IEC activities and mass awareness programmes of the Ministry of Water Resources. NIH works as a nodal centre of the Ministry for effective implementation of the National Water Mission.

VISION

Providing leadership in hydrologic research through effective R&D solutions for achieving sustainable development and self-reliance of the water sector in India

MISSION

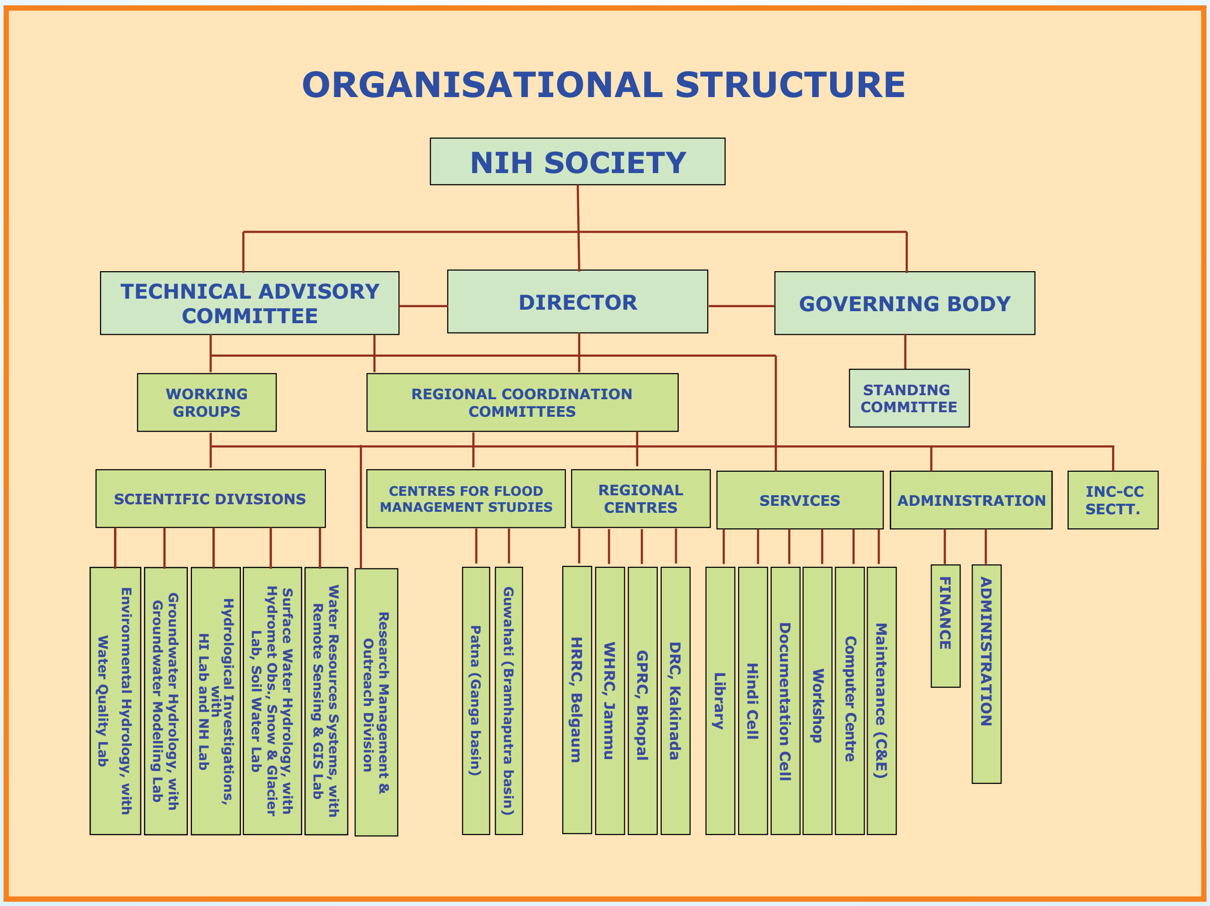
- Develop cost-effective techniques, procedures, software packages, field instrumentation, etc. for hydrological studies
- Study scenarios of water resource availability under varying hydro-geological, climatic, socio-cultural conditions through modelling techniques
- Assess impact of climate change on water resources and suggesting measures for mitigation, adaptation and resilience
- Propagate application of emerging technologies for water resources development and management
- Provide cost-effective R&D solutions to need-based water-related problems
- Provide reliable advice to the various stakeholders
- Empower community through capacity building and awareness on water resources development and conservation

THRUST AREAS

- Water Resources Planning and Management
- Ground Water Modeling and Management
- Flood and Drought Prediction and Management
- Snow and Glacier Melt Runoff Estimation
- Prediction of Discharge in Ungauged Basins
- Water Quality Assessment in specific areas
- Hydrology of Arid, Semi-arid, Coastal & Deltaic Zones
- Reservoir / Lake Sedimentation
- Impact of Climate Change on Water Resources
- Application of modern techniques to provide the solution to hydrological problems

HYDROLOGY PRIMER

Hydrology is the science that treats the waters of the earth, their occurrence, circulation, movement and distribution, their chemical and biological properties and their reaction with the environment, including their relation to living things. The domain of hydrology embraces the full life history of water on the earth.



- The hydrologic cycle is a continuous process that exists on the earth by which the water from over and beneath the earth's surface (including the ocean) is transported to the atmosphere through the process of evaporation and evapo-transpiration from the vegetative cover and to the land surface through the process of rainfall and snowfall, and reaches to the surface and groundwater storages, and the ocean by means of the various paths.
- The various phases of the hydrologic cycle may be short, or it may take millions of years. Water may be captured for millions of years in polar ice caps, groundwater reservoirs (aquifers) and in the sea.
- The hydrological cycle moves enormous quantities of water about the globe. However, much of the world's water has little potential for human use because 97.5% of all water on earth is saline water. Out of remaining 2.5% fresh water, most of which lies deep and frozen in Antarctica and Greenland, only about 0.26% flows in rivers, lakes and in the soils and shallow aquifers which can be readily used.
- Certain hydrological problems and weaknesses have affected a large number of water resources all over the world due to the effect of Climate Change due to Global Warming.
- In case of India, floods and droughts affect vast areas of the country, transcending state boundaries. One-sixth area of the country is drought-prone. Out of 40 million hectares of the flood prone area in the country, on an average, floods affect an area of around 7.5 million hectares per year.

