|| काले वर्षतु पर्जन्यः पृथिवी सस्यशालिनी ||

Gist 2010

www.gist2010.org

CONVENTION & EXHIBITION
ON
SCIENTIFIC & TECHNOLOGICAL APPROACHES
FOR SUSTAINABLE
USE OF WATER RESOURCES

26th & 27th December 2010

An **initiative** for the **sustainability** by **Indian intelligentsia**

GIST

GLOBAL INDIAN SCIENTISTS & TECHNOCRATS FORUM

|| काले वर्षतु पर्जन्यः पृथिवी सस्यशालिनी ||

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SCIENTIFIC & TECHNOLOGICAL APPROACHES
FOR SUSTAINABLE
USE OF WATER RESOURCES

26th & 27th December 2010

Venue : M. E. S. Abasaheb Garware College, Pune

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www.vijnanabharati.org

Maharashtra Education Society, Pune
www.mespune.org.in

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ACKNOWLEDGEMENT

- 93.5 Red FM
- Armament Research and development Establishment
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सत्यमेव जयते

08 December 2010

Dr. APJ Abdul Kalam
Former President of India

MESSAGE

I am indeed very happy to know that the `Global Indian Scientists and Technocrats (GIST) Forum' under the leadership of Dr Anil Kakodkar is organizing a Convention on `Scientific and Technological Approaches for Sustainable Use of Water Resources', in December 26-27, 2010 in Pune, where experts from various sectors of water resource will come together, exchange their views and make a consolidated study of the problems faced by our country.

Water is indeed a very important resource that sustains life on the earth. We need to manage our water resources scientifically in order to cope up with the stress due to growing population, rapid industrialization, urbanization, effects of climate change etc. With passage of time these issues are likely to become critical and hence need proactive approaches to deal with them.

GIST forum is a movement dedicated to connect Indian Diaspora across the world with scientists, technocrats, social workers and the society at large and to provide a platform to the S & T fraternity in analyzing various problems that our Nation is facing and to come up with sustainable and inclusive solutions. Such programmes and tasks are indeed very valuable in the nation building. This Convention is very important and timely. I am sure, this Convention will consolidate the recommendations and share with all agencies including the Government. I wish the Convention and the GIST Movement all success.

APJ Abdul Kalam

10, Rajaji Marg, New Delhi – 110 011, India
Email: apj@abdulkalam.com
www.abdulkalam.com

सत्यमेव जयते

CHIEF MINISTER

MAHARASHTRA

16th December, 2010.

MESSAGE

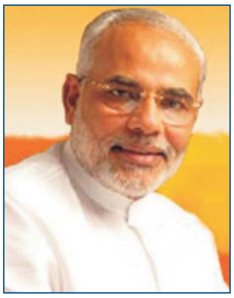
I am happy to know that the `Global Indian Scientists and Technocrats (GIST) Forum' is organizing a Convention on `Scientific and Technological Approaches for Sustainable Use of Water Resources', in December 26-27, 2010 in Pune. It is very important that this first GIST Convention will focus on the crucial subject of water, which is everybody's concern.

I am confident that this Convention will prove to be an effective platform for the experts from various sectors of water resource who will exchange their views and make a consolidated study of the problems faced by our country. It is a matter of great pride that this Convention is being held under the leadership of visionary scientist Dr. Anil Kakodkar.

As we know, WATER is compared to LIFE. Nothing is possible without water. In this era of globalization and development, there is tremendous pressure on natural resources, especially the water. We need to study and manage our water resources very carefully. This is an important task and to be done in a scientific way. We are facing various problems due to global warming and climate changes. I hope this convention will focus on all this issues and give a positive direction to research in this field. I wish all the success to this Convention.

[PRITHVIRAJ CHAVAN]

MANTRALAYA, MUMBAI 400 032, Telephone : 2202 51 51, 2202 52 22, Fax : 2202 92 14



Date:18-12-2010

Message

We Indian call water as Jeevan. Jeevan means Life.. Considering the rapid growth India is pursuing the need of water for domestic, agriculture, Industries, environment is going to increases exponentially. Water being a finite resource its availability per capita will keep dwindling down.

I am extremely delighted to know that a group of scientists, industrialists, educational institutes and a few voluntary organizations from Pune Maharastra, under the banner of Global Indian Scientists and Technocrats (GIST) is organizing a convention on a most important topic of **"Scientific approaches for sustainable use of water resources".**

The concept of GIST as a platform for Indian Diaspora and the local scientific fraternity to exchange the knowledge for building our Mother land India is indeed very novel. With scores of Indian scientists spread all over the world, such a platform is certainly a necessity of the day. I can foresee that this forum will play a very crucial role to take India as knowledge based country of the future.

I hope that deliberations of the scientists & technocrats in this convention will come out with a road map which will be useful for planners and the executors to meet the challenges of future.

I wish the GIST forum and the proposed convention a grand success.

(Narendra Modi)

To,
Dr. Vijay Bhatkar – *Chairman,*
Global Indian Scientists and Technocrats Convention 2010,
IMCC Compound, 131, Mayur Colony,
Kothrud, Pune 411 004.
Email: secretary@gist2010.org

Narendra Modi

Chief Minister, Gujarat State

CHIEF MINISTER
GOA

MESSAGE

I am very happy to know that Global Indian Scientists and Technocrats (GIST) Forum is organizing the GIST 2010 Convention in Pune on 26th & 27th December, 2010.

India is now the country of the youth and its economy would be fueled by knowledge and consequent growth in scientific and technology fronts. We need to tap all our knowledge based resources into a common incubator that would be the country's *'intellectual wealth'*. I am even more happy that eminent scientist of Goan origin like Dr. Anil Kakodkar, Dr. Vijay Bhatkar and others are part of this forum and their very presence with that of personalities like Dr. Madhav Gadgil and Dr. Madhav A. Chitale will further enhance the scientific, technological and engineering platform of the entire forum and ensuing convention.

I convey my best wishes and success to the GIST- 2010 Convention.

DVKamat

(Digambar V. Kamat)
Chief Minister

MINISTER FOR
WATER RESOURCES
(KRISHNA VALLEY IRRIGATION
CORPORATION)

GOVERNMENT OF MAHARASHTRA
Mantralaya, Mumbai 400 032
www.maharashtra.gov.in

Date 15 DEC 2010

MESSAGE

It is very heartening to note that a two day convention on a very important topic of the day, namely "Scientific and Technological Approaches for Sustainable Use of Water Resources", is organized by a competent forum i.e. GIST. Sustainable and optimal use of Water Resources has become a key word in this era of growing population and erratic climate. Water is becoming a scare commodity due to enormous growing demand for drinking, irrigation & industrial purposes. As such more scientific and technological approaches are very essential for sustainable & optimal use of this scarce commodity.

Some experts have already predicted that wars will be fought over the issue of water in this century. As such it is the duty of every stake holder in water sector and Scientific/ Technological community to prove this prediction wrong by devising different scientific methods of water conservation, water saving and its optimum utilization so that it no more remains a scarce commodity. The Govt. of Maharashtra has started implementation of different reforms in water sector through adoption of a comprehensive State Water Policy, enacting different laws namely MMISF Act-2005, MWRRA Act-2005 etc, which ultimately aim at an efficient and optimum utilization of state's water resources.

I hope that different issues vis-a-vis economic and efficient use of water through new scientific & technological approaches will be deliberated upto and addressed at length in this convention and useful solutions will come out, which can be helpful to a common or *'aam'* stakeholder in water sector. I wish a grand success to this convention.

(Ramraje Naik Nimbalkar)

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Member & Session Chair

Chetan Pandit
Chief Engineer, National Water Academy Pune

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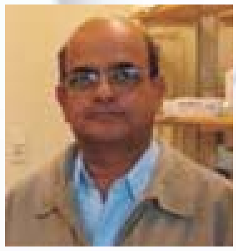

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Officiating Director, Agharkar Research Institute, Pune

Ashok Chavan
Joint Director, Central Water & Power Research Station, Pune

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Director, National Water Academy, Pune

Avinash V. Surve
Superintending Engineer, Pune Irrigation Circle &
Vice President, Institution of Engineers (India)

Vilas Shelke
Former Chief Engineer, Koyna Project

S. P. Bagade
Former Director, Groundwater Surveys and
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Dr. Raghunath Shevgaonkar

Chairman :

Dr. Raghunath Shevgaonkar — Vice-Chancellor, University of Pune

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Dr. P. K. Ingle
Head, Publication and Science Communication Unit

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Editorial

“Water” is indeed the most vital need for living being. Presence of water indicates presence of life. The topic of the first convention of GIST (Global Indian Scientists and Technocrats) forum on “Water” (Scientific and Technological approaches for sustainable use of Water Resources) is most appropriate in today's context where potable water is getting scarcer day-by-day and more and more irrigational land resources are becoming wastelands due to sever droughts. It is true that Water, as a natural resource, touches social, economic and political life around us.

Our Planet Earth has about 13000 cubic km of water, mostly in the form of water vapor, in the atmosphere at any given time. If it all fell at once, the Earth would be covered with only about 25 mm of water. Almost 71% of the world's surface is covered by water but 97% of that is salty. Of the 3% remaining freshwater, three quarters is either trapped as polar ice or locked up in soil. Most of groundwater is within a km of the earth's surface. The groundwater has also depleted drastically particularly in urban holds as well as in well-irrigated agriculture lands due to extensive use of bore wells. Rivers are no more surface rivers, but have only a trace of water line deep down. On the other hand, each day, 1150 cubic km of water evaporates or transpires into the atmosphere. Hence, it is necessary to spread the awareness of saving water and this convention will help to drive the point.

Shri Jayant Sahasrabudhe, National Organising Secretary of *Vigyan Bharati* is the key person for my involvement in this convention. Extensive support and active interest shown by Shri R. V. Kulkarni, Convener, Shri Shrikant Kulkarni, Secretary and Shri Mukund Deshpande, National Co-ordinator has made this convention very successful. The souvenir took its proper shape and focus with assistance from Shri Mukund Deshpande.

The abstract book is divided into the themes such as **River Basin Hydrology & Climate Change, Water for Agriculture, Water for Energy, Water for Drinking, Domestic and Industrial Use, Water for Environment, etc**. Each theme session starts with a theme paper followed by other presentations of short duration. There are presentations from scientists, technocrats, water planners and policy-makers among others. Besides, there is a convention overview by Dr. Madhav Chitale and an overview of Scientific Programme Committee by Dr. C. D. Thatte. I hope the deliberations by distinguished personalities during the convention will result into conservation of this natural resource for sustainable development and identify the thrust areas for further research.

Happy reading!

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GLOBAL INDIAN SCIENTISTS & TECHNOCRATS FORUM

Vision on GIST Forum

As India makes rapid economic progress, the need for inclusive development covering the larger fraction of our weaker population has become far more critical. There are also serious issues with regard to sustainability of natural endowments like good quality air and water, nourishing the soil cover and responsibly managing other earth resources. Further, the threat of climate change requires that we bridge our development deficit in a manner that does not take us irreversibly close to the tipping point.

There are also other issues of sustaining development as we cope up with global warming. For example projected rise in sea level would not only innundate low lying areas but would also necessitate adoption of new strategies in many areas including for example adoption of salinity tolerantt crops in coastal areas.

The challenges that we face need actions at several levels. We need to explore innovative approaches for action by different stake holders to constructively supplement the efforts of governmental agencies. Clearly S&T can play a crucial role. India has a large pool of scientists and technologists both within the country and outside. Many of them would like to participate in such efforts bringing in their experience and expertise. In the modern era of ICT empowerment and cost free access to global information and knowledge pool, it would be very desirable and useful to develop a ICT enabled platform consisting of Indian scientists and technologists all over the world and people seeking development solutions in their place. Such a platform should also involve NGO's, financial institutions and other stake holders wishing to participate in developmental efforts leveraging S&T inputs. With the availability of such a platform several groups can be networked to address specific problems. We could thus create a truly peoples movement to develop the underdeveloped areas particularly in rural domains of our country as also solve problems needing solution where ever they exist. This is the core idea behind the GIST Forum. The GIST forum would facilitate identification of problems needing solution and the group that could engage itself in working out the required solution and its implementation. As a part of its activities GIST Forum would also organize conventions on specific themes where one can do the stock taking of current status, the developnment needs and startegies, exchange ideas and case studies and showcase success stories.

This first GIST convention is focussed on water. A matter of every one's concern. The convention will deal primarily with S&T aspects of the water.

Dr. Anil Kakodkar

Development of Scientific Program for GIST Convention 2010 – A Background

S&T Approaches for Sustainable Use of Water Resources

Dr. C. D. Thatte
Chairman, Scientific Program Committee
cdthatte@yahoo.co.in

The Planet Earth has five main and unique natural resources (NR), viz. energy, land, water, humans, bio-sphere. In pristine condition also, they do provide G&S, which often are short of human needs. First three NRs are nearly constant; human population continues to grow and is likely to stabilize in size by 2050; about the last one – bio-sphere, we are not certain. Freshwater Resource (FWR) needed by us forms a very small part of the Total Water Resource (TWR). With population growth, the per capita availability of FWR is reducing, although it is continuously renewed through a solar energy triggered process of evaporation and condensation. The vast saline stock can therefore be considered as the last resort for mankind!

As the spatial and temporal distribution of the FWR does not match with that needed by the users, each needs 'development' from its natural state of occurrence, for enabling its abstraction, use, reuse round the entire year, and prudent management. It connotes building storages to overcome variability for Surface Waters (SW) and pumping of Ground Water (GW) for use on surface. Proportion of storage to total stock of FWR has to keep pace with population growth. **Unfortunately, FWR's per capita availability is reducing, and rate of increase in stock has also declined recently. The former may stabilize, but the latter has to be augmented.** It is to be clearly understood that development of FWR significantly augments its own pristine contribution of G&S. S&T backup upgrades it further. Sustainable development ensures continued fulfillment of G&S. FWR is thus connected with society's and life's existence and needs, and hence is critical. Humans deploy multi-faceted processes to develop and use the FWR, which include: S&T, social, political, legal, institutional, and economical. Depending upon the current status of its Human Development Index, each society integrates them for optimisation. Although S&T is basic, fruition is a result of achieving balance in deployment of all the processes.

As a subject, FWR is deeply fragmented because of the enormity, complexity of uses and processes and is typically dealt with by more than ten departments of a Government. Professionals and S&T practitioners also have several voluntary Associations. Each has a territory related stake-holder pride, besides differences of opinion on approaches including S&T related ones, largely due to mis-understandings. One often encounters the fable of 'Elephant and Six Blind-folded Men'. Color of blindfolds of-course differs. As a result, one comes across instances of "mis (or dis) information, mis-givings, pseudo S&T, and hype often paraded as facts, which can be collectively labeled as 'myths'. They seem to have led to some – futile, waste, romanticized and unnecessary ideas, concepts, controversies. The blindfolds have to be removed to clear the ambience. Sooner we do it, better it will be.

When, the Scientific Program Committee (SPC) of the 2-day long - GIST Convention on Water, was assigned the task of scoping it, the prevailing confusing status was discussed. The SPC felt the need, first to (if possible) arrive at an agreed 'least common denominator (LCD)' of information and knowledge, within the S&T community to unravel the 'myths' and build consensus on S&T approaches. It was considered necessary to steer clear of controversies due to processes other than the S&T related ones in this Convention. Probably in a future Convention it would be possible to squarely take on and dispel some controversies, to bring out the 'reality' to people. This was necessary, not only for dealing with the present mismatch in supply-demand for various FWR uses, but also to chart a course of action for sustaining the fruition in the coming 4-5 defining decades for the country, by end of which

India's population is likely to stabilise. The Theme for the Convention was therefore decided as: “Scientific & Technological Approaches for Sustainable use of Water Resources”.

SPC decided that the subjects to be dealt with in the convention sessions had to be comprehensive in coverage of FWR availability and important uses. It recognized that the society was harboring a huge concern about FWR availability in future, in particular due to wide-spread 'speculations' about the impacts of the likely Climate Change (CC) during the 21st century. The Convention design needed to address this concern. Five sessions identified therefore started with: 1. Hydrology & Climate Change, followed by FWR uses for – 2. Agriculture; 3. Energy; 4. Drinking, domestic, industry; and 5. Environment. The sequencing of the last two sessions recognized the existing cause-effect relationship between them.

The SPC then approached recognized Indian S&T thinkers to write Theme Papers (TP) for the Sessions to cover the present Status in the subject and figure out the S&T approach for a possible sustainable scenario in say, year 2050. An exposition focusing on recapitulation, compilation, and integrated handling was requested to suit the Convention theme. The Authors were requested to identify / suggest – present / future status of the session subject, required S&T approaches, myths & realities, and subjects for floor discussion. For each session, about 4-5 numbers of RPs from recognized authorities were considered adequate, to keep within the time slot for the session and yet provide enough time for floor discussion focusing only on identified issues. In RPs for each session, one slot was reserved to provide National Coverage, and the second for the host state, i.e. Maharashtra.

Five members of the SPC were requested to co-ordinate activities related to getting TPs, inviting and screening the abstracts for RPs, getting Full Length Papers (FLPs) and further processing. They will Chair the respective Convention Sessions. Rapporteurs will assist them in session time management. Each Chair will draw Session Summary in 5-7 bullets. Convention summary will be read out by the Secretary in the Valedictory Session. A small committee of SPC will give a final shape to it later. FLPs will be included in a CD to be distributed to delegates / participants. A bank of desk-top terminals is to be made available for delegates to access, download, print relevant aspects for facilitating floor discussions.

The brief now provides some useful background information on FWR.

1. Global agenda on FWR has evolved from – Brundtland Commission, Rio Earth Summit 1992 (IWRDM & SD), World Water Vision 1999 (in 3 main sectors), Millennium Development Goals 2000, WEHAB at WSSD in 2002, IPCC 2004-08-09. National agenda from – Famine Commission, Irrigation & Flood Commissions, Country Vision 1999, NCIWRDP 1999, NWP 2002, NWDA 2003 (TF – IBWT), NWM 2009. Some States have had separate Commissions on FWR. As per present projections, for India, CC might not cause decrease in FWR availability, but might increase extreme events for which adaptive measures are required. Basinwise assessments are in progress.

2. FWR supply comes from Rain / Snow. A supply / use assessment and plan based on river basin spread is realistic. But, availability is skewed across the basins, needing remedy. Real use is consumption through evaporation / transpiration. Abstraction / Diversion often mixed up with Use is for meeting with needs for Food, People, Nature as identified by Global Vision (1999). It is necessary to differentiate between Consumptive (food, nature) and Non-Consumptive (other) use. Every 'good' produced by humans has a water foot-print. Water Use Efficiency (WUE) varies and so also productivity of G&S. Every infrastructure is planned to bestow positive benefits but does involve certain adverse environmental impacts. They are to be compensated or accounted in cost-stream. The balance has to be beneficial. India has yet to build several identified storages to generate requisite G&S. Proper care is to be exercised.

3. Each river basin requires a discrete combination of storages – mega to micro scale and conjunctive use from surface / ground water both, to meet needs within available FWR stock. Inter-basin transfers have been practiced in India for a long time. Several new links between basins have been thought of to harmonise supply / demand inequity. The program is however undergoing a flip-flop. Food & biomass (both irrigated / rainfed) is the largest user Sector. By 2050, it is likely to grow by 50% after achieving upgradation in WUE. The People Sector is likely to see growth by 300%. The present backlog and the additional huge generation of human waste both liquid and solid would require urgent attention, action, and monitoing. Rural India is fast getting urbanized, requiring more water. Also, urban facilities need to be provided in areas that will lag behind. It all tantamounts to huge need for additional freshwater supply. The Nature Sector use may rise by 50%, if not more. On hydropower front, India has hardly installed about 27% of identified potential. Most of the remaining lies in Himalayas. But development is facing several hurdles which ought to be overcome early.

