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Wish you a Very Happy & Prosperous New Year 2021

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ABOUT JOURNAL

Water is among the most precious gifts of the nature to mankind. Benign and life supporting in normal times, menacing during floods, and desperately sought in times of drought, the waters of the rivers, aquifers, springs, lakes, etc., have been part of our daily life. However, with the growing requirements of water for diverse purposes, water is becoming a critical and scarce natural resource and can not be regarded as available in abundance as might had been believed earlier. It is widely recognized that many countries are entering into era of severe water shortage. The increase is not only due to population growth but also due to improved life style of the people.

The dramatic expansion of urbanized areas, which has been witnessed over the last few decades is likely to continue in most countries of the world. Such, often unplanned, growth leading to the emergence of conurbation and mega cities, poses a threat to both the availability and quality of surface and groundwater resources. These threats are both unprecedented and of immense scale when viewed from political, social and economic perspectives.

The aim of the journal is to provide latest information in regard to developments taking place in the field of water resources, besides making aware the readers about the activities being carried out in the field of Water Resources, worldwide, such as technical papers, R&D Activities, and information regarding conferences, training programmes and important news.

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From the Editor's Desk

First of all, I take this opportunity to wish all the members and readers a Very Happy and Prosperous New Year.

With the support of all of you, the journal has entered into 10th year of its publication, and the Nineteenth issue of the journal is now in your hands. I thank all the readers for their feedback about the journal. The feedback from all the quarters has given us the encouragement to our initiative and to bring out a quality journal.

The global spread of COVID-19 coronavirus has infected millions of people around the world, and is continuing at a faster pace. At the moment, it's a challenge to contain the pathogen. This crisis is experienced directly by some and indirectly by all of us. We have to fight together this pandemic and come back stronger as this is the need of the hour. In this new COVID-19 situation, skill enhancement and training of professional has emerged as a very important aspect and a challenge.

Considering the pandemic scenario, Indian Geographical Committee of IWRA (IGC-IWRA), in association of Central Board of Irrigation and Power, the Secretariat of IGC-IWRA, organised series of Webinars on Integrated Water Resources Management, Micro Irrigation for Improving Water Use Efficiency and Planning & Design of Piped Irrigation Network, in the year 2020, keeping in view of limited availability of water resources and rising demand for water, which has acquired critical importance for Sustainable Management of Water Resources.

Water conservation is a key element of any strategy that aims to alleviate the water scarcity crisis in India. As drought-like conditions have gripped many parts of India, the pressure to drill borewells in search of increasingly scarce groundwater has escalated. Many regions are in the grip of a vicious cycle of drilling causing the water table to sink further. There is an urgent need to explore what benefits water conservation can bring, whether through modern or ancient water storage structures.

Construction of water harvesting structures, mass awareness among citizens for water conservation, construction of new water storage structures, interlinking of rivers, renovation and repair of existing water bodies are commonly recommended measures to mitigate drought effect. History tells us that both floods and droughts were regular phenomena in ancient India. Perhaps this is why every region in the country has its own traditional water harvesting techniques that reflect the geographical peculiarities and cultural uniqueness of the regions. The basic concept underlying all these techniques is that rain should be harvested whenever and wherever it falls.

Archaeological evidence shows that the practice of water conservation is deep rooted in the science of ancient India. Excavations show that the cities of the Indus Valley Civilisation had excellent systems of water harvesting and drainage. Even today, there is a valid logic in considering these ancient but dependable alternatives to rejuvenate depleted groundwater aquifers. With government support, these structures could be upgraded and productively combined with modern rainwater-saving techniques such as anicuts, percolation tanks, injection wells and subsurface barriers. Storage of surface rain water and rainwater saving techniques has their own role to play.

A.K. Dinkar
Member Secretary
Indian Geographical Committee of IWRA

Reward from Right Decision at Right Time – A Case Study of Uben Irrigation Project

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INTRODUCTION

Uben Irrigation Project is a World Bank aided Project situated near village Bhatgam of BhesanTaluka in Junagadh District of Gujarat State. Total CCA of the project is 2500 Ha, which is already developed with fully lined distribution system extending up to 8 Ha. Block to serve entire command. In the entire command area, the measuring devices ***viz.***, ramp flume, proportional flow divider and other efficient structures are provided for implementing the Rotational Water Supply (RWS) system. Committees such as farmers committee, chak and sub-chak level committee for introduction of RWS were formed initially but now entire command has been hand over to 11 WUAs and recently they have also formed federation of 11 WUAs. Index plan of Uben Project is given in Figure 1.