Role of Hydrologist

- The hydrologist plays very important role in solving water-related problems in society such as quantity, quality and water availability or basin water budgeting through application of the proper scientific knowledge and mathematical principles.
- The hydrologist studies the fundamental transport processes to be able to describe the quantity and quality of water as it moves through the hydrologic cycle (evaporation, precipitation, streamflow, infiltration, groundwater flow, and other components).
- Hydrologists estimate the volume of water stored underground by measuring water levels in local wells and by examining geologic records from well-drilling to determine the extent, depth and thickness of water-bearing sediments and rocks. Before an investment is made in full-sized wells, hydrologists may supervise the drilling of test wells. They note the depths at which water is encountered and collect samples of soils, rock and water for laboratory analyses. They may run a variety of geophysical tests on the completed hole, keeping and accurate log of their observations and test results. Hydrologists determine the most efficient pumping rate by monitoring the extent that water levels drop in the pumped well and in its nearest neighbors.
- The engineering hydrologist, or water resources engineer, is involved in the planning, analysis, design, construction and operation of projects for the control, utilization, and management of water resources.
- He may also deal with the study concerning the municipal water supply, irrigation water supply and management, mitigation of floods and droughts, integrated watershed management, ground water recharge and solving reservoir sedimentation problems.
- Scientists and engineers in the field of hydrology may be involved both in the field investigation and office work.
- In the field investigation, they may collect basic hydrological, geological, meteorological and water quality data, sometimes from remote and rugged terrains with use of measuring instruments and equipments. While, in the office, they may do many jobs that includes the assessment of water quality in the laboratory, remote sensing data processing and analysis using GIS, interpretation and analysis of field data, modelling studies for flood hazards mitigation, groundwater replenishment, water-logging problems, sea water intrusion, reservoir operations in the command area and assessment of their impacts on environment.

International Decade for Action Water for Life 2005–2015

World Water Day, 22 March 2005, heralded the start of the International Decade for Action proclaimed by the United Nations General Assembly. 'Water for Life' calls for a coordinated response from the whole United Nations system. The timing is significant: the end of the action decade in 2015 is the target date for achievement of many of the Millennium Development Goals (MDGs). Those goals were amplified by the 2002 World Summit on Sustainable Development in the Johannesburg Plan of Implementation, which set the following target:

HALVE, BY 2015, THE PROPORTION OF PEOPLE WITHOUT SUSTAINABLE ACCESS TO SAFE DRINKING WATER AND BASIC SANITATION.

PROJECTS SOLVING REAL LIFE PROBLEM

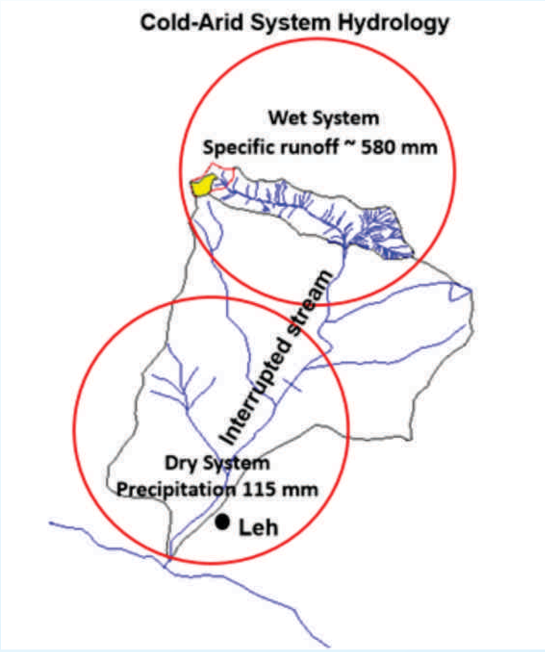
Cryospheric system studies and runoff modeling of Ganglass catchment, Leh, Ladakh Range

The project titled "Cryospheric system studies of Ganglass catchment, Ladakh Range, India" is a first attempt to understand the high altitude cryospheric system hydrology of the cold-arid region of the Ladakh Himalaya. Melt water streams originating from the cryospheric sources is the life line of the people living in this extremely low precipitation zone with mean annual precipitation of 115 mm. However, rugged high altitude terrain and inhospitable climate discouraged a detailed research programme on this unique cold-arid system of the Trans-Himalayan region till date. This project executed in a high altitude catchment in the Ladakh range extending from 4700 m to 5745 m a.s.l. This experimental catchment is spread over 15.8 Km^2 and have a glacier cover of 0.62 Km^2. Phuche stream (Leh Nallah) originating from this headwater catchment is the sole water source for the entire city of Leh, which is a favorite tourist destination in the country. Tourism to Ladakh increased exponentially from 20000 in 2004 to 1.8 Lakh in 2012, putting huge pressure on the water resources- Habitat equilibrium.

To understand the cryospheric system dynamics, a benchmark glacier catchment strategy has been structured and implemented in the upper Ganglass catchment. This strategy has been formulated with a core philosophy of understanding the orographic forcing and feedback on the high altitude cryospheric systems and studying the role of various cryospheric and atmospheric components on the regional hydrology. Weather monitoring at different altitudes, runoff measurement and modelling, isotopic studies of stream flow, precipitation and local water sources were carried out for achieving these goals. Discharge measurements were carried out at 4700 m a.s.l. with the help of a Radar Water Level Recorder. Four years of runoff data, meteorological data, Electrical conductivity data, snow cover depletion data, isotopic data were generated though this project; building the most comprehensive data base for this region.

The study has revealed the sharp vertical hydrological gradient in the cold-arid system. In comparison with the mean annual precipitation of 115 mm, the annual discharge from the upper Ganglass catchment is ranged between 685 to 490 mm w.e (10.7 x10^6 m^3 to 7.7 x10^6 m^3) showing the significantly wetter regime at the higher altitude regions. A tandem study on glacier mass exchange shown that the 4% glacier cover in the catchment contributed only around 5 to 7.5% to the annual discharge. Supported by the field geomorphological evidences, the study proposes that the steady discharge with higher EC values during the years with shorter snow cover may be sourced from the permafrost melt. By employing the two component mixing model it is estimated that the permafrost contribution could be around 25% during the years with shorter snow cover.