Contributions: SPC has been fortunate in eliciting all-round thought provoking responses from eminent thinkers / professionals. Organizations represented by them include :

International : WMO (Climate / Hydrology), UNICEF (India), 3rd World Center (Mexico based), ICID.

Indian Apex Bodies : MoWR, CWC, CEA, Brahmputra Board, CBIP, CWPRS, NWA, NIH, NCL, IITM, IMD, CPHEEO, IISc, BARC,

Institutes : IEMR, IRAP.

Maharashtra : Present and past officials for developing local scenario.

A Pre-View of some emerging realities from the contributions to the five themes:

General : need to mop up WR potential in 2-3 decades, improve WUE, cut losses, reuse/ recycle FWR.

Hydrology & Climate Change : Necessity to develop an India CC model to study likely impacts suiting Monsoon system and river basin wise WR. Snow / glacier melt contribution to North-Indian rivers is not critical. Need for expeditious development of Indus, Ganga, and Brahmaputra FWR. Need to revive IBWT on priority. Understand limits to the RWH / WSD in light of interactive SWR /GWR. Start Adaptive Measures for storages as per NWM. Build defenses against more floods /droughts.

Agriculture : Quickly build remaining irrigation infrastructure, sustain food production and security.

Energy : Huge HP potential in Himalayan rivers and Nepal / Bhutan awaiting storage / cascade development. Work out trade-offs and convince stakeholders. Quickly address environmental issues. Go for carbon-credits. Implement PSS.

DDI : FWR urban supply is fair, augmentation of quantity/quality required for rural supply. Remove mismatch of WW treatment / reuse / recycle; adopt zero effluent strategy for industry. Non-point source pollutants of agriculture – go for organized drainage of irrigated area.

Environment : has to move with development & economic growth, find S&T least cost options to minimize adverse impacts; EFR / MFN illusive, avoid romanticism. Attempt a cut-off date for restoration of eco-system.

PROGRAM FOR CONVENTION

26th December 2010

Day 1

08:00	**Registration & Tea**	
08:45	**Pre - Inaugural Session**	
	Welcome	Dr. Bhatkar
	Introduction	Dr. Kakodkar
	Plenary Speech	Dr. Madhav Chitale
09:20	**Technical Session No: 1**	
	River Basin Hydrology &Climate Change	
	Theme Speech :	Avinash Tyagi
	Six Presentations	
	Floor discussions	
11:35	Summing up by Session Chair V. M. Ranade	
11:45	**Tea and assembly for inaugural session**	
	Inaugural Session	
12:15	Hon. Dr. Kalam arrives at the venue	
	Speeches by Dignitaries	
	Inaugural speech :	Hon. Dr. Kalam
13:15	Visit to Expo & Tea with senior scientists	
13:30	Hon. Dr. Kalam leaves the venue	
13:30 to 15:00	**Lunch**	
15:00	**Technical Session No: 2**	
	Water for Irrigated Agriculture	
	Theme Speech :	Dr. Dinesh Kumar
	Four Presentations	
	Floor discussions	
16:45	Summing Up by Session Chair Dr. D. M. More	
17:00 to 17:30	**Tea Break**	
17:30	**Special Session for Industries**	
	Research And Development Initiatives By Industries	
	Opening Remarks :	Dr. Anil Sahasrabuddhe
	Industry Presentation	
19:00	Summing Up by Session Chair Dr. Kakodkar	
19:30 to 21:30	**Dinner**	

PROGRAM FOR CONVENTION

27th December 2010

Day 2

8:00	**Tea & Assembly**	
08:30	**Technical Session No. 3**	
	Water for Energy	
	Theme Speech	Dr. B. S. K. Naidu
	Four Presentations	
	Floor Discussions	
10:20	summing up by Session Chair M. D. Pendse	
10:30	**Tea Break**	
11:00	**Technical Session No. 4**	
	Water for Drinking / Domestic & Industrial Use	
	Theme Speech	Dr. S. R. Shukla
	Five Presentations	
	Floor Discussions	
13:05	Summing Up by Session Chair Dr. Patwardhan	
13:15 to 14:15	**Lunch**	
14:15	**Technical Session No. 5**	
	Water for Environment	
	Theme Speech	A. D. Mohile
	Seven Presentations	
	Floor Discussions	
16:50	Summing Up by Session Chair C. M. Pandit	
17:00 to 17:30	**Tea Break**	
17:30	**Valedictory Session**	
	Summary of all sessions by	
	SPC Convener	V. M. Ranade
	Valedictory Speech	CM Maharashtra
	Remarks by the Convention Chair	Dr. Bhatkar
	Announcing next year's program	Dr. Kakodkar
	Vote of thanks by	
	Convention Convener	R. V. Kulkarni
18:30	**Program ends**	

Gist 2010

CONVENTION & EXHIBITION

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- Sadekar Enviro Engineers Pvt.Ltd
- Mechatronics Systems Pvt Ltd
- Indian National Center for Ocean Informatics Services
- C-Tech SFC Enviornmental Technologies Pvt. Ltd.
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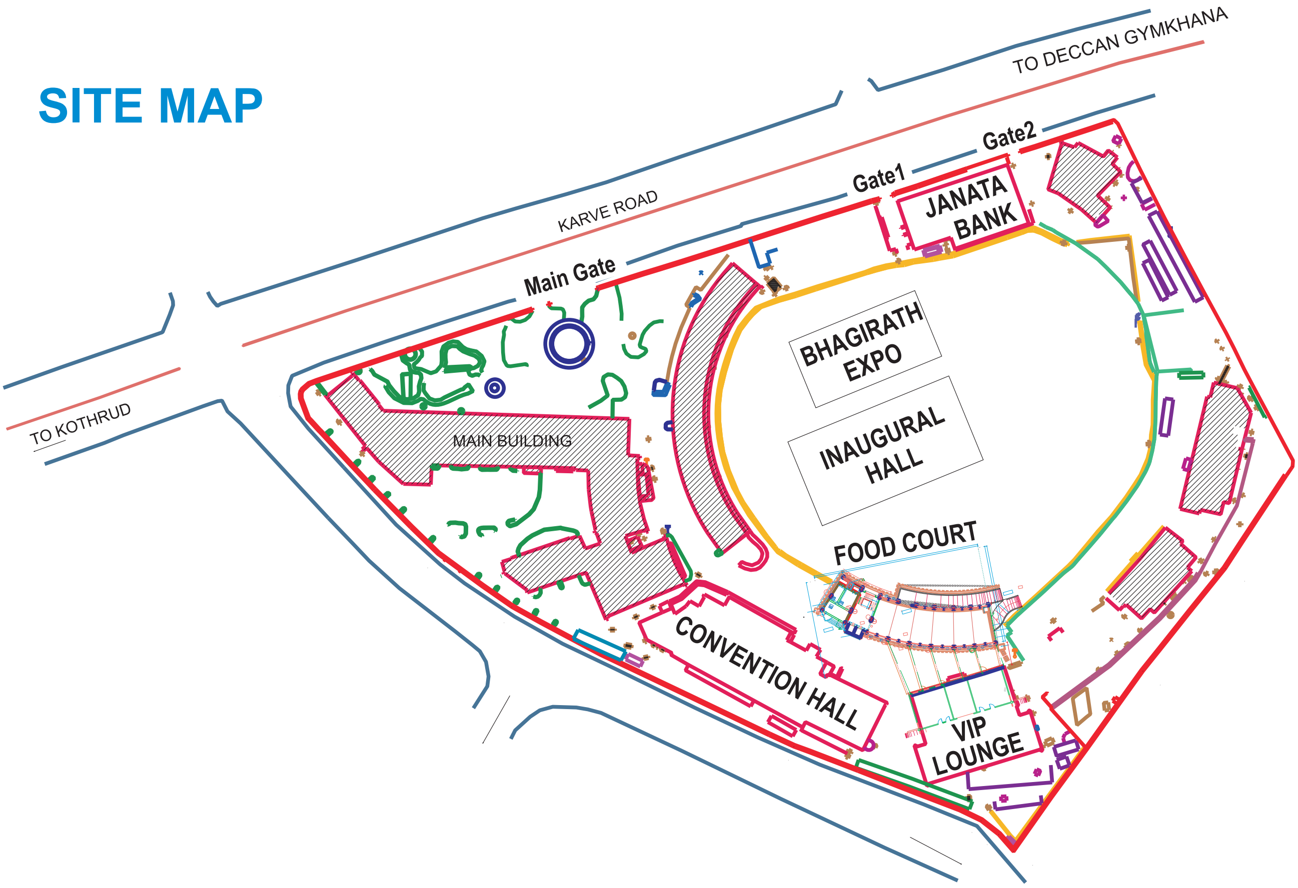

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Science and Technology for Water Management

Overview Speech by Dr. Madhav Chitale
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The current Indian set up

India has its National Water Policy since 1987. It was revised in 2002 and is again currently under review to keep pace with the changing times. Initially the national policy mentioned seventeen topics related to water for "intensifying research efforts" to "push forward the frontiers of knowledge". At the time of review in 2002, the list was enlarged to include ten more topics like water quality, instrumentation remote sensing etc. India also has a network of well established independent research institutes dealing exclusively with the various aspects of water, such as the Central Water and Power Research Station at Khadakwasla (Pune), The National Institute of Hydrology (Roorkee), Central Soils and Materials Research Station (Delhi), and National Environmental Engineering Research Institute (Nagpur) at the national level, and a chain of state level hydraulic research stations and Water and Land Management Institutes.

Along with the nation-wide research infrastructure, a series of national level training and educational institutes have also been established. Many of them have a broader perspective of global reach. Independent schools of Hydrology, Water Management and Earth Quake Engineering at IIT Roorkee have been imparting post graduate level education under. Institutes of the Indian Council for Agriculture Research,Central Soil Salinity Research Institute at Karnal (Haryna) have been undertaking similar research effort in water related issues in agriculture. The very name of the post graduate student's hostel of the IIT Roorkee established in early 1950's is Afro-Asian Hostel. It is indicative of the broader international perspective already adopted in India in the activities related with science and technology.

These pioneering efforts resulted in contributing eminent expert personnel to the International field, such as for the Mekong River Commission. Indian water experts have also been made available to other developing countries like Sri Lanka, Philippines, Ethiopia and Afghanistan. On the other hand, international programmes like the UNESCO's International Hydrology Programme and financial and technical assistance packages from the World Bank, Asian Development Bank or from donor countries like USA, USSR, France, The Netherlands have contributed to the strengthening of the science and technology activities in the water sector of India.

River water partnership

The need for well co-ordinated and participatory global efforts have considerably increased with more complex issues like Global Warming and Climate change affecting the water sector globally. Even otherwise, there is much to learn from the experiments and success stories in river basin management from different parts of the world. The International Network of Basin Organizations has been making steadfast efforts over the past twenty years to strengthen the basin oriented pattern of water management. Simultaneously the concept of "river basin water partnerships" is being pursued by the Global Water Partnership (comprising over 2000 water related institutes / organizations around the world).

India had the benefit of hosting the first South Asian Workshop of such 32 river water partnerships that have emerged in the countries of South Asia. It was clear from that workshop that while there are many common aspects of their work, the scientific and technological priorities of the basins differ very widely. It was seen that the topics that need priority attention by the Tamraparni River Water Partnership (Tamil Nadu) that has to deal with the wastes from a large number of fire-crackers' factories around Shivganga are quite different from those of the Upper Bhima Water Partnership grappling with the huge quantities of domestic effluents of the Pune City. The priorities are also far different from the water partnerships of the flood prone tributaries of Ganga in Bangladesh. Hence while keeping track of the general water related developments and lessons at the global level, local actions will have to be channelised on the basis of specific local priorities.

Watershed development

Rural India has attracted sufficient attention of 'Watershed Development'. But dependable watershed development plans have not yet been possible, because accurate water balance statements can not yet be prepared for individual watersheds, having area spread between 200 and 1000 sq km, in absence of adequate local hydrological information such as the evaporation processes. In Maharashtra alone, there is a need to have an evaporation atlas for the 1508 designated watersheds. But there is not enough local data in hand. In the hard rock areas – covered by basalts (Maharashtra, Karnataka, Gujarat, Madhya Pradesh) or by granites and or quartzites (Andhra Pradesh, Karnataka, Tamil Nadu), for want of adequate information about the local geohydrology, mathematical modeling of the watershed has been very difficult.

In general, scientific and technological research through laboratory work has progressed well. But when it comes to field information and field experiments such as the process of reservoir sedimentation, many things are need to be done.

Reuse of city effluents

Because many river basins in India are water short, there in increasing attention to the possibilities of reuse of domestic and municipal waste water for agriculture. Such efforts are beset with the risks of pathogen transfers and the long term adverse impacts on the productivity of the soil. Because of climatic differences, and different varieties of soil formations, it is not advisable to adopt the treatment methods and management technologies that may have worked well in some other widely different areas. Scientific local experimentation in these matters can only provide the dependable guidelines and rules of operation.

Even the reuse of city effluents and industrial effluents through sprinklers or drips, need considerable scientific research. Materials to be used for them may have to be quite different in composition and quality according to the level of treatment received by the effluents. Our knowledge is very inadequate in this respect. Much of the agricultural research for different crops has essentially been with normal water and not for the grey water. For sustainability of the irrigation systems that will be using grey water hereafter in greater measure, much more scientific and technological inputs will be required for the water application systems on the farms.

Cleaning of water

For a dependable supply of potable water, many clean water technologies have emerged in the developed countries where advanced membrane technologies and processes like reverse osmosis are being used. Ozone applications are also being adopted. While these will be useful for many situations, economical modes of treating water, such as solar radiation of a bottle of water for control of bacterial vector will have an important role to play in the individual's household arrangements. For Municipal bulk withdrawals, green bed technologies are likely to be very helpful in many situations along the polluted river stretches. They will also be useful for treating ground water that is not otherwise safe for municipal distribution.

Greater the scarcity of water, greater will be the need for recycling and reuse. Along with the sophisticated arrangements to be adopted for that purpose, simpler technologies will have to be widely promoted in the water scarce regions. Many traditional practices being already followed by the people, will have to be refined and upgraded with the use of modern scientific inputs.

Water and Energy

Water and Energy have a two way relationship. Hydropower has to be an important component of the electricity distribution network to take care of the peak load of the system. At the same time, pumping of water by using different forms of energy is almost inevitable for most of the water used for the modern life. Industrial supplies, municipal supplies as well as supplies of water for agriculture depend substantially on pumping. Hence water conservation measures have to go hand-in-hand with energy conservation measures. With the increasing role of ground water in the comprehensive water management, energy required for pumping of ground water has to be very carefully planned and handled. The pumping load in India for irrigation alone has been of the order of 30 % of the electricity demand in terms of energy units. In Maharashtra, out of the 11,000 MW of installation, as much as 4500 MW goes for connections to rural pumps.

Water treatment works also need large quantities of power for handling water. Particularly water treatment processes using reverse osmosis and membrane technology require high pressure systems. These are highly energy intensive. Reducing the energy requirements for such processes is one of the new technological challenges. For India, there is much to learn in this respect from the world wide efforts. For research on this aspect, it will be useful to collaborate with the research set ups abroad.

With the spread of electricity generating stations, cooling water is emerging as an important component of water use in a river basin. Large quantities are required for cooling of the thermal and nuclear power plants. Effluent water carrying the unutilized heat energy also has environmental impact. In all such situations, water conservation depends on the improvements in the processes that require large quantities of water. Because water availability is likely to be a main constraint and a determinant of future development scenario in many river basins and regions, technological refinements in the patterns of water uses will indirectly decide the sustainability of the water use system there.

Environmental management

Water's most important role is to provide a life support system in the environment. All man made developments have to see that this basic role of water is not jeopardized. Effluent disposal systems and handling of toxic wastes has to be regulated accordingly. Human health is closely interlinked with water quality. Spread of Infectious diseases like cholera, malaria, dengue etc. get aggravated, where water is not properly handled. Hence water management is at the core of environmental management.

Nature has its own self cleansing mechanisms such as: the cascading river water receiving aeration. Plant root systems also have biological ability to separate the harmful ingredients from water. Studies on the behavior of the plant roots in relation with soil and water have to be pursued in this context. Grasses have proved their capability in cleaning water physically, chemically and biologically. Systematic green bridges for treating dirty wastes have proved effective.

The way forward

Annual Workshops organized by the Central Board of Irrigation and Power had initially provided a good platform for the exchange of outputs from the research efforts in the Indian R&D establishments. Its canvass needs to be much broadened hereafter. Such sessions should lead to identification of specific gaps in the current scientific knowledge, and should help in outlining the research work required to bridge these gaps. National Committees on hydraulic research, on large dams and on irrigation have to some extent provided such inputs. But the country's research needs are getting greatly diversified looking to the expanding list of topics under the heading of science and technology in the revised National Water Policy. Hence, many more National Committees/ subcommittees will be necessary to focus attention on these specific topics. They will have to suggest extension of facilities for the research work required in the future. They should also be able to suggest appropriate collaboration with the S&T work in other counties and within the UN system.

A collective annual national review of research work incidentally result in reshuffling of national priorities in the water sector as many are found necessary. We are not designing water saving toilets or urinals, while succeeding in designs of space crafts. India has a good number of scientific and professional voluntary associations focusing on subjects like hydrology, water works, or ground water. They will have a dual role to play. They will be helping to expand the horizons of Indian Science and Technology on one side, and taking the results to the people at large on the other side.

Language has been a great barrier in spreading the new knowledge amongst the people – whether in ground water management, clean water technologies or water saving and energy saving techniques in agriculture. International Commission on Irrigation and Drainage produces and regularly updates its standard technical dictionary covering more than 20,000 technical words used in water, agriculture and environment. It explains the subtle meaning of those words along with figures and sketches. Many countries translate this dictionary into their own languages for wider use in their country, e.g. in Arabic, French, German, Japanese, Persian etc. But none of the Indian languages has the benefit of such a translation. Indian professional associations in the water sector will have to under take this responsibility if they have to provide an effective bridge between the world wide knowledge and the Indian people. Water related literature published in India's local languages is also meagre. When India's National Water Policy was first adopted, it got translated into all Indian languages to reach the people. Science and Technology work in the country will have also to find a proper place in the literature of the Indian languages.

Technical Session No. 1

River Basin Hydrology & Climate Change

Theme Speaker : Avinash Tyagi

Session Chair : Vidyanand M Ranade

Suggested Points for Floor Discussion :

a) Devising an Indian Model for CC & Monsoon, CC and snowfall, besides CC & River Basin Hydrology

b) Modernising existing WR infrastructure to take care of adaptive measures like addition of carryover storage, raising of dams etc. Suggestions for an action plan.

c) Ways to integrate mega – micro scale infrastructure without affecting existing utilities, in particular for basins nearing closure. Integrating SW / GW resources to avoid excessive loss of WR to evaporation from micro SW structures.

d) Devise and Implement a strategy to counter likely increase in incidence of extreme events / breaks in monsoon.

e) Strategy to quantify impact of CC on North Indian river systems.