The Brief Salient Feature of Uben Irrigation Project are as under

1. Total C.C.A.	:	2500 Ha.
2. Total No. of Farmers	:	1200 Nos.
3. Gross Storage at FRL	:	16.20 Mcm.
4. Dead Storage at OSL	:	0.60 Mcm.
5. Live Storage at F.R.L.	:	15.60 Mcm.
6. Evaporation & Seepage losses	:	5.71 Mcm.
7. Design Cropping intensity	:	Kharif : 94.50 %
		Rabi : 15.00 %
8. Principle Crops	:	Kharif :Groundnut
		Rabi : Wheat

The irrigation was started from ***Kharif*** 1986 and thereafter, strictly RWS system was enforced and water has been released as per pre-determined canal operation plan. After continuous efforts made by Irrigation Department and WALMI, farmers co-operation were achieved for adopting canal operation plan and RWS system.

PREAMBLE

In the changing climate since last 20 years,Gujarat receiving good rainfall except few years. In the year 2014-15, in ***kharif*** season in entire Gujarat rainfall was very less particularly during end of the ***kharif***season. Even during initial period of ***kharif*** season rainfall was just adequate to crop water requirement but no to much runoff for filling the reservoir. In Uben Irrigation Project only 47.46 Mcft water was available against its capacity of 572 Mcft. Even less than 10 % water was available in small reservoir. During this period due to water scarcity in entire Gujarat, the Govt. has issued a circular to all District Collector that no body will allow to use the water for irrigation from public water bodies ***viz***, river, tank, small reservoir etc. As per national water policy Govt. has decided that the water should be reserved for drinking purpose as first priority and hence the circular was issued. In Uben irrigation command area Cotton and Groundnut crops were occupied majority areas. During October, no rainfall was there and even no water available in most of the wells / tube wells of farmers. Cotton and Groundnut crops suffers due to moisture stress in soil. If one irrigation is to be supplied by canal, there was a chance to increased crop yield just double. But initiallyCollector was dis-agree to release water from Uben Irrigation Project for irrigation purpose as he has having strong circular of GOG.

ACTION INITIATED BY f ARMERS

However, Uben command area's farmers are habituated to irrigate the field by Rotational Water Supply System with high with high Water Use Efficiency since the year 1987. All the farmers are very co-operative, no any rules violation and no any internal conflicts for water distribution amongst farmers. Since 2007 farmers are joined in PIM by forming 11 WUAs. All the presidents of WUAs and other farmers were assemble and made a detailed proposal to Collector for water demand in consideration of following points :

1. Uben Irrigation Project has no any domestic water supply scheme at present.
2. No water is needed for domestic purpose surrounding area of Uben Project upto end of April month.
3. Small quantity (only less then 10%) of water could not be retain in reservoir upto end of April month due to evaporation and seepage losses.
4. Cotton and Groundnut crops requires water just in a week because there were a critical stages for irrigating the crop fields (in cotton – boll formation and in Groundnut – Pod development stage).
5. If boththe crops to be supplied water, there was a chance to increase the crop yield just double.