Discharge site equipped with Automatic Radar Water Level recorder (AWLR)



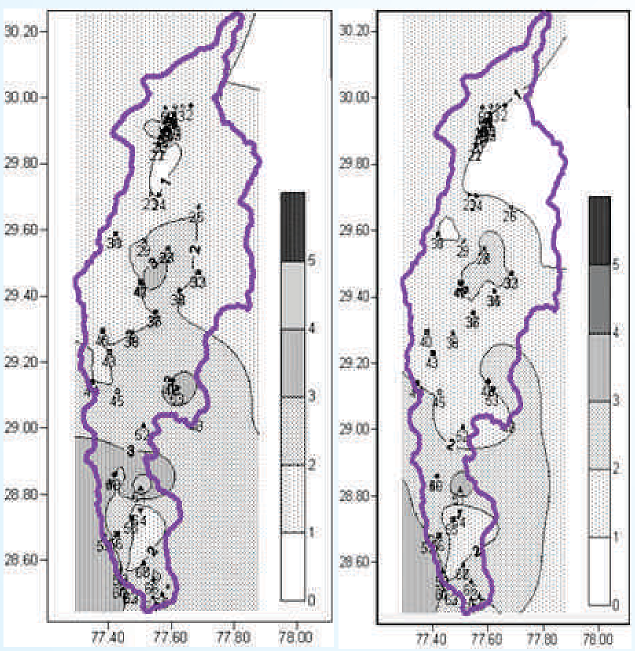
Cryospheric system feeding the arid low land is the hallmark of cold-arid system Hydrology

Temperature lapse rate is the most critical parameter in the snow melt runoff modelling studies. Generally, standard environmental lapse rate ranging from 6.5 to 8.9°C is used for snow melt modeling. Present study demonstrated that the Slope Environmental Lapse Rate (SELR) have significant seasonal variation linked with the moisture influx to the region. During summer months SELR between 3500 to 4700 m a.s.l was consistently ranged between 10 to 17°C espousing the cold-arid climate manifestations sustaining these small glaciers. The study developed a model solution for SELR estimation by generating monthly SELR indices. Trials demonstrated that the model have high efficiency for calculating the monthly SELR. Isotope studies have suggested that the rainfall contribution in summer ranged from 7 to 29% during the four years of investigation.

Assessment of water Quality in Hindon River Basin

The river Hindon is subjected to varying degree of pollution caused by numerous untreated and/or partially treated waste inputs of municipal and industrial effluents. The main sources of pollution in river Hindon include municipal and industrial (sugar, pulp and paper, distilleries etc.) wastes from Saharanpur, Muzaffarnagar and Ghaziabad urban areas. The water quality of the river Hindon gets further deteriorated due to confluence of river Kali and river Krishni. The river is highly influenced due to heavy metals, pesticides, which enter the river system, by direct discharges of municipal and industrial effluents and surface runoff. These toxic pollutants will ultimately reach the groundwater and will enter in the food chain posing a threat to human health because of their carcinogenic nature. In view of these facts, the study of Hindon river basin has been carried out with the objectives: i) to monitor and assess of water quality of Hindon river ii) to examine the suitability of ground water in the vicinity of river Hindon for various designated uses iii) to characterize different point sources contributing river Hindon iv) to estimate rate of re-aeration and de-oxygenation coefficients in different reaches of Hindon river v) to estimate downstream DO deficit in different stretches of river using Streeter-Phelps oxygen sag equation and vi) to explore possible remedial measures for improvement of river water quality. An extensive field survey in Hindon river basin was carried out and three wastewater samples from Nagdev Nala, Star Mill Drain and Dhamola Nala, water samples from river Kali and Krishni, eleven water samples from different stretches of river Hindon and sixty eight groundwater samples from hand pumps of different locations in the Hindon river basin were collected in pre- and post-monsoon seasons during 2012 and analysed for physico-chemical and bacteriological parameters, metal concentrations and organochlorine pesticides. Maximum value of BOD (261 mg/L) was observed in Star Paper Mill Drain. The higher values of BOD and COD observed in the drains and river Hindon indicate high degree of organic pollution rendering the water unsuitable even for bathing purpose. At almost all sites of the upstream and mid-section of the river Hindon, DO was observed to be nil because of high organic load in the river water. The values of re-aeration coefficients and de-oxygenation coefficients for different stretches of river Hindon were computed and the results of estimated BOD at different sampling sites are well in agreement with observed values. The DO Sag analysis (using Streeter & Phelps, 1925 and differential equations of DO Sag) can be successfully used to predict the DO level at different location of the river.

Ground water quality data has been processed as per BIS and WHO standards to examine the suitability of water for drinking purpose. Degraded water quality zones have been identified based on water quality parameters not conforming the drinking water standards. Water quality standards have been violated for TDS, hardness, alkalinity, Ca and Mg at few locations. Nitrate concentration in few of the ground water samples exceeded the maximum permissible limit of 45 mg/L, which may be attributed to contamination by domestic waste disposal. Bacteriological contamination was observed in few ground water samples in the vicinity of river Hindon, which may be attributed to unorganized sewerage system in the study area. The concentrations of Fe, Mn, Ni, Cr, Pb and Cd in few ground water samples exceeded the permissible limit prescribed for drinking purpose, which may be attributed to the leaching of effluent containing wastes from different industries operating in the basin. The concentration of α-BHC, γ-BHC and Methoxychlor were detected in few ground water samples of the study area, which may be attributed to extensive use of these pesticides in agricultural practice in the study area, which might have leached to ground water system. Almost all collected groundwater samples from Hindon river basin falls in rock dominance zone suggesting evolution of water chemistry influenced by water-rock interaction. The scatter plot of (Ca+Mg) vs TZ^+ and high (Ca+Mg)/(Na+K) ratio indicate that carbonate weathering is a major source of dissolved ions in the groundwater of the study area. Assessment of suitability of the groundwater of the study area for irrigation purpose on the basis of total soluble salts, SAR, RSC and heavy metals revealed that these waters are of medium to good quality for irrigation purpose. The water quality of river Hindon at all sites in both season was found to be bad and most of the ground waters were found in the good to excellent category type on the basis of Water Quality Index. Possible remedial measures have also been discussed and recommendations for preventing the deterioration of ground water quality have been suggested.