Technical Session No.1: River Basin Hydrology and Climate Change

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Climate change is one of the defining challenges of our time that only exacerbates the existing and projected challenges on all natural resources due to demographic and socio-economic changes, including the water resources, in most of the countries around the world. Water resources management affects almost all aspects of the economy, in particular health, food production and security; domestic water supply and sanitation; energy and industry; and environmental sustainability. Actually, signs of these future challenges are already visible in the developing countries and given the projected population growth, it is likely to accelerate faster than any other developed region around the world. Water is the primary medium through which climate change influences Earth's ecosystems and thus the livelihood and well-being of societies. Climate change is severely impacting the hydrological cycle and consequently, water management. This will in turn have significant effects on human development and security.

In the past, as a consequence of hydrologic impacts of slow climate change, the ecosystems have transformed themselves and the societies dependent on such ecosystems have either changed the way they live or have migrated. However, recent rate of temperature increase observed across the world is very high in relative terms and the hydrologic systems and the ecosystems dependent on them have little time to adjust and adapt to the new environment. While the dynamics of social and economic changes enable us to foresee the increasing demand side requirements for food, clean drinking water etc, the uncertainty in the science of climate change makes it rather difficult to project the impacts of increasing climate variability and climate change on the supply side dynamics. Climate change grossly manifests in the increase of the Earth's average surface temperature as a result of increase in the concentration of greenhouse gases in the atmosphere, which absorb, reflect and partially re-radiate terrestrial long wave radiation, preventing it from leaving Earth's atmosphere. The hydrologic cycle is intimately linked with changes in the atmospheric temperature and radiation balance. Hydrological processes can be expected to exhibit more variability, more extreme events and result in regional shifts in water balances. This will translate directly to the changes in water resources availability both in space and time. Future projections based on a large number of simulations from a range of Global General Circulation Models (GCMs) under various emission scenarios indicate that the changes in the climate system during the 21st century is likely to be considerably larger than those observed during the 20th century. As a consequence of the higher temperatures, particularly at the higher altitudes, melting of glaciers will result in higher flows in the rivers in the short run, and then decrease, particularly in late summer months. As monsoons are the dominant phenomena over much of Asia, the factors that influence the monsoonal flow and precipitation are of central importance for understanding climate change in this region. Several recent studies suggest that monsoons could become more variable and unreliable, with possible consequences including an increase in the intensity of rainfall and a reduction in the duration of the monsoon.

Downscaling of global model simulations carried out using regional climate model using a limited number of scenarios of increasing greenhouse gases have indicated marked increase in temperature and rainfall towards the end of the 21st century. While the warming is more or less uniform across the country, substantial variations in the projected rainfall changes is expected with West & Central India showing maximum increase in the rainfall. Since water forms the crucial resource for the survival of not only mankind but all forms of ecosystems, it is important to assess the impact that climate change is likely to have on these functions through water. The existing water supply and sanitation infrastructure, previously designed for different resource availability and water use, will likely come under greater pressure owing to hydraulic changes and warmer temperatures. Climate change is expected to impact both rain-fed and irrigated agriculture because, rising temperatures will increase crop water demand. Susceptibility of agriculture to high frequency variability in rainfall intensity and duration make the projection of performance of agricultural systems in relation to long term climate trends very difficult to determine. To address water shortages, it is essential to adopt an integrated supply and demand management of water resources, through increased water storage infrastructure (surface water and groundwater). Changes in river flow regimes are likely to affect the economic viability of existing schemes. For the new schemes the procedures of economic evaluation studies have to evolve under the new paradigm.

Understanding of climate change, its impacts, and the effectiveness of adaptation or mitigation actions requires continued operation of existing long-term monitoring networks and improved sensors. In turn, information about possible or likely future changes to climate improves the effectiveness of planning studies and allows the development and implementation of reasonable strategies for adapting to a changing climate. In order to comprehensively understand the impacts of climate change on the water resources systems and to develop the adaptation strategies, projections of future climate in terms of changes in: air temperature, total precipitation rate, specific and relative humidity, potential evaporation, soil moisture content groundwater recharge and river run-off is required. Global Climate Models (GCM) have been developed the past and the future climate system, driven by assumptions on the evolution of drivers of climate change. GCMs provide information only at a relatively coarse spatial resolution, often not suitable for climate change assessments at a scale required for water resources management. There is a limitation to understand mechanisms responsible for Indian monsoon using GCMs. Regional Climate Models (RCMs) are able to simulate the characteristics and processes of the Indian monsoon. Quality hydro-climatic data collected through sustained monitoring networks are essential for improvements in the accuracy of forecasting methods and downscaling climate information to basin scale. At the national level, it is important that the natural availability of water in different basins within the country is reassessed in a comprehensive and integrated manner using detailed water balance studies at the basin, sub-basin and national level. While RCMs provide greater detail in climate simulations, and help us develop climate change scenarios with greater spatial detail, it must be borne in mind that they are strongly dependent on the skills of the global models driving them. It is therefore important to continue efforts for further improvements in the quality of GCM simulations.

Changes in climate are amplified through water: Small changes in precipitation and temperatures are translated into large changes in river flows and groundwater recharge. At the same time, some of the water management options have the potential to contribute to global warming by releasing green house gases. Water management, therefore, is at the heart of both risks of and response to climate change and plays a pivotal role in adaptation and mitigation. Given the uncertainties inherent in future climate and hydrologic projections, adaptation strategies have to be based on risk management principles. Adaptation programs should consider all options and fully explore the potential offered by integrating: structural and non-structural measures; natural and physical infrastructure; and incentives and sanctions. At the same time managing demands against the backdrop of increasing population, demographic changes and rising economic standards of living, has to be prioritized through appropriate regulations, incentives, and dis-incentives. Concepts such as 'more crop per drop' will have to be re-invented and perused vigorously, while technologies, such as drip-irrigation, which have not been fully exploited in developing countries, would have to be invested in.

Greater climate variability will increase the magnitude and frequency of extreme events that have the potential to turn into disasters. Modern technologies such as satellite and radar monitoring of precipitation that help forecasting of flash floods, the deadliest hydro-meteorological hazards, should be increasingly used. Establishing Global Framework of Climate Services with the aim to “enable better management of climate risks due to climate variability and change and adaptation to climate change at all levels, through development and incorporation of science based climate information and prediction into planning, policy and practice” would help in furthering this objective

The role of multi-purpose storages, in managing risks due to increased frequency and magnitude of floods and droughts, needs to be studied on a systematic and scientific basis. Integrated Water Resources Management (IWRM), which has been accepted as the best practice under the increased pressure on water resources systems due to population and socio-economic developments provides a good framework. In order to identify adaptation measures it is necessary to undertake comprehensive re-assessment of water sources, develop strategies to eliminate shortcomings of the existing water management system, and establish mechanisms for regulation, distribution and efficient use of water resources. Optimal use of available technological advances in weather and climate forecasts and predictions from now casting to seasonal predictions is made to help manage the resources more efficiently. One of the obvious investments in technological development that is expected to have immediate payback is improved forecasting techniques that will undoubtedly improve operation and management of existing water delivery systems. Recent advances in genetic engineering and biotechnology are expected to have the greatest impact on food security and agriculture, alleviating some of the stresses on fresh water supply. Advances in fusion energy and cheaper solar power would alleviate water supply problems for the large urban areas on the coasts, making desalination an economically-competitive option. A new 'paradigm shift' is required in the methods that are used for justifying new water resources investments and projects, which includes very different economic decision criteria.

In conclusion it can be said that, Adaptation to climate change is urgent and 'Water' plays a pivotal role in it. IWRM is the organized, orderly process by which adaptation to changes in population, demands, economic conditions and climate change can be addressed in a systematic and comprehensive manner. IWRM provides the long-term institutional basis upon which climate change adaptation can be sustained through the coordination of numerous adaptive management strategies in water-related sectors. It needs to be supported from a scientific and technological perspective, by taking measures such as increased investments in R & D, developing improved weather forecasting models and methods, building capacities to operationalise technological advances, developing tools and programmes to handle extreme climatic events etc.

Keywords : Climate Change, Environment, downscaling, GCM, variability, adaptation,

Likely Impact of Climate Change on the Indian Monsoon

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Monsoons are experienced over many parts of the world, in Asia, Africa, Australia and America, but the Indian southwest monsoon stands out as the strongest of all. It has linkages with the global atmospheric circulation and it is an important component of the earth's total climate system. The Indian southwest monsoon is India's main source of water. It sustains the livelihood of millions of Indian farmers and influences food production. It is a dominant factor in shaping India's economic growth. The monsoon rainfall is grossly uneven and as such India has some of the wettest places on earth and also the driest. The rainfall is not uniform in time either, being interspersed with dry spells. There are two reassuring facts about the Indian southwest monsoon. One is that it comes every year regularly without fail, although the nature of the onset may be different from one year to another, sometimes weak and delayed, or sometimes early and strong. The other is that the All-India Summer Monsoon Rainfall (AISMR), averaged for the country as a whole and over the period 1 June to 30 September, has not shown much variation in trend since 1875; the data is available since 1875.

The impending threat of global warming can affect Indian monsoon. However, even when the prediction of the monsoon a season in advance can go wrong, as was the case in 2009, foretelling the state of the monsoon 50 to 100 years from now is a daunting problem. There are indications that global warming may reduce the predictability of the monsoon even on the shorter time scales. Nevertheless, a credible climate scale prediction of the monsoon is an utmost necessity and a high priority concerted effort is required in that direction. We must know for sure where the monsoon is heading, so that we can plan our strategies for ensuring water and food security for our population, while maintaining the rate of economic development.

An interesting and often overlooked aspect of global warming is that it is not uniform all across the world. The warming trends observed in the past as well as the temperatures projected for the future under different scenarios, show large regional differences. The warming rate is much higher over the land-covered northern hemisphere compared to the predominantly oceanic southern hemisphere. This means that the Eurasian continent is warming at a faster rate than the Indian Ocean, providing an increased land-sea thermal contrast. From very simplistic considerations, this can be interpreted as being favourable for the strengthening of the Indian summer monsoon in future. In particular context of global warming, it is important to investigate whether temperature and rainfall over India are showing signs of an increasing or decreasing trend. Even if a trend exists, it does not mean that one can just linearly extrapolate it indefinitely into the future. Over the period 1901-2009 which is longer than a century, the annual mean temperature has exhibited an increasing trend of +0.56 ºC/100 yr. However, this value does not apply all over the country. If the spatial pattern of annual temperature anomalies is examined, it is seen that there are some pockets of Rajasthan, Gujarat and Bihar where the trend has been -0.56 ºC/100 yr. There are also some regions, particularly in the north, where no significant trend in the annual mean temperature is discernible.

A rigorous analysis of the AISMR data series for the 103-year period 1901-2003 involving the application of a low-pass filter in order to suppress the high frequency oscillations has revealed no evidence of any linear trend in this series. Even in the rainfall of each of the monsoon months June to September separately does not show any trend. This is important, as fears are expressed that the pattern of monsoon rainfall, including its distribution within the season, is changing. On the spatial scale, 25 out of 36 meteorological subdivisions have no significant rainfall trend. Monsoon processes show up quite differently in different climate models and there is uncertainty in quantifying estimates of projected precipitation changes. A paradox of the results of climate simulations is that while monsoonal rainfall is projected to increase, the monsoon circulation is projected to weaken. Most of the climate models project an increase in the Indian summer monsoon precipitation. However, they generally exhibit a cold bias as well as a dry bias when compared with the observed climate. They capture the general regional features of the monsoon, but most of them have a problem in simulating the observed heavy monsoon rainfall over the west coast of India, the north Bay of Bengal and northeast India. This is mainly due to their coarse resolution which tends to smooth out the orographic processes that produce the heavy rainfall. The projected increase in monsoon precipitation has a wide difference across different models, ranging from 3 to 17 %. Thus the present consensus view emerging out of the climate model runs is that of an intensification of the monsoon, and a possibility not indicated by all models, that the monsoon season may extend somewhat longer than its current period.

However, the real difficulty arises when it comes to a quantification of the results. Most climate models are unable to simulate the observed features of the Indian monsoon in their totality. Many models underestimate the monsoon rainfall while some of them cannot simulate the observed monthwise precipitation pattern or the peak precipitation month. Hence only a few models can be trusted with the job of making a century scale prediction and even these have yielded diverse results. There is no climate model currently available internationally that can be truly relied upon from all angles pertaining to the monsoon. It is a discouraging fact that there has been no effort on the part of Indian scientists to build an Indian model in spite of the continuous upgradation of computational resources and the growth of institutional infrastructure in India. The approach has all along been to test foreign models over Indian conditions and judge their usefulness for predicting the monsoon. The search for an ideal model that could be used for monsoon prediction on the seasonal and climate scale is still on.

Keywords : Monsoon, Global Warming, AISMR

Snow / Glacier Melt Contribution to Run-off in the Himalayan Rivers - Assessment of Potential Impact of Climate Change

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The glaciers are amongst the best recorders of climatic changes. It is a well-established fact that the glaciers are passing through a recessional phase globally. The Himalayan glaciers are also receding like the rest of the glaciers in the world. Fluctuation in the recession rate of the glaciers during recent years has initiated widespread discussions, especially in context to global warming and its effects. Climatic variations and other topographical features obviously are among the controlling factors for the difference in retreat rates of the glaciers. Possible linkage of retreat of glacier with rise in average annual surface temperature of the country is yet to be confirmed. The recession rate of glaciers is indirectly linked to the mass balance, which accounts for accumulation and ablation (seasonal melting) that occurs within the glacial environment during the winter and summer periods, respectively.

Three major systems- the Indus, the Ganga and the Brahmaputra rise in the Himalaya region. Recently, there have been news items and discussions suggesting that the Himalayan Glaciers feeding the North Indian river systems are fast receding. The Gangotri glacier is reportedly melting at a rapid rate and it is likely that it will disappear in the next 20–30 years. Fears are expressed that its disappearance will lead to a dry Ganga. However, using remote sensing technique it has been concluded on the basis that the proportion of snow in the runoff at Bahadurabad and Harding Bridge respectively was about 27% for Brahmaputra and about 9% for the Ganges. Moreover, NIH has estimated the snow and glacier contributions in some of the Himalayan rivers. It is reported that the snowmelt and Glacier melt contributions to the total runoff of River Ganga at Deo Prayag is only 28.7% of the total runoff. The remaining 71.3% contribution is due to rainfall and base flow. At Allahabad it is 4%, reducing faster as one moves downstream due to large contribution to run-off coming from rainfall. The Snow and glacier contribution in Chenab at Akhnoor is about 49%. The Snow and Glacier melt contribution in annual runoff of River Satluj at Bhakra is about 59% and remaining 41% is from rain. In river Beas at Pandoh this is 35%. The total annual flows are thus likely to remain about constant on average for the next few decades, flow regimes are likely to change; inter-annual variability in flows will likely increase.

The current database about the properties and behaviour of Himalayan glaciers needs to be strengthened. Long-term studies on glacier melt contributions and mass balance are needed to understand the behaviour of Himalayan glaciers and the impact of climate change on them. This paper presents a detailed note based on NIH studies on the flow contribution of major tributaries to the flow of the Ganga as well as the likely impact of the Gangotri glacier melt on the quantity of flow in this river at various locations. The sensitivity studies carried out over the Indus basin are also described in detail.

Keywords : Himalayas, climate change, retreat, snow and glacier melt.

Hydrological Projections under climate change : Scale, Issues and Uncertainties

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Hydrologic implications of global climate change are usually assessed by downscaling appropriate predictors simulated by General Circulation Models (GCMs). Results from GCM simulations are subject to a number of uncertainties due to incomplete knowledge about the underlying geophysical processes of global change (GCM uncertainties) and uncertain future scenarios (scenario uncertainties). Disagreement between projections of regional climate change suggests that reliance on a single GCM with a few selected scenarios could lead to inappropriate planning and adaptation responses. This paper discusses climate change impacts on hydrology, including realities and myths about climate change with respect to water resources. The paper summarizes recent published work by the authors. The following methods and tools for statistical downscaling are discussed: (a) Fuzzy Clustering, (b) Relevance Vector Machine (RVM) and (c) Conditional Random Fields (CRFs). Uncertainty modeling with non-parametric methods and possibility theory are discussed. Applications of the methodologies are demonstrated by projection of the meteorological drought in the Orissa subdivision, and by predictions of the inflow to Hirakund dam in Mahanadi river basin of India.

Keywords : Downscaling, uncertainty, fuzzy clustering, relevance vector machine, possibility, conditional random fields

Statistical analysis of the spatial variability of very extreme rainfall in the Krishna river basin

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Natural Hydrometeorological disasters in the Indian region have occurred in the past essentially by outlying storm events characterized by considerable rainfall intensity and rare frequency. The characterization of this type of event is a crucial point in risk mitigation. Because of the rare occurrence of these extreme events, they can be analyzed only on a regional frequency basis in order to reduce the uncertainty associated with parameter estimation at gauged sites, and for risk assessment at ungauged sites. A statistical regional model includes: (i) a probabilistic model that can describe the extraordinary high rainfall observed in the past (outliers) and (ii) analysis of severe rainstorms that can take into account the observed spatial variability of the extreme rainfall. Proper management of the water resources for various purposes such as for domestic use, industrial use, irrigation, hydropower generation are of prime importance. Probable Maximum Precipitation (PMP) is the key design rainfall input in computing Probable Maximum Floods (PMF). If a spillway is not able to safely release the PMF, breaching of the dam wall due to overtopping can occur and cause loss of lives and damage to property. Also planning and management for hydraulic structures of medium and minor nature such as bridges, culverts, storms drainage works etc., require estimates of design rainfall of specific return periods. Considering the importance of the subject, an attempt has been made in this study to carry out extreme rainfall analysis of 570 stations in and around the Krishna basin by statistical method.

Annual extreme rainfall series of 1-3 day durations at stations located in and around the Krishna basin were subjected to statistical analysis in order to estimate point Probable Maximum Precipitation (PMP) and maximum rainfall of different return periods for the durations of 1-3 days. Daily rainfall data of 321 stations ranging from 1901-2000 (with varying data length) has been considered for the present study. Hershfield statistical technique is the widest accepted one; the same has been applied in obtaining point PMP estimate of stations over the Krishna basin, as this method is based on the actual observed rainfall data of long-period stations. Spatial patterns of 1-3 day extreme rainfall over the basin have been prepared. Extreme Value Type-I (EV1) distribution has been fitted to 1-3 day extreme rainfall series and various return period values were estimated. Using the same fit it was found that, PMP estimates for 1-3 day durations, have return period of the order of 1000-year. Extreme rainfall features and estimates of point PMP and maximum rainfall for different return periods documented in this study will be useful, for designing and planning the water resources projects in the basin.

Keywords : Extreme Rainfall, Extreme Value Type–I Distribution, Return Period, PMP

Water Resource Development Strategy in India – Focus on Hydropower

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Water is a precious national resource and its development forms the core for economic growth of the country. As estimated, out of 4000 BCM of average annual precipitation, only 690 BCM of surface water and 433 BCM of ground water can be categorised as utilisable. This quantum has to cater to multifarious demands of drinking water for population and animals, irrigation leading to food security, hydropower, thermal power, industrial use and maintaining and managing ecology. Inter-se priorities between various uses have been fixed with drinking water generally at the highest priority. As with most other natural resources, the temporal and spatial variation of water resources availability is a prime factor governing optimum uses of the water for a particular sector. Focused attention is provided to Hydropower in this paper.