Water type = 0-2: Excellent; 2-3: Good; 3-4: Poor; 4-5: Very Poor; >5: Unsuitable for drinking purpose

Fig. 1 Classification of ground water on the basis of Water Quality Index

Monitoring and Modeling for the Streamflow of Gangotri Glacier

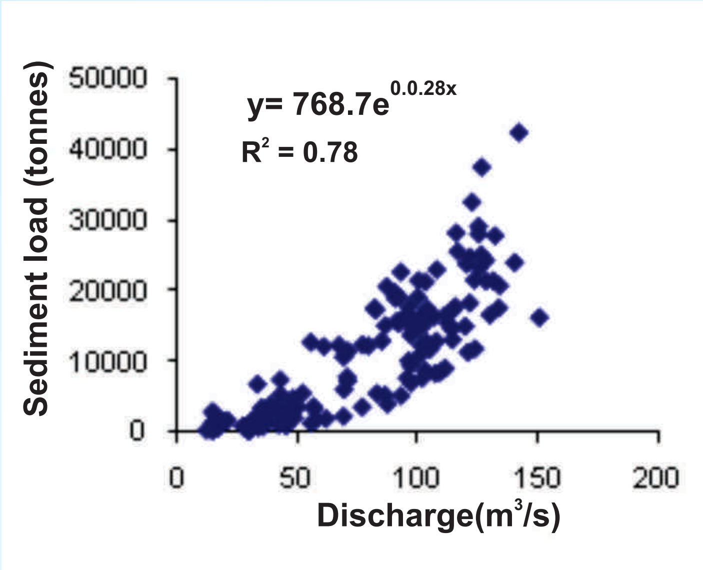
The Institute has established a meteorological observatory, AWS and discharge monitoring station near the snout of the glacier. The data set includes rainfall, temperature, humidity, wind speed and direction, sunshine hours, radiation, evaporation, discharge, suspended sediment and suspended load. Continuous records of temperature, relative humidity, rainfall and sunshine hours were collected. The main objectives of the study are given below:

(i) Installation and monitoring of the hydro-meteorological instruments for the continuous observations of meteorological and hydrological data.

(ii) To study the melt water storage and drainage characteristics of the glacier.

(iii) To simulate daily streamflow using a conceptual hydrological model using observed meteorological and hydrological data. Degree-day approach would be used for the modelling of runoff.

(iv) Estimation of suspended sediment concentration and load from the Gangotri Glacier and its relationship with discharge.



The mean monthly minimum temperatures for June, July, August and September for the year 2011, 2012, 2013 were 4.2, 7.2, 6.5 and 3.8°C respectively and the total rainfall for the whole summer season for 2011, 2012 and 2013 was found to be 293, 128 and 357 mm. In terms of volume, the total melt water from the Gangotri Glacier for the ablation period 2011, 2012 and 2013 was estimated to be 844.7, 899.5 and 1043 MCM. The total suspended sediment from the Gangotri Glacier was estimated to be 1.09, 1.84 and 1.96 $\times 10^6$ tonnes for 2011, 2012 and 2013. The average total suspended sediment load for the melt season was computed to be 1.63×10^6 tonnes.

National Program on Isotope Fingerprinting of Waters of India

During past four decades in India, to understand the hydrological and hydro-meteorological processes, it was not possible to holistically characterize the water resources on a sub-continental scale. Further, there remained knowledge gaps on certain aspects of hydrological cycle over India due to the fact that available isotope data were insufficient to address those aspects which involved synoptic processes on a large spatial scale or region specific processes or subtle processes on a smaller time scales. Some of the topics on which there is only limited understanding are:

1. identification of rain bearing vapors originating from different sources (e.g. Arabian Sea, Bay of Bengal, and Mediterranean, local recycling) during different seasons and affecting the same or different regions of the country;
2. rain-vapor interaction and evolution of ground level vapor front;
3. quantitative identification of constituent components (including snow/ice melt) of river discharge;
4. meteorological influence on isotopic characteristic of precipitation;
5. spatio-temporal variation in isotopic composition of surface waters of the Arabian Sea and the Bay of Bengal and its relevance to river discharge.

With a view to address some of these issues, India, uniquely, initiated a multi-institutional[1] collaborative research programme to isotopically characterize all the components of its hydrological cycle. A National Programme on Isotope Fingerprinting of Waters of India (IWIN), funded by the Department of Science and Technology (DST) was launched in 2007. The IWIN now makes it possible to address to some of the above open-ended issues. The spatio-temporal characterization of various water sources of the country, based on the above data, has enabled identification of broad regions, in which hydrological and hydro-meteorological processes/factors have imparted characteristic isotopic signatures governed by subtle interactions between atmospheric, surface and sub-surface components of hydrological cycle.

To achieve the above objective, NIH has established 8 stations for collection of samples at Roorkee, Sagar, Jammu, Kakinada, Tezpur, Kanpur, Manali and Patna (Fig,. 1). NIH has carried out the following sample collection schedule at these stations:

- Roorkee: (1) Rain (event based), (2) air moisture by Condensation and P&T methods (daily), (3) groundwater and (4) surface water (River Ganga)
- Sagar: Items 1-3 as at Roorkee (air moisture by condensation)
- Jammu: Items 1-3 as at Roorkee (air moisture by condensation)

Location	Altitude (m)	Distance from Sea (km)	Starting Date
Roorkee	268	1545	Jul. 2007
Sagar	527	867	Apr. 2008
Jammu	292	1973	Apr. 2010
Kakinada	2	19	May 2010
Tezpur	48	640	May 2011
Kanpur	128	957	Jul. 2011
Manali	3000	1610	Sep.2011
Patna	53	550	Jun. 2012

Fig.1. NIH-IWIN sampling locations

- Kakinada: Items 1-2 as at Roorkee (air moisture by condensation)
- Tezpur: Items -2 as at Roorkee (air moisture by condensation)
- Kanpur: Items -2 as at Roorkee (air moisture by condensation)
- Manali: Items -2 as at Roorkee (air moisture by condensation)
- Patna: Items -2 as at Roorkee (air moisture by condensation)

The new scientific knowledge generated so far from the IWIN National Programme has been given as below:

[1]Other institutions participating in the IWIN Programme arranged alphabetically are: Anna University (AU, Chennai); Bhabha Atomic Research Center (BARC, Mumbai); Center for Water Resources Development and Management (CWRDM, Kozhikode); Central Ground Water Board (CGWB, New Delhi); Central Pollution Control Board (CPCB, Delhi); Central Research Institute for Dryland Agriculture (CRIDA, Hyderabad); Central Water Commission (CWC, New Delhi); Indian Institute of Technology (IIT-Kharagpur); India Meteorological Department (IMD, New Delhi); National Geophysical Research Institute (NGRI, Hyderabad); National Institute of Hydrology (NIH, Roorkee); National Institute of Oceanography (NIO, Goa); Nuclear Research Laboratory (NRL)-IARI, New Delhi.

- A new, simple and cost effective method of complete cryogenic trapping of moisture from the stream of ambient atmospheric air has been designed, developed and tested successfully. This method circumvents the requirement of elaborate pumping lines and vacuum pumps but requires only liquid nitrogen. Besides this cryogenic trapping method, another simple and cost effective method of sampling ambient atmospheric water vapour by condensing it on ice-cooled conical surface has been designed, developed and tested. The kinetic isotope fractionation occurring in this method can be corrected by an empirical formula relating (i) the degree of super-saturation during condensation; (ii) the measured isotopic composition of vapour (though fractionated); and (iii) its true value determined by cryogenic trapping. A simple, robust and cost effective method of collecting fortnightly accumulated rainwater sample has been designed, developed and tested which minimizes the evaporative losses and maximizes the sample collection. Details of sampling protocols can be downloaded from the IWIN website http://www.prl.res.in/~iwinoffice/.

- The atmospheric water vapors received during SW monsoon period are always depleted as compared to the vapors received during non-monsoon period (fig. 2) and is recorded in all the sampling stations. The variation in isotopic pattern in all the stations shows a good temporal correlation and a striking pattern of increasing depletion with the increasing distance of the station from the sea-coast. However, station Jammu indicated a minor deviation to this, its pattern is moderately enriched compared to Roorkee data suggesting an additional source of moisture such as the Bay of Bangal for the Jammu station. The dual source of moisture for Jammu station is a new observation reported from India through the present project. The isotopic data at Roorkee station also clearly indicated changing monsoon pattern (increasing rainfall pattern and shortening & shifting of monsoon period) over the observation period from 2007-13. The extent of depletion in isotopic composition of moisture and period over this depletion continues is directly linked with monsoon strength (intensity, episodes and duration), therefore, isotopes may be used to track movement of monsoon vapors and regional influx of moist vapour and the South-West monsoon transect was established.

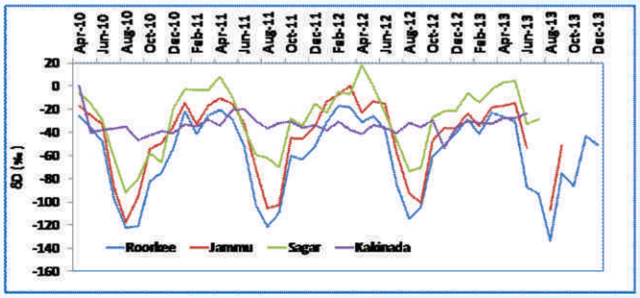


Fig.2. Variation in isotopic composition δD of atmospheric water vapour at Roorkee, Jammu, Sagar and Kakinada

- The isotopic analysis confirms the continental and altitude effects which were earlier deciphered by the precipitation. The isotopic data analysis validates the impact of local moisture on rainfall and help in resolving the moisture sources in different seasons and the sources at Roorkee are identified on the basis of relationship among stable isotope composition of air moisture, wind pattern and Kalpana satellite images of cloud movement and the sources identified are as: Arabian Sea, Indian Sea, Mediterranean Sea (Western disturbance), local and regional sources.

- The isotopic composition of air moisture can be applied for finding the onset and withdrawal of SW monsoon and for studying the climatic conditions.
- Empirical relationship between meteorological parameters (absolute humidity, vapour pressure and temperature) and stable isotopes composition of water vapour in different seasons of the year for Roorkee station is developed.

Besides the new hydrological knowledge IWIN programme also contributed significantly to development of isotope analytical procedures for large throughput, students internship programme, human resource development and collaborative research.

Development of low cost media for fluoride removal from drinking water of fluoride affected areas

Deprived sections of society in the world consume contaminated water which may result in epidemics. The sources of water contamination may be by natural or human activities. One such contaminant is fluoride, which together represent about 0.06–0.09 per cent of the earth's crust. Many epidemiological studies have shown that fluoride in drinking water has a narrow range between intakes that cause beneficial and detrimental health effects. Fluoride intake to humans is necessary as long as it does not exceed the limits. The World Health Organization (WHO, 2011) estimates the maximum allowable limit for fluoride uptake to human's in drinking water as 1.5 mg/L. Excess fluoride intake causes different types of fluorosis, primarily dental and skeletal fluorosis. White line striations followed by brown patches and, in severe cases, brittling of the enamel are common symptoms of dental fluorosis. Skeletal fluorosis first causes pain in the different joints, then limits joint movement and finally causes skeletal deformities, which become particularly acute if fluoride uptake occurs during growth. Since these ailments are incurable, fluorosis can only be mitigated by preventing intake of excess fluoride. In India, out of 28 states, 20 states have naturally high concentration of fluoride in groundwater, which is prime source of drinking water. In order to get rid of this pollutant, fluoride specific media was developed from bagasse fly ash (BFA), a solid waste from sugar industry.

The dried BFA having <75 μm mesh size was suspended into 3M NaOH solution (4:1 liquid/solid ratio) in a 2L round bottom flask equipped with reflux condenser. The mixture was refluxed for 24h with intermittent stirring at reaction temperature of 373±5K. The resultant mixture was cooled at room temperature, filtered and washed with double distilled water until the removal of excess free sodium hydroxide and dried at 373±10K in hot air oven. The sodium hydroxide added to the fly ash not only works as an activator but also adjusts the sodium content in the sorbent material. The yield of the final product (ZBFA) is about 55±5 %.

The batch sorption studies indicated increase in sorption potential with increase in agitation time, initial fluoride concentration, and temperature. Fluoride sorption potential decreased with increase in T-ZBFA dosage and pH. The Langmuir adsorption capacity of media for fluoride sorption was 1.2 mg/g.

In order to understand the applicability of developed media as column filter, column trials were conducted in a 1.0 cm diameter column. The column was filled with 4 g sample of T-ZBFA. The bed height was 16.5 cm, and the bed volume was 13 ml. The initial concentration of fluoride ion solution prepared in de-mineralized water was 20 mg/L and the solution pH was 6.7. The hydraulic flow rate was 0.65 ml/minute. Initially, all the fluoride was adsorbed on T-ZBFA, and fluoride free water was produced. The treated water volume at breakthrough was 20 bed volumes. The column capacity at breakthrough was 1.1 mg/g. The column capacity to produce water containing less than 1.5 mg/L fluoride ion was 0.8-0.9 mg/g.