Flagship programmes like Accelerated Irrigation Benefits Programme (AIBP) and Command area development are providing vital financial inputs to the irrigation and water management sectors. It has created 5.486 Million Hectares of irrigation potential along-with associated benefits of drinking water and industrial components. The WR projects implementation has been suffering due to land acquisition problems, delays in resolving the water sharing issues and environmental issues associated with submergence and R&R in reservoir areas.

Hydropower is a renewable and a clean source of energy. It has a high level of reliability and lower operating cost. The generation is much better suited to meet demands for peak loads. Various incentives have been provided for a speedier execution of the projects under different programs. However, the special requirements of topography and water availability for power generation restrict the hydro power development to specific areas. The hydropower can be storage based as well as run-of-the river based with each option having its own benefits and drawbacks in the context of the basin and country as a whole. Alternative development scenarios are examined before a pure cost-benefit based solution is selected.

A reassessment study completed in 1987 revealed the hydropower potential as 84,000 Mw at 60% load factor. A study of FY Plan-wise growth of Hydropower in India indicates about 37 times increase (from Ist to XIth FY Plan – up to 31.8.2010); however, its share has reduced in total power generation from 36.78% to 22.5% in this period. The Western and Southern regions in India have developed their hydropower capacity to 68.28% and 58.14% respectively, whereas, Northern, Eastern & North-Eastern regions stand at 25.80%, 27.23% and 1.91% respectively. A study of delays in capacity addition during the Xth Plan indicates that the major factors for slippage are environmental clearance / geological surprises / R&R issues followed by delay in investment decisions. The sector wise XIth Plan Hydro capacity addition programme aims at 8654 MW for Central Sector, 3482 MW for State Sector and 3491 MW for Private Sector. Various measures taken for increasing the hydro power capacity include - creation of power corporations, three stage clearance procedure, 50,000 MW initiative, development of model contract document etc.

Major policy initiatives taken for increasing the hydropower capacity include- policy liberalisation for private sector participation, Policy on Hydro Power Development - 2008, National Water Policy 2002, Electricity Act 2003, National Electricity Policy 2005, National Rehabilitation & Resettlement Policy 2007, Mega Power Projects Policy (revised). Apart from hydropower, there is a steady demand on water from thermal power, though for consumptive use. As against the hydropower, the thermal power presents a time-invariant demand for water. The demands - though smaller in quantity - occur in water short areas leading to development constraints for the power sector. Innovative solutions for reducing the demands during the lean seasons stretching for about nine months in a year are required.

The spatial variation of the water resources availability combined with the topographical and land use constraints make each site for a water development project a national asset to be viewed in an overall context of optimum development. At present, the developments are being constrained keeping a small subset of parameters in view with each stakeholder assigning the highest priority to own issues and arguing for them to the exclusion of others. An integrated basin wise approach is advocated for WRD for future demand management. Once the basin is recognised as a building block, the assemblage of the basins can interact with each other and provide a nationwide solution for the water resources availability.

Keywords : Accelerated Irrigation Benefit Program, Hydropower, Clean energy, spatial variation

Need of Integrated Water Resources Development and Management in India

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Water is a prime natural resource, a basic human need and a precious national asset. Planning, development and management of water resources need to be governed by national perspective. Water has to planned, developed, conserved and managed as such, on an integrated and environmentally sound basis, keeping in view the socio-economic aspects and needs of the States. Water resources development and management will have to be planned for a hydrological unit such as drainage basin as a whole or for a sub-basin, multi-sectorally, taking into account surface and ground water for sustainable use incorporating quantity and quality aspects as well as environmental considerations. All individual developmental projects and proposals should be formulated and considered within the framework of such an overall plan keeping in view the existing agreements / awards for a basin or a sub-basin so that the best possible combination of options can be selected and sustained. Water resource development projects should as far as possible be planned and developed as multipurpose projects.

A main goal of IWRDM at the river basin level is to achieve water security for all purposes, as well as to manage risks while responding to, and mitigating disasters. The path towards water security requires trade-offs to maintain a proper balance between meeting various sectors' needs, and establishing adaptable governance mechanisms to cope with evolving environmental, economical and social circumstances. IWRDM addresses the “three E's”: Economic efficiency, Environmental sustainability and social Equity, including poverty reduction. The three basic ”pillars” are the *enabling environment* of appropriate policies and laws, the *institutional roles* and framework, and the *management instruments* for these institutions, to apply on a daily basis. IWRDM addresses both the management of water as a resource, and the framework for provision of water services to all categories of users, and addresses both water quantity and quality.

The paper highlights the importance of IWRDM at river basin level, important conditions for role of River Basin Organizations, interstate and international sharing of waters. The paper also lists important steps India needs to take to achieve IWRDM with focus on Development and Management, Water Quality, Environment, Rehabilitation and Resettlement, Project Planning & Prioritisation, Economic & Financial management, Inter-basin water transfer, Institutional Framework, Legal aspects, International dimensions and Research & Development needs.

Views expressed in the paper are those of the authors and not necessarily of the Organisation.

Key Words : Integrated Water Resources Management, Institutional Mechanism, R&D Needs, Stakeholder Participation, Environmental and WQ Issues.

Technical Session No. 2

Water for Agriculture

Theme Speaker : Dr. Dinesh Kumar

Session Chair : Dr. D. M. More

Suggested Points for Floor Discussion:

a) How to dispel the myths? Lessons from SSP.

b) RWH, WSD has to be undertaken with lot of care, keeping their limitations in view. Suggestions?

c) Water infrastructure enables Water Transfers (within and inter-basin) to areas which otherwise can't be serviced. What methods to adopt to bring about public awareness?

d) How to ensure continued food sufficiency with cash crops for earning revenue for farmers?

e) Instances where micro WRD is carried out successfully in supplementation of mega schemes.

f) Evaluation of reform pattern of Maharashtra WRD.

Water and Agriculture in India : Many-a-Myth

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Water is important for agricultural growth and rural poverty alleviation. Since Independence, there has been a remarkable increase in water supplies for irrigation, rendered through building of large and medium surface irrigation schemes, and groundwater development. But, most of the major schemes for irrigation had been planned and implemented much before major advancements in hydro sciences were made in the world. As a consequence, the efficiency of utilization of water for irrigation has been extremely low in the country, like many other developing countries. Potential for adoption of water-saving micro irrigation systems to improve water use efficiency in agriculture appears to be quite small when compared to India's gross irrigated area.

On the other hand, as projections by scholars in the recent past suggest, demand of water in agriculture is growing due to increasing food grain needs of the growing population, and the growing preference for water intensive cash crops. In the urban and industrial sectors, the growth would be rather rapid, owing to the faster growth in urban population and rapid industrialization. By one such estimate, the total water requirement for human and animal uses, industrial production and irrigated agriculture would be 104.50M ha m in the year 2025. Comparison of water requirement and utilisable future supplies showed that, by the year 2025, the magnitude of scarcity would be 26.20M. But, the scarcity is not going to hit all regions uniformly. The naturally water-scarce regions would be hit badly, as the demand for water from agriculture, industrial and urban sector is quite high in these regions, while the renewable water resources available from within the region are low. This is compounded by the demand for water for reducing environmental water stress in the rivers of these regions. In the absence of proper legal and institutional regimes under which water rights can be allocated among the competing uses, rights may be politically contested, leading to conflicts.

The water utilities of large urban centres in India are heavily dependent on water imported from distant reservoirs. Many of these large urban areas are in naturally water-scarce regions. Urban areas being economically and politically powerful, it is very likely that they will manage the huge additional supplies required from the rural areas. This can have major implications for irrigated agriculture, especially for the economically weaker groups. Within irrigation commands, when supplies decline due to increasing reallocation of water to other sectors, the rich and influential farmers corner lion's share of the limited water and continue to enjoy as much access as when supplies were in plenty, often taking advantage of their location within the hydraulic system, depriving the less privileged poor farmers of their rights. Thus, the agriculture sector in naturally water-scarce regions would be facing severe competition for water from other sectors such as industry, urban drinking and environment.

While scarcity of water for irrigation to meet the growing needs of cereals, oil seeds and fiber for the growing population, and micro economic needs of the farming communities at the aggregate level is imminent, what magnify the problem are the remarkable variations in the demand-supply balance across regions, and competing claims made by urban domestic, manufacturing and environmental sectors. But, there were attempts to downplay the grave situation facing the country from the point of view of agricultural growth, rural development, food security and livelihoods, by strong and influential interest groups which propagate several myths. These myths cripple healthy debates on water management solutions for future. They pertain to future role of agriculture and therefore irrigation in an economy which is in transition; potential of water-surplus regions to produce surplus food for less endowed regions; potential of supplementary irrigation to enhance rain-fed yields, and rainwater harvesting to provide water for supplementary irrigation; potential of micro irrigation systems in saving water in agriculture; and feasibility of introducing water-efficient crops in naturally water-scarce regions to improve water productivity in agriculture. They are as follows: 1. In a growing economy, agriculture would require less water in future, and domestic and manufacturing sector would require more. 2. Naturally water-scarce regions of India should and can follow a soft water path to development, without depleting the precious water resources in those regions for irrigation. 3. Water-scarce regions can import cereals and other agricultural produce, which require large quantities of water to grow, from water-rich regions of the country. 4. Supplementary irrigation can enhance water productivity of rain-fed crops, remarkably. 5. Small water harvesting structures are the silver bullet for augmenting water supplies for supplementary irrigation in naturally water-scarce regions. 6. Much can be done to enhance agricultural production by focusing on new rain-fed varieties. 7. Micro irrigation systems can help expand irrigated areas significantly. 8. In water scarce regions, shift to high value crops can significantly improve agricultural water productivity and reduce irrigation water use.

Our analysis shows the following. 1. With population growth, as economy grows and per capita income rises, the pressure on land for producing more cereals, feed, fibre and oil seeds, and maintaining livelihood security would be greater. 2. The naturally water-scarce regions are agriculturally more prosperous than water-abundant regions, and engage larger number of people in agriculture, and therefore cannot move people out of agriculture. 3. Water-rich regions are food deficit regions and won't be able to produce surplus for water-scarce regions because of inadequate arable land. 4. Supplementary irrigation to enhance crop water productivity is neither physically feasible nor economically viable in rain-fed areas where productivity is really low. 5. Water harvesting for supplementary irrigation is neither hydrologically viable nor economically sound proposition in naturally water-scarce regions. 6. The extent to which rain-fed crops can contribute to agricultural output and surplus at the basin and regional scale would be extremely limited and major growth in agricultural outputs and wealth would continue to come from irrigated areas. 7. There are major constraints in expanding area under MI systems in India, induced by physical and socio-economic factors. 8. Finally, there are major constraints to improve water productivity in agriculture and reducing irrigation water withdrawals in water-scarce regions, induced by concerns of food security, farming system resilience, and labour absorption in agriculture.

These inferences suggest that surface irrigation development in naturally water-scarce regions would be crucial for enhancing agricultural production in the country for meeting the various needs of the growing population. But, renewable water resources in these naturally water-scarce regions are far less than the demand from agriculture and vice versa, and that water resources in the naturally water-scarce regions are already “over-appropriated”. Hence, unlike in the past, such irrigation development can come through inter-basin transfer of water resources from water-rich regions to water-scarce regions. Studies indicate that higher economic value would be realized through such transfers. In addition, as analysis of global data suggests, water security can drive human development and economic growth, and the same can come from increased storage in hot arid and semi arid regions. But, such water transfers face political, financial, environmental, ecological, engineering and scientific issues. The most important issue is political in nature, and has its genesis in the lack of strong legal and institutional regime for inter-state transfer of water from water-rich basins. The institutional regimes such as the inter-state water disputes tribunals are sufficient only for allocation of water of trans-boundary river basins. The current legal regime with regard to utilization of water resources within the administrative jurisdiction of states, which have abundant water resources, will have to change for them to be under the purview of national laws. This would enable speedy decisions for development and utilization of these water resources.

Keywords : Rural Poverty Alleviation, Population Growth, Economy, Supplementary Irrigation, Micro Irrigation, Water scares regions.

Irrigated Agriculture Through Sardar Sarovar

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The Sardar Sarovar (Narmada) Project in Gujarat having +138.68 m (+455 ft) high dam, +91.44 m (+300 ft) FSL main canal of 1133 m3/s (40,000 ft3/s) capacity and 1450 MW hydropower installations is in an advanced stage of completion. It is implemented as a Joint Project of Madhya Pradesh, Maharashtra, Rajasthan and Gujarat. Hydropower at Sardar Sarovar is shared by Madhya Pradesh, Maharashtra and Gujarat and water resources of Narmada Basin are apportioned among Madhya Pradesh, Maharashtra, Rajasthan and Gujarat. The dam is raised upto crest of the spillway at + 121.92 m (+400 feet) and river bed and canal head power stations are completed and are in operation for generation of power. The main canal 458 km long is completed and is operated for supplying water for irrigation and / or domestic and industrial uses in Rajasthan and Gujarat. Extensive works of construction of branch canals, distributaries and minors have been done in Rajasthan and Gujarat. Construction of sub minors and field channels has made good progress and has peaked up in Gujarat now so as to complete command area development in 2015. The objective of supplying drinking water in vast drought prone areas in Gujarat is fully realised by the project. The command area of 4,46,000/- ha in phase - I between Narmada and Mahi rivers has been largely developed and that of 13,99,000 ha in phase - II is now progressing well.

The Sardar Sarovar receives funds under **Accelerated Irrigation Benefit Programme** of Government of India for command area development. The National Remote Sensing Agency has using 2.5 m resolution Cartosat Satellite Data assessed that 3,92,000 ha in phase-I and 2,67,430 ha in phase - II are irrigated in the command area. The Bhaskaracharya Institute for Space Application and Geo-informatics (BISAG), Government of Gujarat has using IRS satellite data also assessed that an area of 3,14,000 ha in phase-I is irrigated in the command area. BISAG has suggested use of Global Information System and Remote Sensing to study drainage aspects of the command area and a pilot study in phase - I representing one irrigation block of 5-8 thousand ha is proposed to be taken up by the project. Micro irrigation systems based on micro-tube drip and sprinkler technology are proposed for use at 6-8 ha sub chak level in the command area. The use of ground water is focussed objective of the project and it is estimated that 2.71 maf of useable ground water would be available for developing conjunctive use.

There are several issues raised against Sardar Sarovar. The field work done by Desai Vaidy Prerana, Sneh-Setu Foundation, 2010 has demonstrated that in Tilakwada and Naswadi Talukas having predominant tribal population 80 percent of farmers are availing irrigation benefits and are growing more than one crop in a year. In his book Managing Water In River Basin 2010, M. Dineshkumar has shown that there has not been any significant change in the rainfall over the years in the Narmada Basin. Therefore there is no basis for claiming that water available from Narmada is decreasing over years. The Government of Gujarat has revised cost estimates of Sardar Sarovar at 2008-09 price level for ₹ 39,240 crores and benefit cost ratio of 1.63 is worked out in Central Water Commission. The Planning Commission has given further investment clearance in May-2010. Economic viability of the project is, therefore, fully established even in its completion phase.

Keywords : Sardar Sarovar Project, Hydropower, GIS, Remote Sensing, drought prone areas

Land Drainage Technology For Increasing Land and Crop Productivity

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In India, large scale canal irrigation schemes are in operation since more than a century. Today, India has the world's largest irrigated area (61 million ha). The irrigation development has been widely acknowledged to have helped the country not only to achieve a food self sufficiency but also become an exporter of agricultural produce in recent times. However, as the irrigated area was expanding, menace of waterlogging and salinity also slowly developed not only in the canal commands but also in some lift irrigation schemes all across the country. This twin problem adversely affects the crop and land productivity severely affecting the livelihoods especially of small and marginal farmers, besides causing other environmental distress. Presently, some 4.5 million ha are waterlogged with varying degree and 6.73 million ha are salt affected in irrigated areas. In general, land drainage has not been given adequate attention and equal focus as that of expansion of irrigation infrastructure. Drainage provisions were generally deferred or postponed in many cases due to paucity of funds in the initial stages and thus were left to be taken up subsequently or were taken as a curative measure.

Conventionally, land drainage was defined as the removal of excess surface and sub-surface water from the land including the removal of excess soluble salts, to enhance crop growth. However, as per the recent integrated approach, drainage is defined as 'land and water management through the processes of removing excess surface water and managing shallow water tables – by retaining and removing water – to achieve an optimal mix of economic and social benefits while safeguarding key ecological functions'. In India, the waterlogging and salinity of agricultural lands are caused both due to natural causes and/or due to human interventions. Vast flat lands in north-western part of India, despite low annual rainfall get waterlogged due to lack of natural drainage outlet. Inadequate water regulating and control structures, improper canal operation schedule and water distribution system, traditional water application methods, negligible maintenance of the drainage network, among others have been adding to this twin problem.

Owing to varied agro-climatic, physiographic and socio-economic situation in the country, the drainage issues and consequent measures also vary widely. Beside conventional drainage systems like surface and sub-surface drainage, some site specific non-conventional drainage systems like vertical/chimney drainage, and bio-drainage systems have been found useful. Despite availability of the modern land drainage technology and the scientific knowhow about various preventive and curative measures; due to lack of investment, neglect by policy makers, and institutional constraints, the speed of the land reclamation/ drainage provisions has been very low and lags the requirement significantly. Currently, only about 12% of the affected area has been provided with drainage measures. This paper provides a brief review of the historic developments in land drainage, some examples of major reclamation/ drainage works, and attempts to address the key issues in implementation and up-scaling of the drainage technology in India. It is argued that with an investment of about ₹ 5000 crores, 1 million hectares of ill-drained farm land can be reclaimed using latest drainage technology, which in turn will produce at least an additional 1 million tons of food grain per year from the same land. Thus the investment cost of the drainage provisions can be recovered within a period of 5-6 years, besides resulting into other positive environmental impacts.

Keywords : Waterlogging, salinity, drainage provisions, subsurface drainage system, command area.

An Overview of Rainfed Farming in Maharashtra

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The rainfed farming occupies 82% of the total cultivated area in Maharashtra. The yields of crops under rainfed conditions are much lower than the irrigated crops both in the state and and the Country. The problems facing rainfed farming fall under three categories i.e. avoidable but unmanageable, unavoidable but manageable and unavoidable and unmanageable. Drought and heavy rainfall are unavoidable but can be managed with use of certain technological options available now. The variations in rainfall from year to year, pose severe problems of either severe moisture stress or excess soil moisture. Most of the area falls under sub-humid and semi-arid climatic situations. The moisture stress management is faced even in high rainfall areas such as Sakoli and Igatpuri as the crop grown is rice which faces moisture deficit, during late period of growing season. The paper includes discussions, remedies, technology transfer, adoption by farmers and policy decisions. The reader's attention is focused on options such as rainwater planning for dry spells, late advent of monsoon, prolonged rainy season along with excessive rainfall, appropriate tillage, timely operation like sowing, integrated nutrient management, watershed development, provision for life saving irrigation, development of farm ponds, use of micro irrigation, mulching, stress tolerant varieties development and use thereof.

In addition, the paper indicates that there is a great need to carryout research in bio-technology for suitable varieties of several crops. Climate change also demands appropriate research so that the problems arising could be faced with technology adoption to overcome the adverse effects of high temperature and harvest increased carbon-dioxide.