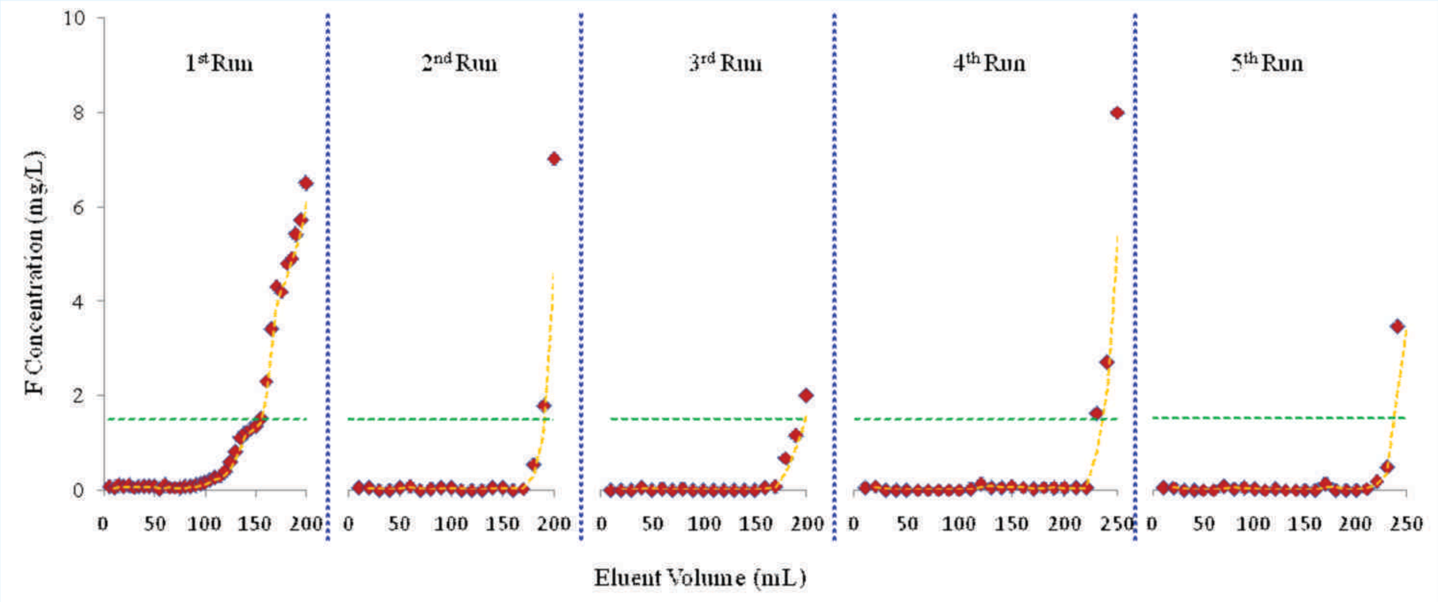


Fig. 1. Fluoride removal by T-ZBFA in Different Cycles of Column Operation

Regeneration and reuse of the adsorbent material carries utmost importance, which directly affects the cost factor and hence it's utility in continuous batch/column operations. The reusability capacity of T-ZBFA column was performed by carrying out desorption studied with 2.5% $AlCl_3$ solution (5 ml). As shown in figure 1, the fluoride sorption capacity of T-ZBFA was more or less same for all the five cycles of operation.

Water Quality Modeling using Soft Computing Techniques

Soft computing technique as Mamdani-Fuzzy Inference System (M-FIS) is being used to study the ground water quality with water quality index (WQI) for Administrative blocks Alipur and Kanjhawala in New Delhi. Mamdani Fuzzy Water Quality Index (WQI), Guidelines given by Canadian Council of Ministry of Environment for Water Quality Index (CCME_WQIG) and Empirical method are applied in order to assess the degree of drinking water resources in a administrative block of NCT Delhi region. This study has also offered the creation of a new fuzzy inference water quality index to evaluate this tool applicability and the use of Guidelines given by CCME user's manual, 2001 for Water Quality Index. The problem of water quality classification can be approached using combination of Degree of Match and the Fuzzy Rule-based System. In M-FIS, input data are categorised into three linguistic terms ("Desirable", "Acceptable", & "Not-Acceptable") based on water quality standards for drinking water, whereas the output data are categorized into six classes (Excellent, Very Good, Good, Fair, Marginal, & Poor) based on WQI. Total three models have been developed using three methods/ techniques for each block. To develop the models and approve the technique for future use, data for eight different physico-chemical water quality have been used for block Alipur with 39 samples and for Kanjhawala block with 44 samples (Report, 2000). Results calculated by Empirical method, is being used as an alternative to the expert knowledge in M-FIS technique.

Water quality indices (WQI) aim to give a single value to the water quality of a source, which translates the list of constitutes and their concentrations present in a sample in a single value. Water quality Modelling with three methods have been employed to calculate the water quality index as Empirical Method, Soft Computing Techniques (SCT) - Mamdani_Fuzzy Inference System (M_FIS) and Canadian Council of Ministry of Environment Water Quality Index Guidelines.

RESULT ANALYSIS: Analysis has been done for Alipur and Kanjhawala block separately.

For Alipur Block: Figure 1 shows the comparative results obtained from Fuzzy Water Quality index, CCME WQI and Empirical equation. It is observed that the Fuzzy WQI give nearly same results as other two methods so once a model is developed , it can be used in future for any values of input data within the grey and white range of membership functions.

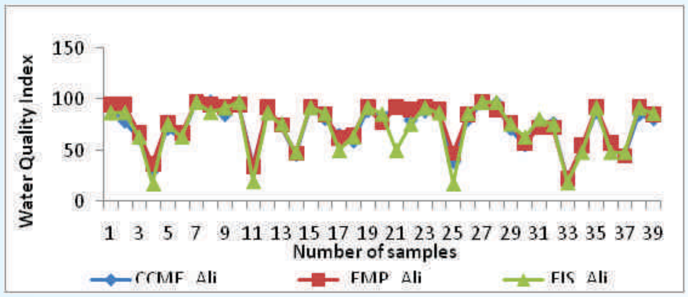


Fig. 1: Water quality Index by CCME_WQIG formula, Fuzzy technique and Empirical equation for Alipur block.

Table 1 : Number of samples lying with different categories with respect to Water Quality Index for Alipur block.