Keywords : Rain Fed Farming, Variation in rain fall, water shed development, integrated nutrient management, micro irrigation, bio-technology

Overview of Development and Reforms in Water Resources Sector in Maharashtra

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Maharashtra is one of the largest states in India. About 75% of its area is culturable. In spite of good rainfall in monsoon, different water sectors like agriculture, water supply, industries, etc are not getting water as per their requirement, because the water received is not evenly distributed over time and space. Large investment by the Government of Maharashtra (GoM) in construction of water storage projects since its formation has increased irrigation potential from 0.386 million ha to 5.846 million ha and no. of storages created are fulfilling agricultural, domestic and industrial needs to a greater extent. However, there is still large area facing drought situation and drinking water problem and some parts experiencing floods every year. In some parts, the ground water level is going deeper due to over exploitation, where as some part is facing problem of water logging and salinity. This diverse situation is because of lack of integrated water resource management. Due to increase in population and speedy industrialization, demand of water is increasing manifold, creating several challenges. Some of these are: a) large gap in potential created and utilized, b) conflict between different water sectors and water users, c) poor quality service delivery, d) lack of integrated water management and, e) pollution of water bodies.

Maharashtra has already adopted many reforms. They include, a) Maharashtra state water policy (MSWP), b) water pricing, c) enactment of Maharashtra Water Resources Regulatory Act 2005 and Maharashtra Management of Irrigation System by Farmers Act 2005, d) benchmarking and water auditing of irrigation projects and publishing annual reports, e) restructuring of Water Resources Department. The reforms under process include, a) preparation of integrated water resources management plan for each basin and consolidated state water plan b) Ground Water Act. Reforms adopted so far are showing general acceptance and good results. These reforms along with those coming up hopefully will reduce the intensity of challenges faced by the water sector in the state.

Keywords : conflict, challenges, reforms, entitlement, integrated.

Sugarcane - Potato Inter-cropping for Sustainable Use of Water Resources

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Sugarcane, a long duration and wide spaced crop, occupies the field for 12-18 months, depending upon the planting season (pre- seasonal- Autumn: October-November, seasonal: January- February, adsali: July-August).The planting is done in furrows .First irrigation is given at planting ,second 4-5 days later and subsequently the crop is irrigated about every three weeks. The shoots start emerging 15-20 days after planting and continue to emerge for 3 weeks more. For the initial twelve weeks, the crop growth is slow.

Potato, on the other hand, is a short duration (about three months), fast growing, and cold weather crop mainly grown from Oct-Nov to Jan-February, in most parts of India. It is planted in ridges. First irrigation is given at planting, second 4-5 days later and subsequently, every 10-12 days interval. Shoot emergence is complete in about two weeks. Potato is world's fourth largest food crop following rice, wheat and maize. It fits well as an intercrop in pre-seasonal sugarcane because of common planting times and complementary cultivation requirements of the two crops. Both the crops grow well in medium to heavy fertile well drained soils, having pH from 6.0 to 8.5.

Various experiments were conducted by the author at Marathwada Agricultural University, Parbhani to identify appropriate modification favouring logistic management of intercropping system. A viable technology of intercropping of potato without any adverse effect on the yield of sugarcane has been developed in which the field operation of making furrows for sugarcane has been synchronized with initial ridging of potatoes and that of initial earthing of sugarcane with the harvesting of Intercrop. On an average sugarcane and potato yielded 142.20 and 19.08 tons/ha respectively, with respective costs of cultivation as ₹ 11400 and ₹ 8300/ha, respective net returns being ₹ 15630 and ₹ 10780/ha.Thus, timely extra income from intercropping potato (₹ 10780) helps the farmer to meet the cost of cultivation of sugarcane for the whole season (₹ 11400).This technology was recommended for adoption by the cultivators in Maharashtra, during 1984.

Most economical and efficient use of water, of inter-row space and of sunlight is assured by the simultaneous cultivation of two crops. Only four extra irrigations are required for potato in this intercropping system. Moreover, once potato crop canopy covers the ridges, water evaporation losses from soil are minimized resulting in reduced irrigation water requirement, and biological weed control is assured after initial weeding of intercropped field. Thus cropping system fits well with present irrigation network. A large number of field demonstrations and programs were carried out in various districts of Maharashtra over a period of 25 years, since the release of this technology. Selection of well drained soils and timely planting(last week of October to third week of November)and proper management practices, resulted in potato yield levels of 15-20 tons/ha.

A number of sugarcane growing states, including Maharashtra, where there is great potential for cultivation of potato, could become self sufficient in potatoes, if about 10-15% cane area is brought under this intercropping system. In spite of all the advantages in favour of this technology, there are still two limitations to the success of potato cultivation in a number of nontraditional potato growing states: 1) timely acquisition of potato seed 2) storage and marketing of perishable produce after harvest, when ambient temperatures rise fast.

Brazil, India, China. Thailand, Pakistan, Mexico, Colombia, Australia, Argentina and United states are the top ten producers of sugarcane in the world (2008).In most of these countries, particularly Asian ones, where climatic conditions are favorable at planting sugarcane and potato, the technology can very well be adopted in toto or with some modifications assuring sustainable food production in the countries concerned.

Keywords : Intercropping, Economics of Water Use, Seed acquisition, Perishable Products

Technical Session No. 3

Water for Energy

Theme Speaker : Dr. B. S. K. Naidu

Session Chair : M. D. Pendse

Suggested Points for Discussion in Convention :

a) Scope for PSS. Evaluation of existing schemes. Public awareness about 'Renewable' nature of all HP schemes. Problems of Himalayan schemes. Co-ordination of multi-agency (private) basin schemes.

b) Integration of HP generation and irrigation or other requirements. Tidal projects- prospects.

c) Case studies for Carbon credits for HP schemes. Ranking of new HP projects.

d) Methane emissions and Reservoirs. Trials with application of Sustainability Protocol of IHA.

e) Scope for dam-foot power houses in existing dams.

Hydropower and Its Importance - Some Basic Issues

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Introductory – Water and Power: Massive gravitating influx of surface water unleashed by the hydrological cycle has enormous potential for energy generation, particularly in a monsoon blessed country like India. Every drop of circulating water above mean sea level has potential energy inherent in it by virtue of its position. The energy of waterways can be converted into useful "kilowatts" to energize the nation.

Hydro Power – Perpetual Source of Energy: Hydropower represents non-consumptive, non-radioactive, non-polluting use of water resources towards inflation-free, highest density renewable energy development with most mature technology, highest prime moving efficiency, spectacular operational flexibility and diverse incidental benefits. However, resource mix in the world's commercial energy supply today is intriguingly dominated by "Fossil Fuels & Nuclear Sources" to an extent of 90% and remaining 10% only by the perennial "Hydro & New renewables" With the present rate of consumption, world is left with only 200 years of coal & 100 years of nuclear resources and only 25 and 50 years of oil and gas respectively; while conventional Hydro & other new renewables like small hydro, wind and solar are perpetual sources of energy, deserving attention not only as long term-sustainable options but also as ecologically favorable choice with negligible carbon foot prints.

Indian Scenario - India's annual rainfall is of the order of 400 million ha.m., 90% of which comes down in just 30 days, unless patterns are changed by climate shifts. The country therefore has to store water for its regulated releases throughout the year for irrigation, drinking and other purposes. India has therefore constructed more than 4000 dams across the major rivers, implying a mega potential for hydro power incidental to release of water downstream. India has one of the largest irrigation canal networks in the world containing small hydro potential for distributed generation which can be fed through the smart grids to the remotest areas.

Small Hydro Power (SHP) Schemes – Innovative and simplified: While designing SHP schemes, one has to bear in mind that Small Hydro is just not a mere miniaturization of Large Hydro but is an innovative exercise of technology packaging of simplified systems for cost effectiveness. While losing on economy of scale, if enough care is not taken to gain on costs of simplified technologies, we would not be able to optimize the systems on techno-economics.

Importance of Proper Hydro Thermal Mix: India's power sector seems to have lost its sense of proportion down the line. From a Hydro:Thermal mix of 45:55 during the late sixties, it has today landed to a mind-boggling proportion of 25:75. Had we managed it at just the reverse proportion of 75:25, the average cost of generation of this country would have been Rs 2/unit against Rs 3.5/unit today and there would have been no peaking shortage under the same MWs installed, under the same investment.

Impact of Hydro Power on Economy and Environment: Water and energy nexus has significant impact on economy and environment in India. Hydropower accounts for 1/4th of power capacity and contributes to 1/7th of energy output in the country. Water is an essential input for generation of thermal and nuclear power. About 1/3rd of total electricity is used for pumping groundwater for irrigation as well as for domestic water supply in urban and rural areas. There are substantial synergy benefits from the use of water for hydro power that, in turn, is used for pumping water for irrigation. In the case of the multipurpose Bhakra dam system, the total (discounted) benefits from canal irrigation and hydro power together are almost three times the sum of separate benefits from canal irrigation and hydroelectricity. The water sector is becoming more energy-intensive for pumping deeper groundwater, large-scale (inter-basin) water transfers and desalination etc. On the other hand, the energy sector is becoming more water-intensive. We need to increase the efficiency of water use hand in hand with energy efficiency.

Water is an important element of environment matrix. A proper management of water within the ecosystem is an art to be understood and practiced in this dwindling era of resources. The non-consumptive use of water in the hydro sector with marginal interceptions within the hydrological cycle in drawing useful energy from it for the mankind is an environment friendly science to be continually developed. Positive environmental impacts of Hydro projects like moderating ambience temperature, stabilization of ground water table and flood control in the command area etc. need to be quantified and matrixed as an important input to EIA instead of taking them for granted and scaling only negative impacts like submergence. Internalizing environmental concerns in a balanced manner during planning & design of the schemes hold the key to sustainable development.

Storage of Power- Pumped Storage Schemes: Hydro is renewable energy that can be stored- needed to back highly intermittent wind and solar power for instance. Norway for example, wants to become a peak power supplier/ battery to the European Continent. Being 100% Hydro, it wants to provide 50 % of storage capacity in Europe for peaking support and Hydro is back on their agenda again!! Himachal Pradesh can become that kind of model for the Indian sub-continent. All that is needed is extra reservoir capacities and addition of reversible pump-turbines. World is yet to see a better electrical storage system than a Pumped-Storage, which actually stores surplus power during off-peak hours in the form of Hydro potential by pumping water from lower reservoir to upper reservoir and turbines it back into the system in fraction of a minute on demand during peaking.

Need for Constant Upgrading of Designs and Uprating of Plants as also Performance Audit for Better Efficiency: Hydro schemes are susceptible to silting problems of staggering dimensions particularly in monsoon governed tropical countries like India where hard summer cracks the soil and the flooding waters of monsoon carry the eroding soil to the streams. Though hydro projects do not cause siltation, they are victims of the same. Siltation, in fact, is an encroachment on Hydro. Though around 10% of existing hydro power stations in India suffer from acute silt erosion problems, they are wide spread. Silt consciousness has to be generated in the minds of hydropower engineers to be cautious during investigations, planning, design and operations to handle silt laden flows of varying degree of silt concentration and their variable characteristics. Hydro plants after serving for 15 years or so become potential candidates for uprating and refurbishment with the growing material technologies and innovations in hydrodynamics and power electronics. From the same turbine space 15-20% higher outputs can be produced making them superior peaking partners. A thorough plant audit, field investigations including signature analysis of generating machines in conjunction with design studies for upgrading of Hydro Power Plant, is required to be done with clinical precision that such power plants deserve. India had prepared a National master plan for the first time in the world.

Keywords : Hydropower, Renewable Energy, SHP, Hydro Thermal Mix, PSS, Design Up-gradation.

Managing the Wealth and Woes of the River Brahmaputra

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Our understanding about the North-eastern region of India and even its neighbourhood cannot be complete unless we have the correct understanding about the river Brahmaputra. It's basin is shared by four countries, namely India (33.6.%), China (50.5%), Bangladesh (8.1%) and Bhutan (7.8%). In China, it is called as Yarlong Tsangpo. After several tributaries (from Arunachal Pradesh) like Lohit, Debang, Siang, etc. join the Tsangpo it is called Brahmputra. The river meets another giant river system namely Ganga and a smaller one namely Meghana in Bangladesh before debouching into the Bay of Bengal. Brahmaputra river has immense Water Resources potential (586 BCM out of 1860 BCM for the entire country) to bring wealth and prosperity to the people of the region, but presently as it remains under-developed, is more a cause for woes than blessings. The Author attempts in this article to bring out as to how the wealth needs to be utilised, shared with other water-deficit basins of the country and the woes / threats converted into opportunities through judicious actions.

Important facets of the WR use in the basin are: flood and sediment management, jhoom cultivation & irrigation, hydropower development, fisheries, navigation, etc. The paper synoptically covers these issues and brings out how they are being dealt with today and what is in store for future. An extremely dominant monsoon rainfall regime interacting with a unique physiographic setting, fragile geological base, active seismo-tectonic set-up together with anthropogenic impacts on eco-system makes the Brahmaputra river basin one of the world's most intriguing and gigantic fluvial system. The article outlines the different dimensions of this river basin that have influenced / and can profoundly alter the lives of the people in the region for better than ever.

Key Words : Brahmaputra, Facets of WR, Seismo-Tectonic set up, Eco System.

Tidal Power : Central Board of Irrigation and Power

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Introduction : Tidal power, also called tidal energy, is a form of hydropower that converts the energy of tides into electricity or other useful forms of power. The tide moves a huge amount of water and harnessing it could provide a great deal of energy. Now that the world is going back to nature as far as the energy needs are concerned, it is pertinent to mention here that if less than 0.1%of the renewable energy available within the oceans could be converted into electricity, it would satisfy the existing global demand several times over. The vastness of this resource, if realized, can bring benign energy systems into a less polluted human development effort. Innovations and improvements in technology have been and will continue to expand this process in the next few decades. Although the energy supply is reliable and plentiful, converting it into useful electrical power is not easy. Tidal energy is extremely site specific and requires mean tidal differences greater than 4 m and also favourable topographical conditions, such as estuaries or certain types of bays in order to bring down costs of dams etc. The only cost which needs to be incurred is the huge initial infrastructural investment required for building the tidal energy plant and the plant runs with almost negligible maintenance costs and the plant life is usually 35 years.

Categories : Tidal power can be classified into three main types: viz. Tidal stream systems make use of the kinetic energy of moving water to power turbines, in a similar way to windmills that use moving air. This method is gaining in popularity because of the lower cost and lower ecological impact compared to barrages. Barrages make use of the potential energy in the difference in height (or head) between high and low tides. Barrages are essentially dams across the full width of a tidal estuary, and suffer from very high civil infrastructure costs, a worldwide shortage of viable sites, and environmental issues. Dynamic tidal power exploiting a combination of potential and kinetic energy: by constructing long dams of 30–50 km in length from the coast straight out into the sea or ocean, without enclosing an area.

Tidal Power Potential – World Scenario : Covering more than 70% of the Earth's surface, the ocean is the world's largest untapped, renewable energy resource. It produces both mechanical energy from its tides and waves and thermal energy from the sun's heat. As new technologies are developed, ocean resources will be able to meet many of the world's energy needs. Although not yet widely used, tidal power has potential for future electricity generation. Tides are more predictable than wind energy and solar power. Tides and marine currents are 832 times denser than the air flowing over wind turbines and are predictable up to the minute at least 100 years in advance. Ocean energies are guaranteed to deliver high output indefinitely. Among sources of renewable energy, tidal power has traditionally suffered from relatively high cost and limited availability of sites with sufficiently high tidal ranges or flow velocities, thus constricting its total availability. However, many recent technological developments and improvements, both in design (e.g. dynamic tidal power, tidal lagoons) and turbine technology (e.g. new axial turbines, crossflow turbines), are suggesting that the total availability of tidal power may be much higher than previously assumed, and that economic and environmental costs may be brought down to competitive levels.

Tidal Power Potential in India : Since India is surrounded by sea on three sides, its potential to harness tidal energy has been recognized by the Government of India. Ministry of New and Renewable Energy (MNRE) have also listed Tidal Energy as one of new technology programme with the objective to study the potential of tidal energy in the country and to harness it for power generation. The potential sites for tidal power development have already been located. The identified economic tidal power potential in India is of the order of 8000-9000 MW with about 7000 MW in the Gulf of Cambay in Gujarat, about 1200 MW in the Gulf of Kachchh in Gujarat and less than 100 MW in Delta of the Ganga in the Sunderbans region in West Bengal. The most attractive locations are the Gulf of Cambay and the Gulf of Kachchh on the west coast where the maximum tidal range is 11 m and 8 m with average tidal range of 6.77 m and 5.23 m, respectively. The Ganges Delta in the Sunderbans in West Bengal also has good locations for small scale tidal power development. The maximum tidal range in Sunderbans is approximately 5 m with an average tidal range of 2.97 m. The Kachchh Tidal Power Project with an installed capacity of about 900 MW is estimated to cost about ₹ 1460/- Crore with cost of generating electricity at about 90 paise per unit. Government of West Bengal is making special efforts to harness tidal energy by developing its first tidal power project in Sundarbans.

Principle behind generation of power through tides: Because the Earth's tides are caused by the tidal forces due to gravitational interaction with the Moon and Sun, and the Earth's rotation, tidal power is practically inexhaustible and classified as a renewable energy source. A tidal generator uses this phenomenon to generate electricity. The stronger the tide, either in water level height or tidal current velocities, the greater the potential for tidal electricity generation. Tidal power schemes do not produce energy all the 24 hours a day. A conventional design would produce 6 to 12 hours in a day. Since the tidal cycle is based on the period of revolution of the Moon, while the demand for electricity is based on period of revolution of the Sun, the energy production cycle will not always be in phase with the demand cycle.

Types of Tidal Stream Generators: Since tidal stream generators are an immature technology, no standard technology has yet emerged as the clear winner, but large varieties of designs are being experimented with, some very close to large scale deployment. Several prototypes have shown promise with many companies making bold claims, some of which are yet to be independently verified, but they have not operated commercially for extended periods to establish performances and rates of return on investments. The schemes are categarised in different types viz. barrage power stations, ebb generation schemes, schemes generating, tidal power during floods, dual basin type schemes, lagoon power stations. These stations are classified as per the pattern of generation and layouts of the power stations. At present different types of tidal power schemes are operating in France, United Kingdom, Northern Ireland, Korea, China and USA.

Environmental Impacts and other advantages of tidal power stations: Long-term research on environmental impact of tidal power stations does not exist at present. However, studies are being done to assess the effects of these power stations on Hydrology, salinity, turbidity, movement of fish and movement of sediments etc. The main advantages of tidal power are that it is environment friendly, renewable and almost perpetual. It is however, somewhat costly at present due to initial high investment cost. It is still considered to be a source of alternative renewable energy for 21st Century.

Keywords : Tidal Energy, World Scenario, Tidal Stream Generators, Environmental Impacts, Lagoon Power Stations.

Hydropower Scenario of Maharashtra – Present & Future

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At the time of creation of the state of Maharashtra in 1960, the first five year plan was about to complete and the installed capacity of power generation was 828 MW. Out of that hydropower and thermal power was 289 MW and 538 MW respectively. By the end of 10^{th} five year plan installed capacity was 16392 MW. Today, as on September 2010, total installed capacity is 17829 MW. Over the years the thermal capacity has raised to 10654 MW and hydropower capacity has risen to only 3545 MW. The gas based power generation is 2916 MW and Nuclear is 692 MW. Thus the share of base load thermal power is 80% and Hydropower is 20%. The Hydro-thermal ratio has thus changed. Therefore to stabilize the frequency hydropower installed capacity needs to be enhanced, to the accepted ratio of base load to peaking hydro capacity of 60:40.

The sector wise contribution shows Maharashtra State Electricity Generation Company (MAHAGENCO) Water Resources Department (WRD), and private sector generates 10772 MW (61%) while National Thermal Power Company (NTPC) and Nuclear Power Company Limited (NPCL) produce 2495 MW(14%), TATA and Reliance generates 2527 MW(14%), gas based Dabhol power plant generates (8%) and Tarapur Nuclear power station generates 555 MW (3%). The region wise installed capacity of hydro shows that Pune region is on top with 1764 MW (50%) while Konkan region is having only 484 MW (14%) capacity. Attention shall have to be given to the Konkan region to enhance the capacity. This region is having abundant water resources, which should be systematically identified, planned and exploited to its fullest extent.

This paper deals with present status of hydropower in Maharashtra and its policy of privatization. The water required for energy and its availability is also discussed considering completed, ongoing and future identified projects in the state. It also deals with the need for systematic and balanced long term planning in power sector with particular reference to hydropower for which at present, unfortunately there is almost absence of such planning. The paper highlights the policy changes required and the role of scientists and technologists in resolving the challenges in developing the hydropower sector.

Keywords : Maharashtra State, Government of Maharashtra (GOM), Peaking Hydropower, Seasonal Hydropower, Small Hydro Projects (SHP), Pumped Storage Schemes (PSS), Long Term Planning, Policy Changes

Hydropower Projects On Bouldery Rivers With Steep Gradient

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The approach to planning and design of diversion structures (15-25 m in height) for Hydro-electric Power generation in upper bouldery (D50 from 10 to 30 cm) narrow section reaches of Himalayan rivers having steep gradient (up to 1:50) and deep pervious foundation is quite different from those on lower reaches of rivers with finer river material (D_{50} ranging from 0.2 mm to 2 mm). Majority of Hydropower sites to be developed are concentrated in five Himalayan States - J&K, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh where such conditions are prevalent. There are various issues that are yet to be resolved and as such the existing guidelines by Bureau of Indian Standards for design of weirs and barrages are found inadequate. The bouldery reach is characterized by supercritical flow. The current IS codes on 'Guidelines for Hydraulic Design of Barrages and Weirs: Part - I, Alluvial reaches' (IS : 6966 - Part I, 1989) and other related codes (IS : 7720 - 1991, IS: 7349 - 1989) are applicable for rivers with fine and medium size sediments. A new code IS: 6966 - Part II for bouldery reaches is under preparation based on experiences gathered so far. The paper brings them out with the help of some recent case studies.

Major considerations in the hydraulic design of a barrage include: a) Length and Thickness of Impervious Floor, b) Raised Crest vis-a-vis Crest at River Bed Level, c) Energy Dissipation Arrangement, d) Downstream cutoff for Protection against Scour, e) Downstream Protection Works and f) Flushing of sediments from reservoir.

Length and Thickness of Impervious Floor

Khosla's theory is not exactly applicable to bouldery rivers. The designer has to endeavour to reduce the sub surface flow and consequently the uplift pressure on the impervious floor. The loss of head of the seeping water depends upon the upstream depth of cutoff, gradation of soil and nature of valley. Due to the coarse gradation, it is found that there is more head loss, less sub-surface flow of water and apparently less uplift on the impervious floor.

Crest at River Bed Level

A raised crest is not considered desirable as it causes accumulation of stones, cobbles, gravels etc, in turn needing higher crest elevation for power intake resulting in higher MDDL and FRL. The crest gates are therefore provided at river bed level. This helps drawdown flushing of sediments. It also helps keep the power intake area free from sediments.

Energy Dissipation Arrangement (EDA)

Rivers with finer bed material undergo deep scour downstream if EDA is incomplete. Usually hydraulic jump type stilling basins are provided which are found inadequate. Various alternatives for bouldery reaches now available are described. A diversion structure with the downstream floor closely matching with the general river bed level often serves the purpose.

Downstream cut-off for Protection against Scour

Lacey's scour depth computations are not applicable. As scour depth is far less due to armouring effect of large sized boulders, a downstream cutoff of 8 m to 10 m is found adequate with an extra cut-off of 5 m to 7 m depth at the downstream end of the protective concrete apron.

Downstream Protection Works

Instead of the conventional interconnected concrete blocks of size 5m x 5m x 2m laid over filter downstream of cutoff after the stilling basin, a single monolith 20 m concrete apron with single slope floor from upstream to downstream is found suitable. It needs 20 cm size pressure relief holes, 2m centre to centre both ways. Beyond the block protection, loose large up to 1 m in size protection of boulders is useful.

The author advocates extensive hydraulic research to fine tune these adaptations for standardisation.

Keywords : Hydropower, design considerations, EDA, Downstream Cutoff protection.

Technical Session No. 4

Water for Drinking, Domestic & Industrial Use

Theme Speaker : Dr. S. R. Shukla

Session Chair : Dr. A. D. Patwardhan

Suggested Points for Floor Discussion :

a) Myths about India's urban water management as pointed by Prof Biswas.

b) Ways to achieve full treatment / recycling of urban / industrial waste water.

c) Is 24x7 supply a solution to bring about equity in urban W/S?

d) How to bring about PURA in India? Can we not stop use of rivers / streams for individual village W/S schemes? Permit only organized regional W/S schemes. How and when will we achieve stop to open defecation?

e) How to achieve equity in W/S within urban areas?

An Invited Contribution

Dr. Asit K. Biswas
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More than six decades after independence, India's urban water quality is worse than before. Admittedly, the population has grown tremendously. Equally, agricultural and industrial activities and the levels of urbanization were not issues to consider. However, even though population of the country is well over one billion at present, and industrial activities and urbanization have increased very significantly during the post-independent period, the country's economic development has also accelerated substantially, as also have its knowledge, experience and technology. At present, there is absolutely not a single good reason as to why the urban population of India cannot have access to clean water which can be drunk without treatment from the taps, wastewater cannot be properly treated before being discharged to the rivers, and monsoon rains cannot be promptly drained so transportation systems are not paralyzed. The problems have been known for centuries, solutions have been known for at least five decades, and financial and management needs can be successfully met. Yet, the problems continue to persist. Analysis of the current situations and trends indicate that there is no realistic possibility that the problems will be solved during the next 30 years in any meaningful way for the most of urban India. The question thus arises why it has not been possible for India to solve its urban water problems.

Let us first consider some myths which are often used as excuses for the status quo. The first myth, confirms Benjamin Disraeli's wisdom: “There are three kinds of lies: lies, damned lies, and statistics”. This is very appropriate for the urban water sector of India! The problem is effectively hidden under the statistical fog! According to the latest report (2010) of WHO and UNICEF, as well as those of the Government of India, 98 percent of urban India has access to “improved sources of water”. If one believes that “improved sources” means drinkable water without any adverse health impacts, which most of the world interprets it to mean, they could not be more mistaken! The real fact is that “improved sources” have no linkage to quality. The water quality of an urban centre may have declined very significantly, as has been the case for many of India towns and cities, but officially they are considered “improved sources”! When I proposed the International Drinking Water Supply and Sanitation Decade IDWSSD to the Secretary General of the UN Water Conference, in early 1976, our thinking was unambiguous. The view of access to clean water meant that everyone will have clean drinking water which is safe to drink without any health hazard. This simple definition now means that as long as people have access to water, no matter what is its quality, it is an “improved source”. The main issues should be availability of adequate quantum of water per person, of right quality, and with easy access.

The second myth is there is not enough water to assure 24-hour supply. Take any large Indian city. The unaccounted for water is usually over 50% (mostly between 40-60 percent of supply). Even then, most inhabitants of these cities use more than twice the average daily consumption of any citizen of Hamburg, Munich or Rotterdam, and people are told that there is not enough water to assure a continuous 24/7 safe water supply! Water is almost free in nearly all India cities. Ask anyone what is their electricity bill, they would know the actual amount. Ask the same person, what is their water bill, they mostly have not a clue! Yet, while municipalities provide almost free water, the coping costs of the Indian householders is quite high and significant. In fact, nearly all the households in urban India have become mini-utilities. When water comes for a few hours a day, it is stored in underground tanks. It is then pumped to an overhead tank from where it is withdrawn for a 24-hour supply. Each household has its own treatment system, often provided by the private sector companies like Aqua-guard, before it is drunk. The coping costs for poor and ineffective water supply means that each household now pays for electricity costs for pumping water regularly during the day, operation and maintenance costs to the private sector for the treatment system so that water can be drunk, and cleaning of both underground and overhead systems every two to three months. Thus, the cost of using municipal water is quite high to each household, even though supply is basically free from the municipalities.

The third myth is that 75 percent of the urban residents have “improved” or shared sanitation. When I proposed the idea of the IDWSSD, sanitation meant that wastewater would be collected from the cities, taken to a wastewater treatment plant, treated properly and then discharged safely to the environment. This objective has also been corrupted with the catch-all term “improved”. Cities like Delhi discharges its untreated, or very partially treated, wastewaters directly to Yamuna River and Ahmedabad to the Sabarmati River and both claim that they are doing well with sanitation! Last time I visited Ahmedabad, its primary treatment plant was not even working and raw sewage was being discharged straight to the river. One could smell the stink from a distance of 1 km from the sewage outfall to the river, and I was informed that the even primary treatment plant was not working for years. One wonders what the State and Central Pollution Control Board are doing. Sadly, the present situation for a country like India is difficult to justify. If we consider a city like Phnom Penh, Cambodia, in 1993, it was even in a worse situation compared to what are now in Delhi, Kolkata or Mumbai. The unaccountable water loss in Phnom Penh then was around 75 percent, few people had access to water and that to for only for 2-3 hours each day, and quality of water was poor. The utility was bankrupt and corrupt. The Cambodian Government put a good, competent and dedicated manager, Ek Sonn Chan, in charge. Within a short period of five years, the situation changed dramatically. By 1997, Phnom Penh Water Supply Authority, an autonomous public sector corporation, started to make a profit, and since then its profit has increased each year. The consumers pay for a 24-hour supply of good quality water which can be drunk straight from the tap without any health concern, corruption has been virtually eliminated through enlightened leadership, strict enforcement of rules, better salaries for all staff, and good training. In fact, by 1997, PPWSA had to pay a tax to the government on its profit as a public corporation. It was $550,000. Since then every year its profit, and taxes paid to the government, have increased. In 2009, it paid a total tax of over $12.5 million. The consumers cover all its expenses for an excellent supply, and it has a tariff system which has actually reduced the water cost of the poor households by around 75%.

Compared to the Indian urban centres, Phnom Penh appears to be a fairy tale! How did Phnom Penh do it? It reduced its unaccountable loss from the system to about 7 percent at present, which is very significantly better than London, Paris or Los Angeles. Every household now pays for water, rich or poor, that is metered and which covers all expenses and also a reasonable profit which is reinvested to continually improve and expand the system. This “miracle” was achieved in only five years, and the system has been continually improved since then, every year. Yet, Cambodia does not have the same technical, management and administrative expertise as in India, no private sector to which some work could be outsourced. Mr. Chan and his team completely transformed the Phnom Penh Water Supply Authority. Impressed by their performance, I nominated them for the prestigious Stockholm Industry Water Prize, which they received in 2010. If Phnom Penh can do it, why cannot cities like Delhi, Kolkata, Mumbai or Chennai follow its example? The water utilities can give many excuses, none of which can withstand any serious scrutiny. Public in India is now used to receiving a third grade service, and has accepted that they have to cope with this poor service by spending through own efforts. There is absolutely no reason, technical, economical or social, as to why the Indian urban population can not have a 24-hour uninterrupted good quality water at around half the total cost which the households are spending at present.

Key Words : Urban Water Management, Water Quality, Myths, Phnom Penh experience.

Water a Scarce Resource for Domestic & Industrial Demand

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The Paper holistically puts forth various options available in India for this essentially non-consumptive sector of Drinking, Domestic, and Industrial (DDI) Water Use. The options aim to make up the present deficit / mismatch, coupled with steeply increasing demand with population, due to economic upsurge / urbanization / industrialization. The scope covers: DDI water supply and sanitation needs arising therefrom. At the same time, the paper highlights the decreasing per capita availability and yet addresses the options as: Development, Conservation of Water, and Reuse, Recycling, Reclamation of waste-water, underlining need to account for urgency and adequate funding. The paper describes relevant provisions of the National Water Policy (2002) and different facets of the Sector indicating present status of provisions in 11th plan on both aspects, emerging as: fairly satisfactory for supply, but deficient in sanitation. It covers both surface / ground waters use in agriculture, people and nature sectors identifying weaknesses and remedial actions. At the end, the Author charts the course of action as follows: 1. Making up the deficit requires improved strategy and management of Water Quality. 2. Improving pollution control mechanisms. 3. Control on disposal of human waste. 4. Regeneration of polluted water bodies,

In meeting the DDI Water Demands, it highlights need for i) service delivery improvement, ii) improving reliability, iii) achieving financial & environmental sustainability, iv) improving affordability, v) improving capacity building. Key issues identified in management of domestic and industrial water supply are: Supply & Demand Side management, encouraging processes to minimize pollutants in industrial wastewater, reduction of Wastewater generation, evacuation, transport and decentralization of treatment infrastructure, reclamation and reuse.

The paper examines: a) need or otherwise for dedicated storages, en-route rural supplies, regional / individual schemes for villages; b) house to house connections to remove inequity; c) metering of supply; d) limits of rainwater harvesting; e) role of septic tanks in rural / urban peripheries; f) dual piping for drinking / other uses; g) decentralized vs centralized sewerage systems. While covering the 'Way Forward' it advocates preparedness to face impending water scarcity, through: Water Conservation, Rainwater Harvesting, integration of multiple uses of reclaimed wastewater; through comprehensive study of all S&T issues; metering of all supplies and desalination where feasible. Other approaches suggested cover: adoption of zero-effluent strategy for industry, cost recovery, public – private partnership, water quality surveillance, institutional development and capacity building.

The paper concludes as follows :

For urban India, access to safe drinking water supply (including un-piped) rose from about 82% in 1991 to 90% in 2001 and 100% by now. Millennium Development Goal (MDG) in 2015 however related to piped water supply. It was 74% in 2001, and may be 86 per cent by 2017 (end of 12th Five-Year Plan). The share for access to basic sanitation, rose from 43% in 1990 to 61.5% in 2001. It is likely to go to 81.5% in 2017, thus exceeding the MDG target. In rural area, access to drinking water increased from about 65% of population in 1990 to 90% in 2001. It appears that India could achieve 100% coverage by 2012. The rural basic sanitation was low at 5% in 1990. It rose to about 20% in 2001. It may rise to 53% by 2017 remaining way behind MDG target.

The success of the National Water Policy (2002) will depend on maintaining a national consensus and commitment to its underlying objectives. Inter-ministerial co-ordination is essential for effective and efficient implementations. Concerns of the community ought to be addressed on priority in DDI Water Sector on priority. The role of an aware, active and vigilant citizen is paramount.

The wastewater recycling and reuse as a water supply augmentation measure has to be adequately addressed. There is need to create a market for treated wastewater through regulatory mechanisms. Adaptation of advanced technology for use of DDI wastewater will considerably impact environmental market. In order to ensure universal access to safe drinking water, it is necessary to introduce operational and institutional reforms, besides improved management, leading to water conservation and reduction of waste. Considerable benefits can accrue from the present infrastructure if managed better. PPP model can be helpful.

A comprehensive water quality management strategy, including strict implementation of pollution control laws, adoption of clean technologies, with fiscal incentives is necessary. Vigilant stakeholders with strong and technically institutional support will be necessary.

For future, concerned utilities should focus on (1) S&T based preparation of feasibility studies; (2) advance evaluation of various limitations associated with present infrastructure and correcting them; and (3) preparation of manuals / guidelines on appropriate / affordable technologies for use. The following principles enunciated in the recent National Water Mission Action Plan have to be woven in DDI approach for future: (a) increased water use efficiency, emphasizing recycling & reuse, (b) augmentation through cost-effective and sustainable water sources such as: reclaimed wastewater, desalinated brackish water, (c) water conservation measures and source augmentation, reduction of wastage through improved instrumentation, (d) improved governance and regulation through reforms.

Keywords : DDI water use, Reclaim, Recycle, Reuse, Metered supply of water, dual piping for drinking and other house hold use, National Water Policy.

The Status of Domestic Water Supply and Sanitation in Rural India and the Future Challenges

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This paper takes stock of the status of domestic water supply sector, in terms of basic access to safe water and toilets at household level in rural India. While doing this, it also takes a quick look at the water supply and sanitation situation in urban areas in view of the increasing urbanization in India which will have a great bearing on the future of rural areas. In fact, the differences in aspirations with regard to the levels of these services between urban and rural areas are expected to close dramatically in the coming years.

The paper also takes serious notes of the past trends of slow growth and huge gap in household sanitation coverage in India. It is estimated that unless the past trends are drastically altered, we may end up having 33 % of the overall population (47% from rural and 8% from urban areas) still defecating in the open in 2025. To put it more strongly, by the turn of the first quarter of the twenty-first century, India may have an equivalent of her entire urban population no access to basic sanitation facilities. Lack of basic sanitation and its linked risk to the health and wellbeing of people, especially the children would be the biggest challenge for India.

Though various important issues of demand management, waste water treatment, disposal, recycling and related technologies are integral part of the sector, the primary focus of this paper is on access to adequate safe water and basic sanitation facilities at household level. In this regard, an effort is made to assess the latest situation, and also future challenges on the basis of projections. An analysis is also carried out to understand the disparities in water supply and sanitation coverage that exist amongst income segments; the paper also highlights the decline in quality of coverage, and impending risk of further deterioration in future. Based on these analyses, the paper argues for inclusive programming strategies in the sector, and suggests a thorough review of the policy and regulatory framework for water resources management and allocations for various uses, available technology options, institutional structures, delivery mechanisms and partnerships; for future.

Keywords : Domestic water supply, household sanitation, demand management, quality of coverage, delivery mechanism & partnerships

Rural Drinking Water Sector Overview for Maharashtra

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The rural water supply and sanitation in Maharashtra has undergone substantial change in last decade. Sustainability of the rural water supply sources, systems and the management of water quality have been the main challenges, confronting the government. A paradigm shift was essential in the policy and programs to effectively deal with the challenges. The Government of Maharashtra adopted a new policy in 2000 and adopted a demand led community driven approach, different form earlier supply driven approach. Enhancing the ability of community to manage their drinking water and environmental sanitation and creating the enabling environment through various policy program initiatives has been the prime motive of the paradigm shift.

The reform process also addressed the issue of integrated management of water resources at a village level to ensure the sustainability of sources; technical, institutional and financial management of systems to ensure system sustainability and institutionalization of water quality management at village level. This has been a challenging task especially in the context of business processes which were established for more than 30 years. Along with the new policy framework, it was also necessary to initiate various actions leading to change in the mind set of community, elected representatives and the government staff to adapt to the reformed approach and their respective new roles. This paper describes the process of operationalisation of reform, the initiatives and contemporary challenges.

Keywords : Sustainability of rural water supply, paradigm shift, reform process.

Development of Ultrafiltration (UF) Membrane Based Technology For Drinking Water Purification

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Membrane based separations are gaining increasing importance owing to techno-economic feasibility offered by these processes. This is brought about by new inventions in materials, process design and related optimizations. This paper is devoted to efforts at NCL on membrane material investigations for ultrafiltration (UF).