Models/ Categories	No. of samples in different categories with respect to WQI					
	Excellent (Ex)	Very Good (VG)	Good (G)	Fair (F)	Marginal	Poor
EMP_Ali	7	10	3	10	6	3
CCME_Ali	5	3	11	7	8	5
FIS_Ali	4	6	10	5	11	3

For Kanjhawala Block : Figure 2 shows the comparative results for Fuzzy Water Quality index with respect to fuzzy inference system (FIS), CCME_WQI and Empirical equation. Through graph it can be observed that the Fuzzy WQI give nearly same results as other two methods so once a model is developed , it can be used in future for any values of input data within the grey and white range of membership functions.

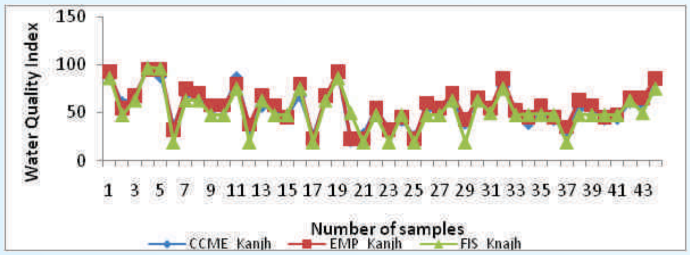


Fig. 2: Water quality Index by CCMEWQG formula,Fuzzy technique and Empirical equation for Kanjhawala block.

Table 2: Number of samples lying with different categories with respect to Water Quality Index for Kanjhawala block.

Models/ Categories	No. of samples in different categories with respect to WQI					
	Excellent	Very Good	Good	Fair	Marginal	Poor
EMP_Kanjh	2	2	4	9	18	9
CCME_Kanjh	1	1	4	7	17	14
FIS_Kanjh	1	0	1	4	26	12

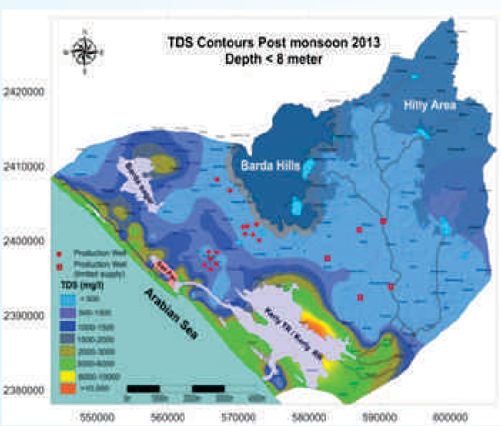
Although the performance of CCME-Kanjh model is better than FIS_Kanjh model but still Fuzzy model can also be recommended to use for future analysis because once this model is developed, by using its FIS file, user can get online results just by giving the input data.

Comparative results have been shown by different graphs with all three methods. CCME _WQI is slightly better than FWQI but still the use of FWQI is recommended for future use because once the model is developed, its FIS file can be used to calculate WQI just be giving the observed values of the input parameters without considering the environmental changes of study area.

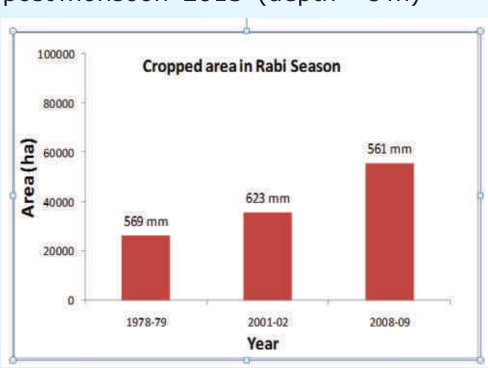
Coastal Groundwater Dynamics and Management in the Saurashtra Region, Gujarat

Groundwater is a vital strategic resource that provides and supplements the demand for freshwater in coastal regions of India. In Gujarat, with a coastline about 1600 km long, agriculture is the primary occupation of most of the rural population. More than 70% net irrigation needs of this drought-prone state are met from groundwater. However, due to proximity to the sea, almost the entire groundwater system along the coast of Kachchh and Saurashtra is affected by salinization, which makes it unfit for irrigation and human consumption. Under the Purpose Driven Study taken up during the World Bank aided Hydrology Project-II, detailed investigations have been carried out in the Minsar River Basin, located in the Saurashtra region of Gujarat, to study the coastal groundwater dynamics, hydrogeology, water quality and saltwater intrusion phenomenon.

Hydrogeologic investigations have revealed that the Miliolitic limestone forms the potential aquifer system in the coastal belt. In the upland area, the weathered zone of the Deccan Trap, forms a good aquifer. The direction of groundwater flow is, in general, towards the sea. Geochemical surveys have shown that close to the sea coast, groundwater is saline even at shallow depths. The salinity generally decreases with increasing distance from the coast. In the coastal belt, the groundwater salinity increases steeply with depth and at places reaches more than 10,000 mg/l. Several factors contribute to groundwater salinity in the Minsar basin viz., intrinsic salinity, upconing of underlying groundwater, seawater ingress in certain pockets. For protection of groundwater quality, construction of 'bandharas' at the mouth of creeks has enabled conservation of surface water runoff from the catchment of Minsar River and prevention of seawater ingress through the creeks. As an outcome of several such conservation measures taken over the last two decades, relatively more freshwater is available for crop cultivation, and a gradual change in cropping pattern is witnessed with more farmers opting for cash crops. For sustainable development of the coastal zone, several recommendations have been made such as long-term monitoring of groundwater levels and salinity, restricted groundwater pumpage near sea coast, adoption of efficient irrigation techniques etc.



TDS (total dissolved solids) contours in Minsar basin for post monsoon 2013 (depth < 8 m)



Comparison of cropped land area for Rabi season during the period 1978-2009. Figures above bars depict corresponding rainfall for the year.

Spreading channel running parallel to the coast through the limestone formation

Groundwater quality monitoring

Water quality monitoring near sea coast

Publications in Journal

1. Krishan, Gopal, M.S. Rao and C.P. Kumar (2014). "Isotope Analysis of Air Moisture and its Applications in Hydrology". J Climatol. Weather Forecasting 2014, 2:1. http://dx.doi.org/10.4172/2332-2594.1000106

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3. Satyaji Rao , Y.R., B Krishna, B. Venkatesh, "Wavelet Based Neural Networks for Daily Stream Flow Forecasting" International Journal of Emerging Technology and Advanced Engineering, Volume 4, Issue 1, January 2014.