Today, UF membranes fill an important place in industrial separations, water treatment, laboratory and medical fields due to their high retentivity for relatively small molecules and their relative unreactivity with proteins, nucleic acids, and other biological polymers. Ultrafiltration (UF) is primarily a size exclusion based pressure driven membrane separation process. UF membranes typically have pore size in the range from 10 to 1000 Å and are capable of retaining species in the molecular weight range of 300 to 5,00,000 daltons. Several membrane characteristics, viz., porosity, membrane morphology, surface properties, mechanical strength, chemical resistance, etc. are important in determining a membrane's suitability for desired separation application. Other aspects such as operating parameters, membrane configurations have a great role in defining membrane performance and its life.

Insights gained through basic investigations in UF membranes were utilized for developing specific separation applications. NCL has developed and patented a flat sheet ultrafiltration (UF) membrane, which has pores small enough to exclude virus and bacteria, yet porous enough to operate on tap water pressure (~ 0.5 bar). These membranes were wound in spiral module form. The performance of membrane and modules were investigated for retention of virus, bacteria (E. coli broth) and molecules like proteins. The 4 log reduction for virus, 7 log reduction for bacteria and a pore size corresponding to 50,000-60,000 Dalton molecular weight cut-off for these membranes was ideally suited for the disinfection of water. After these basic investigations, spiral module based prototypes were prepared for providing pathogen-free drinking water during national calamities like Orissa-cyclone and Gujarat earth quake; where the water quality proven and assessed by independent organization. This was followed by rigorous evaluations of such prototypes by various NGOs with the help of Department of Science and Technology. The technology for membrane preparation was then transferred to a commercial entrepreneur for commercial manufacture of these membranes. A success story of ultrafiltration membrane from lab scale development till successful commercialization will be presented

Keywords : Membrane based separation, UF membranes, Membrane preparation

Rural Adaptation of Membrane based Water Purification Systems

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Scarcity of safe drinking water is a real issue especially at coastal and rural areas. Drinking water with physical, chemical or biological contamination of water has harmful effects on human beings. Surface water from rivers and lakes are normally affected with disease-causing organisms such as, bacteria, viruses, protozoa, parasitic worms etc. and seawater contains very high loads (more than 30000 mg/L) of dissolved salts. Ground water at certain locations contains salts (1000 - 3000 mg/L) and toxic metals. The desirable limit of salinity in drinking water is 500 mg/L as per WHO standards. Membrane based Ultra-filtration (UF) is very effective in removing biological and other colloidal species and Reverse Osmosis (RO) is used for removing all types of dissolved salts (desalination). As the membrane based water purification systems are pressure driven, they require considerable amount of energy in the form of electricity.

Several remote/rural areas in India do not have access to grid electricity. Utilization of renewable energy sources such as sun and wind is the solution for this situation. These sources are inexhaustible, freely available and emit no harmful gases to the environment. The use of renewable energy for water treatment is a very attractive proposition, addressing both environmental concerns and long-term sustainability. Solar or wind energy can be converted to electrical power, using photovoltaic (PV) panels or turbines respectively.

Domestic and community level (200 - 500 litres/hr) water purification systems are more suited for rural areas, considering the rate of consumption, distribution of drinking water and the ease of operation & maintenance of the units. For ground water (brackish water) desalination plants, two design approaches - once-through or with reject recycling - can be adopted depending on the raw water quality & quantity. Water conservation becomes an issue when the natural recharge rate of the source is slow. For this reason, a significant fraction of the reject flow is recycled back to recover the maximum product water, so that fresh feed as well as discharge volumes can be minimized. In the reject recycle system, chemical conditioning of the feed is essential to avoid precipitation of the sparingly soluble salts on the membrane surface. The once-through design is suitable for low salinity feed, where the product recovery can be kept minimum, so that, the reject salinity will be close to that of the feed, making it still usable for non-potable purposes. As the salinity of the concentrate stream is low, chances of precipitation is minimum and thus not requiring any chemical conditioning. Also, as 100% of the initial feed is utilized for different purposes, wastage of water and reject disposal issues are eliminated.

Bhabha Atomic Research Centre (BARC) has developed solar energy based RO & UF systems for producing safe drinking water from contaminated water. This paper deals with the technical aspects of those systems.

Keywords : Reverse Osmosis, ultrafiltration, solar energy, rural water treatment.

Malkapur (Karad) 24X7 Water Supply Scheme - A case study

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Malkapur, a town of 35000 population adjoining Karad, had inadequate water supply of water till 2006 due to its abnormally high growth in population. The problem could be converted into an opportunity to provide water 24X7. The micro detailing of the water demand from house to house, the anticipation of future developing areas of the town with the help of the elected representatives and citizens of town, and using the latest hydraulic modeling software "Water Gems", having capacity to provide extended period simulations, apart from steady state analysis could provide a design capable of making 24X7 water a dream turned into reality. The success was also due to choosing the latest and best material and equipment. The HDPE pipes manufactured from PE 100 grade resin in coil lengths reducing the number of joints, The fusion welded couplers and specials used for jointing pipes, the connections given simultaneous to pipe laying to the houses using fusion welded tapping tee, followed by quality ferrule, MDPE blue pipe of half or three fourth inches, in a single length from ferrule to the property, stop cock in property and Automated Meter Reading (AMR) type meter imported from Arad of Israel could assure the leak proof distribution network which is the crux for 24X7 systems.

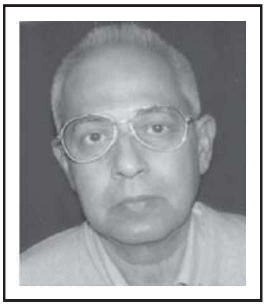
The elected representatives and the field Engineers of Maharashtra Jeevan Pradhikaran (MJP), worked transparently and cohesively as a single team carried out IEC for the citizens of Malkapur explaining them the importance of having 24X7 system. They were informed of each and every aspect of the system and what the citizens are going to gain in terms of good quality water, reducing health problems, no need for waiting for water and get it whenever you want in day or night. The people were continuously informed of using water as per actual need and not wasting it. The rate structure was decided as telescopic rates so that one who uses more than per capita norms has to pay the exceeded quantity at higher rates. A house to house enumeration of number of inhabitants could make it possible to implement the concept.

The people accepted the system and made it into a grand success, proving that i) Assumption of consumers that the metered water systems will increase the bills and ii) Assumption of supplier that 24X7 provision of water will increase the consumption by people: are false and myth. A well implemented 24X7 system for fully informed people, managing their demand through awareness and telescopic tariff can reduce the water bills for those who consume water to their minimum requirements, and conserve water which is proven by the actual measured data in the operation of this system in last 2 years.

Keywords : 24 x 7 water supply experience, HDPE pipes, fusion welding, AMR, Leakage proof distribution, telescopic tariff.

Technical Session No. 5

Water and Environment



Theme Speaker : Anil D. Mohile

Session Chair : Chetan Pandit

Suggested Points for Floor Discussion :

a) How much water is required by nature? Can this be decided "scientifically", or are trade-offs an essential part of the game?

b) What constitutes the water requirements of nature? Does it include both the terrestrial natural ecologies and also the aquatic natural ecologies?

c) What constitutes the EFR for the aquatic environments? Do we accept the ICUN definition?

d) What needs to be done for river basins already fully developed without considering EWR? Can we have ecologic river /basin reserves?

e) What methods should be used to decide the EFR for aquatic ecology?

Introduction to Deciding Environmental Water Requirements through Analysis and Trade-offs

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Introduction : India is one of the largest users of water, and has harnessed the water from its rivers and aquifers, and in the process achieved the stupendous task of providing food security to its people which is about 16% of the world's population, on roughly 4% of the land of the earth, endowed with less than 4% of earth's precipitation. In this process it caused large anthropogenic changes in its water cycle, impacting ecology. Of late, the concern about these impacts is growing. When dealing with the anthropogenic changes one has to realise that the human civilisation could not have grown, and the unusual predominance of humans, on the earth, cannot be sustained, but for these. There is no going back to nature, unless Humans become hunter-gatherers again, and their population reduces due to constraints of that style of living. A middle position is inevitable; but perceptions differ about what is desirable.

Need for environmental flows, the basis, and the policies : In recent years, there is a wide agreement that development needs to be 'sustainable', but 'sustainability' is much debated. The International Law Association (ILA) adopted the New Delhi Declaration of Principles of International Law Relating to Sustainable Development (ILA New Delhi Declaration) which includes, perhaps a better accepted definition. The International Watercourse Conventions also have some specific provisions in this regard. In India, the National Water Policy-2002 has made the preservation of the quality of environment and the ecological balance in the planning, implementation and operation of a project a primary consideration and has advocated for ensuring minimum flow in the perennial streams for maintaining ecology and social considerations. Similarly, the National Environmental Policy-2006 is concerned on environmental degradation and the role of freshwater resources.

How much water is required by nature? : The worldwide debate has lead to two broad schools of thinking: i) preserve the natural ecology because it has an ' a priori' right, ii) preserve natural ecology because it provides 'goods and services' to humankind. The latter anthropo-centric approach is becoming more popular with the environmentalists, since it provides a meeting ground. The Author advocates a negotiated approach between the surrogates of nature, and of humans, in resolving the issue through tradeoffs which base themselves on scientific studies and respect the societal preferences. He does not agree to the human-centric approach as ecologies and life forms, which seemingly provide no goods and services to humans, also need to exist.

What constitutes the environmental water requirements? : The in-stream water at any place on the stream may have to meet, at least in part, many downstream demands. These may include: aquatic ecology, river morphology, drinking and domestic needs of riparian communities, traditional or established agricultural and other uses downstream, new agricultural and other uses downstream, cultural and religious needs, needs of downstream political units. The Author advocates that except for the first two, others should not be considered as part of the aquatic EFR.

Definitions of environmental flows, and their critique : IUCN defines: “Environmental flows as the water regime provided within a river, wetland or coastal zone to maintain ecosystems and their benefits where there are competing water uses and where flows are regulated”. The clear distinction between what is needed and what is provided, and defining the latter as the EFR is a strong point in this approach. However, in further discussions, it suggests that the EFR may have to be 65% to 95% of the “natural flow”. The author opines that, by narrowing this window, the need for a 'case by case' trade off based decision is diluted.

Estimating environmental flow requirements- the approach : In view of the realities of the need for irrigation and its further augmentation in order to remain self-sufficient in food production, the Author suggests an approach for maintenance of ecosystems even at “less than pristine conditions”. Wherever possible, even at some pain and cost, a hydrologic regime, which is less than the natural one, but which sufficiently mimics the nature so as to allow the natural aquatic ecology to sustain, needs to be maintained. However, if this is impossible in a basin or its part, a serious thought may be given to the idea of Aquatic Ecologic Reserves in stretches/ basins with similar natural aquatic ecology. The aquatic ecosystem would also require water of an acceptable quality. Maintaining pristine water quality may be impracticable, due to non point pollution, but the quality can be much improved if all industrial effluent and all domestic sewage, at least from all urban areas is treated as per the standards available. Dilution of pollution, by releases through dams, as an alternative to treatment, is not at all recommended.

A more acceptable concept of environmental water requirements : The Waters of a basin are to be shared between the nature and the human needs. The use by the anthropogenic / natural terrestrial ecosystems (Agriculture and Irrigated Agriculture; Forests, Savannas, etc), is mostly an in-situ consumptive use. On the other hand, anthropogenic uses, like water supply, industrial use, etc are partly consumptive. Returns, which add to the resource, but which also can create quality problems, take place. The natural aquatic ecosystem requirements are non- consumptive, but preclude alternate consumptive use. All these are legitimate uses, and the actual allocation has to be decided through societal trade-offs based on the analysis of each use. No one sub-sector should be considered intrinsically superior, and no block allocation on this basis needs to be made.

Methods for estimation of efr : EF studies are used extensively in USA. Australia, UK, Canada, South Africa, New Zealand, Spain, Italy, France and Portugal, in that order. The available methodologies are described. In the present Indian context, a beginning would have to be made with Hydrology based methods like the look up tables, or desk top analysis. But, unless aquatic ecology of a particular river is studied, and unless inter-disciplinary trade-off negotiations are held, purely hydrologic studies may not help.

Keywords : Environmental Flows, ILA, National Water Policy, Water needs of nature, estimation of EFR.

From There To Here

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In 1992, the Ministry of Environment and Forests (MoEF), published a "Policy Statement for Abatement of Pollution". After 13 years, it published the draft National Environment Policy (NEP) and in 2005, it notified in 2006, without accounting for what happened during the intervening 13 years. Indeed, what was needed was a National Environmental Plan indicating objects, targets and time frames. In 1992, it stated: "The norms will be revised to lay down standards…". In 2006 it said: "It is also important that the standard is specified in terms of quantities of pollutant that may be emitted…" By now, mass standards for wastewater discharges only for a few industries are notified. Similarly, wastewater generation rate per unit of product is specified for some sectors. What about remaining sectors? In 1992, it stated "Economic instruments will be investigated to encourage the shift from curative to preventive measures…" In 2006 statements are: 1. "Consider the use of revenue enhancing fiscal instruments to promote shifts to clean technologies…" 2. In future…a judicious mix of incentives based and fiats based regulatory instruments would be considered…". 3. "Prepare and implement an action plan on the use of economic instruments for environmental regulation…..". Yet, this seems to be an area where nothing seems to have happened.

Should there be a negative list ? Yes, perhaps for Basic Drugs, Dyes and Intermediates, Metal Plating, & Textile Processing. Another area is 'environmentally viable size' of a Common Effluent Treatment plants (CETPs). Around 120 plants are commissioned or are at various stages of implementation. Yet, problems of CETPs continue. The advantages of "combined" against "common" treatment were realized. Little is done.

Waste Minimisation and Clean Technologies : 1. Reasonably significant R & D efforts in the development of clean technologies are reported including developments at NEERI. 2. Waste Minimization Circles as initiative to encourage small units to implement "in plant control" are introduced. About 118 units are now operating across the country. Case studies of Indian experience have been recorded and are available in various data bases. How do we put this wealth of information to future use?

River Action Plans and Rivers : One of the major initiatives since 1992, was the River Action Plans promoted by the National River Conservation Directorate. Six major groups of rivers covering numbers of towns so far covered are as follows: i) Ganga Phase I – 10 nos. ii) Ganga (addition) – 49 nos. iii) Yamuna – 21 nos. iv) Gomati – 3 nos.. v) Damodar – 12 nos. vi) Others – 46 nos. Total - 141 nos. A holistic study to ascertain: a) the performance of these plants, and b) their impact on water environment is necessary. Should professionals remain satisfied with the statement that " Rivers remain polluted even after the River Action Plans". Should we not ask why and do something about it?

Governments usually indicate a 'Wish List', NGOs – a 'Deam List'. S&T Professionals should move to a 'Could' list from a 'Should' or a 'Would' list. They ought to propose an 'Action Plan' from what is 'essential' and what is 'possible'.

Keywords : Clean Technologies, Regulatory instruments, environmental regulations, Common ETP, River Action plans.

Environmental Flow in Rivers of India

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Quantifying & maintaining environmental flows in rivers of India is a very complex issue which requires not only detailed technical approach but is also associated with various conflicting and diverse issues (Development Vs Poverty, religious issues, livelihood issues etc.). Whatever the nature of the problem, a beginning has to be made for understanding the problem and its management. In this paper a brief about the various methods available for determination of environmental flows has been provided along with a discussion on the hydrological approach arrived at by the Working Group of Water Quality Assessment Authority(WQAA). Even after the quantification of environmental flow has been done, the implementation part of it will be more of a political exercise than technical.

The water resources in India, is a State subject and there is no practical mechanism in place which can take care of implementation of the environmental flow norms. Certainly political consensus and adopting a balanced and enforceable ACT within the existing provisions of the Constitution of India may be one of the options for implementation of the Environmental flows in rivers of India.

Keywords : Quantifying & maintaining EFR, Water Quality Assessment Authority.

Rescuing EFR from Impractical Romanticism

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Beasts, birds, bees, . . . all have a right to water; rivers are sacred, and render important ecological services; this is unsustainable development; there is enough for our needs but not for our greed; . . . we have been chanting all this for last 15 years or so. But far less ensure any decent environmental flows in our rivers, it has not even helped us formulated guidelines on quantifying the EF Requirements (EFR).

The participants in discussion on EFR can be divided in three broad groups.

a) The executive - water engineers, scientists and administrators working for the Government.

b) Environmental scientists, usually, academicians.

c) Environmental Activists;

The executive has a responsibility to implement what they may advocate; and the though the academicians do not have such responsibility, they understand and respect the science. Therefore, both these groups try to seek solutions that are practical. But the discussion on EFR is dominated by the activists. They live in a world of their own, where 2 + 2 can be 3 or 5, if so dictated by their ideology. This has caused the discussion on EFR get increasingly alienated from practical aspects, and shift towards romanticism.

In most basins in India, the total water requirement is more than the supplies. It is impossible to think that the farmers will allow their crops to wilt away, agree to live in poverty, and the nation will gladly accept a return to the era of severe food shortages, to allow more water for EFR. Therefore, most of the present discussion on quantifying EFR is a sterile discussion. Because the EFR suggested by this discussion is most unlikely to be possible. Lately, the activists have started demanding “the Government must allow the rivers to flow uninterrupted”. In simple English this means - no abstraction from the river, not even for a non-consumptive use. Anyone who thinks this is possible, is living in a world of make-believe.

The discourse on EFR must take cognizance of following points: 1. In water short basins, there can at best be only a token EFR. Protagonists of environment will have to accept some reduction in biodiversity; 2. Where water allocation is governed by either a tribunal award or an inter-state MoU, getting more water for EFR will require a review of the award, or a revision of the MoU. Neither of this can be achieved by seminar hall debates. 3. In climates where 80% of the annual rainfall occurs in just 4 months, storages are the only way to maintain EFR. No storages = No EFR. 4. The case for EFR will have to be argued at par with other uses, and not on emotional appeals, bombastic ideology, and a moral high ground.

The activists have put the EFR on a pedestal. The present discussion on EFR is mostly romantic riff-raff. Unless it is rescued from romanticism, and brought to ground level, there will be plenty of EFR in seminar halls, but none in rivers.

Keywords : Ecological Services, sustainable development, EFR, water needs more than supply, activists & EFR, Impractical EFR expectations.

Environmental concerns in IWRDM for Maharashtra, India - A case study of Dudhna sub basin of Godavari Basin.

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Demand for water is increasing with time. Balancing our increasing demands with diminishing availability of usable water resources has become an environmental challenge. The prevailing sectoral approach is leading to fragmented and uncoordinated development and management of the resources causing environmental problems. There is a need to replace the conventional sectoral approach by Integrated Water Resources Development and Management (IWRDM) approach on river basin scale. The Govt. of Maharashtra is always one step ahead in the country The State Govt. has decided to develop the integrated State Water Plan considering the watershed as a hydrological unit of development. Preparation of master plan adopting IWRDM approach for Godavari basin is in progress.

The paper covers various issues related with the environment concerns in Integrated Water Resources Development and Management for Maharashtra. Issues include - 1. sea water ingress, 2. deforestation, 3. progressive groundwater depletion, 4.water scarcity, 5.sand mining in rivers, and 6. water quality problems. The paper also describes how and through what type of measures the government, the community and the individual can help to protect the environment. A case study of Dudhna sub basin includes environmental concerns related to loss of irrigation command and Issues related to sedimentation in reservoirs. It also includes issues concerning groundwater assessment, depletion & efforts at artificial recharge, rainwater harvesting, watershed development and other methods. Water quality problems have been addressed identifying the hotspots, assessing their causes and efforts to reverse the situation.