4. Tyagi, J.V., Rai, S.P., Qazi, N., Singh, M.P. (2014). Assessment of discharge and sediment transport from different forest cover types in lower Himalaya using Soil and Water Assessment Tool (SWAT). International Journal of Water Resources & Environmental Engineering, DOI: 10.5897/ IJWREE2013.0448, Vol. 6(1), pp. 49-66

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6. Singh, Seema, B. Parkash, A.K. Awasthi S. Kumar, 2014, Do stable isotopes in carbonate cement of Mio-Pleistocene Himalayan sediments record paleoecological and paleoclimatic changes?. Palaeogeography, Palaeoclimatology, Palaeoecology, Volume 399, 1 April 2014, Pages 363–372. (Int. Jr. I.F.-2.745)

7. Krishan, Gopal, Lohani, A.K., Rao, M.S., Kumar, C.P., Kumar, Bhishm, Rao, Y.R.S, Jaiswal, R.K., Thayyen, J., Renoj and Tripathi, Shivam 2013. Studying Dynamics of the South West Monsoon in Indian Sub-Continent through Geospatial Correlation of Isotopes in Air Moisture. Journal of Geology and Geosciences 3:1. http://dx.doi.org/10.4172/2329-6755.1000139

8. Rao, M. S., P. Tabassum and C. P. Kumar. 2014. Techniques and methods for reuse of waste water for irrigation: a review. International Journal of Earth Sciences and Engineering, 7 (01): 39-51. Impact factor = 0.15

9. Rao, M. S., P. Purushothaman, Gopal Krishan, Y. S. Rawat and C. P. Kumar. 2014. Hydrochemical and Isotopic Investigation of Groundwater Regime in Jalandhar and Kapurthala Districts, Punjab, India. International Journal of Earth Sciences and Engineering, 7 (01): 06-15. Impact factor = 0.15

10. Krishan, Gopal, D. J. Lapworth, M. S. Rao, C. P. Kumar, M. Smilovic and P. Semwal. 2014. Natural (Baseline) Groundwater Quality In The Bist-Doab Catchment, Punjab, India: A Pilot Study Comparing Shallow and Deep Aquifers. International Journal of Earth Sciences and Engineering, 7 (01): 16-26. Impact factor = 0.15

11. Sharma, Manishi, M. S. Rao, D.S. Rathore, Gopal Krishan. 2014. An integrated approach to augment the depleting ground water resource in bist- doab, region of Punjab, India. International Journal of Earth Sciences and Engineering, 7 (01) : 27-38. Impact factor = 0.15.

12. Rathore D.S., Tanveer Ahmad, G. Vinay Kumar, L.N. Thakural "Snow Delination using Modis in Indus Basin" "International Journal of Earth science & Engineering" ISSN 0974-5904 Vol 07 No.01 February 2014 pp 01-05.

13. Chakravorty, B. and P. Mani (April-2014), "Use of mathematical model and satellite data for performance evaluation of flood protection scheme", International Journal of Research in Management, Science & Technology, Vol-2, No.-1, (ISSN:2321-3264) (Published online)

Organization of Workshops/ Training Courses/ Seminar/ Symposia

S.No.	Name of the Course	Duration	Place
1.	Scripting and dashboard in Decision Support System for Water Resource Planning	Jan.20-24, 2014	Roorkee
2.	Climate Change and Drought Management	Feb. 3-7, 2014	Khajuraho, M.P.
3.	MIKE-HYDRO	Feb 3-7, 2014	Roorkee
4.	Water Resource Investigation and Management in Coastal Region	Feb.3-7, 2014	Kakinada
5.	Application of GIS to GW modeling & Management	Feb.10-21, 2014	Roorkee
6.	Assessment of reservoir sedimentation using remote sensing	Feb.12-14, 2014	Kakinada
7.	Water Conservation	Feb.12-13, 2014	Jaipur
8.	Flood Inundation Mapping and Modeling	Feb.17-21, 2014	Patna
9.	Hydrological Analysis using Statistical & Stochastic Technique: Special reference to Flood Estimation	Feb. 24 - 28, 2014	Roorkee
10.	Advanced Hydrologic Modeling	Feb.24-28, 2014	Kakinada
11.	GIS Application in Water Resources	Feb. 24 - March 7, 2014	Roorkee
12.	Drought Risk Assessment and Management	March 10-14, 2014	Roorkee
13.	Drought Monitoring and Mitigation	March 24-25, 2014	Chennai
14.	A training workshop sponsored by "Indo-German Science and Technology Centre (IGSTC) on "Indo-German Bilateral Workshop on "Science-based Master Planning for Bank Filtration Water Supply in India", was jointly organized by NIH-Roorkee and HTWD-Germany.	April 7-11, 2014	Dresden, Germany
15.	International Training Course cum Working Sessions on "Analysis of Monitoring Networks for Precipitation and Surface Water", Sponsored by IAEA, Vienna.	April 7-18, 2014	Vienna
16.	UNFAO sponsored international training course "Hydrological modeling and GIS", for participants from Afghanistan	May 26 – June 06, 2014.	Roorkee
17.	Water Resources Development and Management	June 10–20, 2014	Roorkee

Mass Awareness

S.No.	Activities	Organised by & Date
1.	"IWRM studies in Yerrakalva basin" for farmers	30 Jan. 2014 at Jangareddy Gudem, Kakinada
2.	Water Conservation & Water Quality	4 Jan., 2014 at NIH, Roorkee
3.	Water Conservation & Water Quality	5 Jan., 2014 at Nandy Farm, Rishikesh
4.	Hindi Workshop	25 March, 2014 at NIH Roorkee
5.	Mass awareness workshop on Hydrology	21-23 March, 2014 Joint activity of NIH & DoH, IITR

Other News

Distinguished Visitor's Lecture

Mr. Elliot Grunewald, Chief Geophysicist, Vista Clara Inc., USA delivered lecture on "Vista Clara Products and NMR Technology" on May 22, 2014 in the Society Room at NIH, Roorkee

Institute Important Meetings

1. 40th Working Group Meeting, held at Roorkee during 4-5 June, 2014.
2. 74th Governing Body meeting held on 26th June 2014 in the conference Room of MoWR, New Delhi.

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We Will Appreciate Your Guest Articles!

You can share your knowledge with others on topics highlighting 'water resources for community benefits' by contributing an article to the Guest Article Column. For more information, please contact: Dr V C Goyal, vcg@nih.ernet.in or vcgoyal@yahoo.com

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Printed by : Anubhav Printers, Rke 9719004321