Environmental And Forest Clearances And Issues Concerning Hydropower Development In India

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India is undergoing rapid economic and industrial makeover and power plays a decisive role in its growth. Generation of clean and eco-friendly power, with minimum environmental consequence, is need of the hour. India is experiencing energy shortage of about 9% and peak demand shortage of about 13%. As per the latest estimate, the required installed capacity of 2,06,000 MW is required by 2012 to meet the energy demand in India, which is unlikely to be achieved by 2012. India is bestowed with immense hydropower potential and therefore, development of hydropower is essential for the economic upliftment. Hydropower is a renewable, economic, non-polluting and environmentally benign source of energy. Hydropower projects are usually situated in remote hilly and inaccessible area. The construction and operation of hydropower projects, is comparatively more environment friendly than thermal, and can bring about environmental enhancement of the area besides providing benefits to the local people residing in the project area.

Government of India is giving special emphasis to accelerated hydropower development, which can contribute to the country's energy security in an environmentally sustainable and socially responsible manner. However, due to long gestation period and delays in getting clearances associated with the hydropower projects, the development of hydropower in slow. Ministry of Power has also come up with new Hydropower Policy to ensure accelerated development of hydropower projects in the country.

In India, hydropower project, like other projects, has to pass through certain mandatory scrutiny under the provisions of relevant Acts & Guidelines related to Environment (Protection) Act, Forest Conservation Act and Wildlife Protection Act, etc. The procedures for scrutiny by Ministry of Environment and Forests (MOEF) and getting environment and forest clearances for Hydropower projects have been streamlined so that there can be accelerated development of hydropower projects in the country.

The environment clearance of the project is obtained from MOEF following the procedure specified in EIA Notification 2006. The projects have been divided into different categories viz. A, B1 & B2, depending upon potential of environmental impacts. As per EIA notification 2006, clearance for pre-construction activities is given by MOEF during the scoping stage along with the Terms of Reference (TOR) for undertaking the Environmental Impact Assessment (EIA) studies. TOR provides a format and structure for EIA and EMP reports and the parameters to be considered while appraising the process and enable the project proponent to have all detailed information to address all issues, undertake field data collection, identify impacts and propose mitigation measures as part of EMP. Once the clearance for pre-construction activities is accorded by MOEF, along with the approval on TOR for the EIA studies, comprehensive EIA studies are conducted through reputed Institutes/ Universities etc. After completion of EIA/ EMP studies Public Consultation/Public Hearing is conducted through the concerned State Pollution Control Board. After completion of the public hearing, the environmental concerns expressed during the process are addressed in the draft EIA & EMP reports and the final EIA & EMP reports and executive summary of Detailed Project Report (DPR) are submitted to MOEF for appraisal by the Expert Appraisal Committee (EAC). After recommendation of EAC, Environmental clearance is issued to the project subject to compliance of conditions stipulated in the clearance letter.

Forest clearance is to be obtained for diversion of forest lands for non-forestry purposes under Forest (Conservation) Act, 1980 and the process is specified in the Forest conservation rules, 2003. It is applicable to whole of India except the State of J&K. The project proponent applies to the concerned Divisional Forest Officer (DFO) / Nodal Officer (FC) for formulation of forest proposal. The DFO then surveys the relevant forest area required for the construction of project and conduct a cost-benefit analysis and formulates Compensatory Afforestation (CA) scheme to compensate loss. The project proponent provides undertaking/ certificate to meet the cost of compensatory afforestation and the Net Present Value of forestland diverted. The NPV rate varies from Rs. 4.38 to Rs. 10.43 lakh per hectare and is payable to the "Compensatory Afforestation Fund Management and Planning Authority" (CAMPA). The forest clearance is issued in two phases viz. in-principle and formal forest clearance.

The Wildlife Clearance is to be obtained if diversion of forest land for non-forest purposes involving part of National Parks & Wildlife Sanctuaries. The State Government has to first take consent of National Board for Wildlife (NBWL). After recommendations of NBWL, every case is to be taken to Supreme Court for seeking its permission for de-reservation of the required area of National Park/ Wildlife Sanctuary.

However, various procedural, technical and social issues related to the project cause delay in implementation of the projects. Some of the major procedural issues related to environment and forest aspects of development of Hydropower projects are given below:

- non- adherence to time period for Environment & Forest Clearance by MOEF
- No- separate forest clearance for pre-construction activities
- Multiple Stage Forest clearance
- Multiple scrutiny of EIA and EMP
- Cumbersome procedure for de-reservation of National Park/ Wildlife Sanctuary

The other major technical issues involved in delay of projects are related to the fact that there is no specific guideline for minimum flow and downstream concerns. Further, MOEF is now stressing on getting cumulative Environmental Impact Assessment of river basin, these studies have not been conducted earlier and hence delays individual projects.

The major Social and R&R Issues that are involved in construction of hydropower project are related to non availability of land records, demand for employment by the locals with the project proponent which may not be always possible and insistence of State Govt. for earmarking various percentages of the project cost for different environmental management plans, which are already being undertaken by the project proponents.

These issues need further deliberations at a common platform, so that accelerated development of hydropower is achieved with objective of sustainable development. Further, MOEF may constitute a single Expert Committee, comprising of experts from different fields, which may appraise Environmental, Forest and Wildlife proposals of a hydro project in totality and submit its recommendations to concerned authority for final approval as a single window clearance. There is a need to initiate a thought process at administrative and decision makers' level so that concerted effort is made in addressing such issues.

Keywords : Hydropower policy, Environmental Impact Assessment (EIA) studies, Compensatory Afforestation Fund Management and Planning Authority" (CAMPA), wildlife clearance

Bioreduction of hexavalent Chromium by Immobilized P. Chrysosporium

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Biological reduction is a safe, green and economical detoxification procedure for wastewaters containing Cr(VI). The aim of this study was to evaluate the Cr(VI) tolerance of P. chrysosporium, a white rot fungi, under various growth conditions and different immobilization matrices. The biomass was entrapped in alginate, agar, and polyacrylamide gel. In order to optimize the bio reduction of Cr(VI) the gel and beads were prepared with varying the inoculums concentration and the culture age. Cell free beads and gels were used as reference to study the adsorption capacity of the matrices. The concentration of the Cr(VI) in the bio reduction media was varied between 10 mg L-1 to 40 mg L-1. Alginate with 5 % inoculum gave a maximum of 79 % of Cr(VI) accumulation with initial Cr(VI) concentration of 40 mg L-1. The optimum pH was found to be 4. A maximum of 83 % reduction of Cr(VI) to Cr(III) was obtained for the same initial chromium concentration. The accumulation capacity of the cell free alginate beads and the gels were found to be negligible for all the concentrations studied. The experimental results showed that the immobilized beads have more advantage over the free cells as the toxic load can be increased and the pH constraints suffered with the free cell studies can be overcome. The significance of the present study is that the immobilized P. chrysosporium can be used for removing the trace amount of Cr(VI) present in wastewaters. Further studies with increased Cr(VI) initial concentrations are under progress .

Key Words : Waste Water, Chromium contamination, bio reduction, Alginate, Chrysosporium,

Research and Development Initiatives by Industries

Session Chair : Dr. Anil Kakodkar

Session co-ordinator : Dr. Anil Sahastrabuddhe

Research and Development initiatives in Kirloskar Brothers Limited

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The economies of the world are governed by innovation made through research and development. Kirloskar Brothers Limited (KBL) foresaw the changing demands of agriculture and shifted its manufacturing focus to providing water for farming. Subsequently, KBL branched into the field of fluid handling and fluid control and soon became a leader in manufacturing of Pumps.

KBL has state of the art and well equipped Research and Engineering Division with capabilities of performing model studies and various analysis like Computational Fluid Dynamics, Surge analysis, Sump model analysis to name a few. KBL has Asia's largest Hydraulic Research Center. We have presented several research papers at various reputed forums. We internally undertake projects for product innovations. We call these projects as i-Mission projects. We have filed 5 patents from these innovations.

We received a US patent for Siphon Making and breaking arrangement. The Siphon creation and breaking arrangement for Sardar Sarovar Project at Gujarat was a step towards the concept of energy conservation. This provides annual saving in electricity to the Rs.13 crores.

ICP

On the occasion of our centenary celebrations we introduced pump for the chemical industry. The totally seal-less and gland-less features makes the pump deliver high efficiency with zero leakage and zero maintenance. The move will support in reducing cost pertaining to energy consumption and maintenance.

Tamper proof Valve

To address the issue of water shortage on account of losses in the transmission system, KBL created the tamper proof valve. This will help in avoiding water wastage at distribution lines. Engineering of the valve has taken care of the environment by ensuring no leaking spots.

We have shared our knowledge and understanding by presenting papers at various platforms. Some of the notable ones are

- Coast down characteristics of a centrifugal pump presented at NCFMFP, Pune: Pumps used in Nuclear application call for specific trend of slowing down of the pump speed when power is taken off. The numerical simulation presented here confirmed the desired speed-time curve.
- ICONE7 Conference on 'Development of Canned motor pumps for Nuclear Application': The lubricant used in canned motor pumps is the same fluid as handled by pump. They are known for zero leakage capability.
- Energy saving in Centrifugal pumps by Design in Energy saving seminar: Increasing the efficiency of pump can contribute to substantial power saving.
- Product development and challenges for nuclear applications at INSAC, Chennai: Nuclear program calls for special class of pumps with severe QAP.

DEVELOPMENT OF SODIUM PUMPS FOR 500 MWe PROTOTYPE FAST BREEDER REACTOR

We are proud to be associated with NUCLEAR POWER CORPORATION OF INDIA LIMITED who has undertaken the setting up the development of Prototype Fast Breeder Reactor (PFBR) at BHARTIYA NABHIKIYA VIDYUT NIGAM LIMITED with the design back up from INDIRA GANDHI CENTRE FOR ATOMIC RESEARCH (IGCAR), Kalpakkam.

We are really proud to be the only pump manufacturing company in India to develop Sodium pumps (Primary Heat Transport Pumps) for Prototype Fast Breeder Reactor (PFBR).

Adoption of Piped Distribution Networks and Micro Irrigation Systems in Canal Command Areas

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India is a vast country and has approximately 17% of the total population of the globe. It is estimated that its population would be in the range of 1200 million in 2010, 1449 million in 2025 and 1751 million in 2050.To feed such a vast population we need to increase our food production substantially. That means we have to increase agricultural productivity on top priority. Agricultural productivity can be increased by adopting following ways : 1) By introduction of high yielding hybrid varieties, 2) By increasing the additional area under cropping and 3) By increasing area under irrigation : By increasing area under irrigation we can definitely increase the productivity of crops without any limitations/side effects such as diseases etc. However there are exceptional cases where because of over irrigation the soils have become saline/alkaline. These types of problems can be taken care of by judicious use of available water resources by introducing modern irrigation systems such as drip and sprinkler irrigation. Thus irrigation and judicious use of water resources plays vital role in increasing the productivity of crops. It seems to be the only solution to increase the food production and thereby provide food for all.

In order to increase the productivity per unit volume of water, use of piped network systems (Conveyance) and micro irrigation systems (End use distribution) becomes necessary. Use of piped distribution network systems and micro irrigation systems in canal command areas will not only result in to increased productivity but also into increased water use efficiency. There are various models already available for modernization of canal systems through use of micro irrigation systems and piped network systems. Every model is tailor made and no single model suits for all the conditions. Choice of the model will depend up on topography, soil type, cropping pattern, land extent etc and it has to be a location specific.

Comprehensive India centric solutions to water challenge and managing the fast depleting natural resource using triple tools of technology, innovative solutions and adequate policy measures

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Enough has been said about the impending crisis of availability of good drinking water to humanity in this millennium. India with its 1 plus billion population and exponential increase in industrial development will face water crisis sooner than later. We need therefore a far sighted approach to meet the challenge head on. The solutions need to be innovative enough and should have necessary cutting edge technology elements. Policy instruments are also essential to make some of the solutions mandated so that deployment is fast tracked.

The entire water challenge can be categorized in to three. Water for mega and metros where major usage is human consumption and commercial establishments and the water challenge for metros fall under category I while water for tier two or three level cities have major usage for industrial applications and have challenge under the category II. Rural water demand pattern – category III - is skewed to agricultural needs and there are real issues of making available quality drinking water to villages given the wide nature of contaminants in the water resource available.

Reduce, recycle and re-use – the triple R is mantra for India's water challenge. In mega cities, treatment and recycle at source level using waste (sewage) water treatment technologies and recycling the treated water within the facility by recycled plumbing system is the answer to increase stress on water for these cities. This would require creating new plumbing standards for buildings and making them mandatory.

The places where Industry is a major consumer (typically tier 2 cities), a cluster level water treatment and then recycling the treated water to the original source would reduce the fresh water demand by as much as 50%. Besides membrane technologies, electro- de ionization technology has a great potential to generate quality of recycle water which is better than intake water at very attractive costs. Then there are technologies which can convert the waste water and waste matter into energy and good quality drinking water.

The village level water challenge is the most difficult due to the diversity in the water challenges and poor availability of water resources. The biological contaminants – mainly due to poor sanitation facilities – compounded by contaminants like Arsenic, Flouride and alkali and alkaline earth metal salts make providing a affordable water to people a real challenge. However, there are many elegant but simple solutions for these challenges. The author discusses some of these solutions including the community level water conservation and rain harvesting techniques which can solve majority of the problems.

In the end, the talk forcefully brings in the need for demonstration of several such technologies and innovative solutions in a true spirit of Public – Private Partnership. The current WAR mission (Water augmentation and reuse) by DST is a good move and Thermax has actively participated in this mission for rural water solutions. There are six different models which Thermax has developed to solve the rural water challenges.

Going forward India needs multiple solutions and India centric technologies for water Adequate policy measures are also necessary. Some of the good concepts from energy efficiency domain like PAT (perform, achieve and trade) system can be introduced in water domain so that well performing industry gets incentivized.

SOLUTION FOR PRESENT WATER CRISIS BY SEWAGE RECYCLE - C-TECH SHOWS THE WAY

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Water is the lifeline of all living beings. All human settlements on earth are developed near the source of water. Even though two thirds of earth is covered with water, only a small fraction of total water is actually usable by mankind. As the population and industrialization is increasing, demand for water is also increasing. This is exerting more stress on the existing water resources. With changes in climatic conditions, and steadily declining rainfall in many areas, the problem is further aggravated. Many major cities in India are under severe scarcity of water. The stress on water resources results from an imbalance between the consumption of water and the available water resources. The time has come to understand the root cause of the problem and address the impending threat of a water crisis which jeopardizes the existence of millions of people around the world. A catastrophic water shortage could prove the biggest threat to mankind in coming years. If we value our own futures on this planet, we should sit up and take notice of the many ways we can conserve water and live in a way that does not pose a danger to the delicate natural climatic processes of the earth.

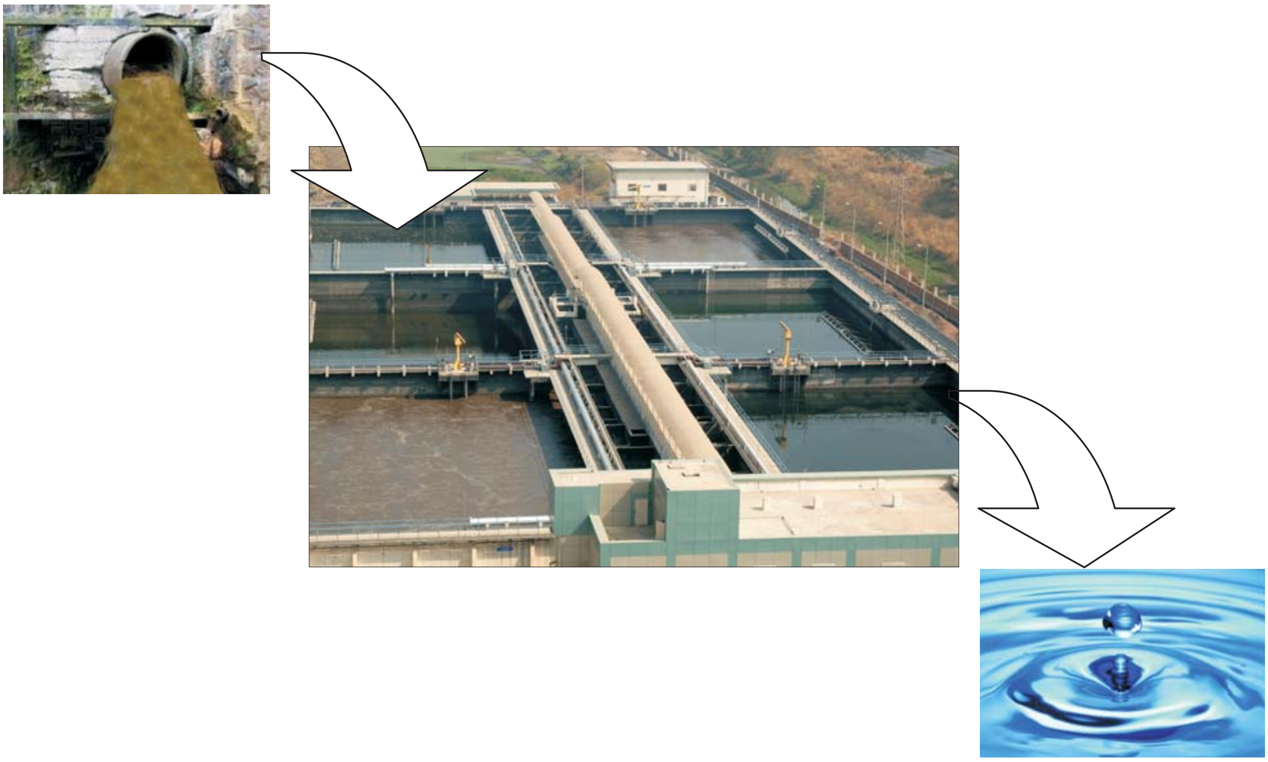
First and foremost thing to do for reducing the water crisis is "Water Conservation". Everyone has to stop wasteful and luxurious use of water and start using it judiciously. Next possible activity is to find out alternative sources of water like Rainwater harvesting, Desalination of sea water, etc. In addition to this, there is one more unconventional source of water, "SEWAGE".

Sewage is seen as an alternate source of water supply when treated with modern treatment technologies. Sewage treatment and its safe disposal is necessary anyway for protecting our valuable water sources and also to check pollution and spread of deceases. A little additional cost and little care in operating sewage treatment plants can add to available water resources. Sewage recycle is most economical and viable solution when compared to other alternative sources of water such as sea water desalination. As the sewage is available right in the center of human settlements, its transportation costs are minimum reducing overall cost of the scheme.

Various technology options have been implemented in India for treatment of domestic Sewage. However conventional technologies have not been able to solve the problems as they are unable to remove some of the pollutants present in sewage (such as Nitrogen & Phosphorous) and can only remove others to certain levels. The pollution Control boards had earlier issued treatment guidelines, which were mainly based on the capacity and the cost effectiveness of available technologies to do the job of meeting disposal standards. As the sewage recycle is becoming a practice now, treatment objective is much beyond meeting disposal standards.

C-Tech

Cyclic Activated Sludge Technology



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