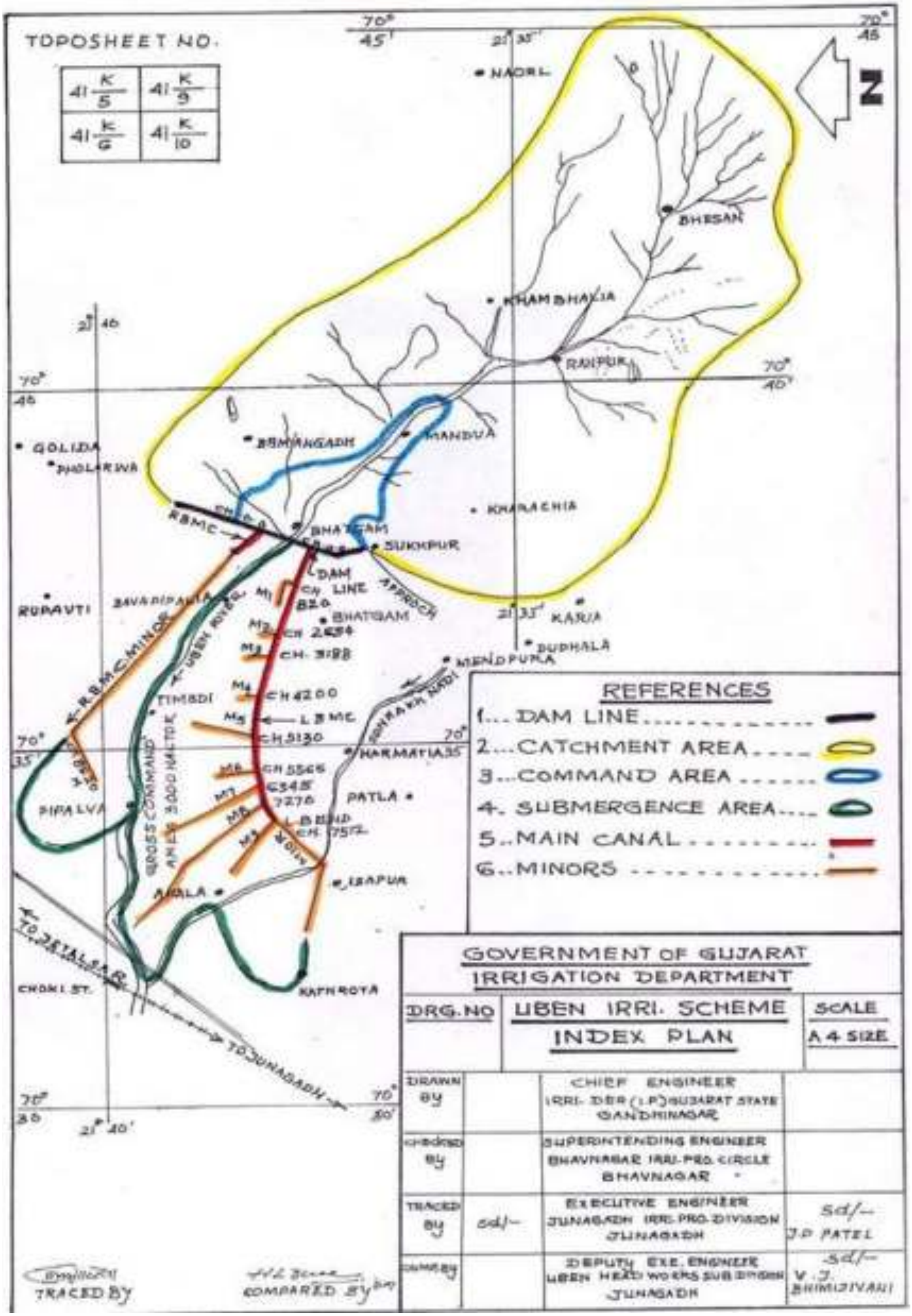

fig. 1 : Index Plan of Uebn Irrigation Project

Considering abovepoints the proposal was submitted to the District Collector through the concerned Irrigation Engineer with their recommendation. DistrictCollector has review the proposal and he has realized the water demand ofUben farmers and immediately he has sanctioned the proposal and grant the permission to release water from Uben Irrigation Project for irrigating the Cotton and Groundnut crops. The date-wise events are as under :

Date	Events
04-10-2014	Federation of 11 WUAs has made proposal for water demand to the District Collector through Irrigation Department.
05-10-2014	District Collector has granted permission for releasing water from Uben Project for irrigation.
08-10-2014	A meeting of Uben Federation was arranged in which 11 WUAs presidents and another 24 members remained present for plan-out water distribution and likely area to be irrigate.
08-10-2014 to 12-10-2014	Collected water demand forms from farmers through11 WUAs with water rate collection in advance. Side by side farmers had resolves weeds, silts from canal network and make a clean canal for running water smoothly with minimum losses.
12-10-2014 to 13-10-2014	Irrigation department's dedicated staff has started preparing canal irrigation schedule, water allocation schedule from evening of 12-10-2014 considering forms received upto 12-10-2014 evening. By morning 13-10-2014 the time allocation schedule were ready due to use of computer in irrigation sector. All the farmers were intimated for their turn for irrigation upto evening of 13-10-2014.
14-10-2014	Early morning water was release from Uben Project to canal network and upto 1400 hrs. canal network was filled up with water and after that all the 11 minors has started irrigation and farmers got water one by one as per pre-determine schedule even in all water courses (outlets).

The details of water demand and water rates collection is given in Table 1. The figures of Table-1 indicate that from 8 villages 532 farmers has demanded water for 842 ha. against that irrigation department has sanctioned 829 ha. area for one irrigation only. WUAs has collected advance water rates amounting Rs. 2,84538=00 i.e. 100 % recovery. It is a general principal that taking and giving :farmers has demanded water, Govt. has demanded water charges and co-operation from farmers.

Farmers has paid 100 % water charges in two days and it is a cumulative effectsof last 28 years of culture developed viz; co-operation, co-ordination, un-selfish mentality etc. This environment created by continuous efforts of WALMI, Central Design Organizations, Agriculture Deptt. and Irrigation officers.

The time allocation schedule for tail minor No.10 is given in **Table 2**, which reflect that 24 hours are equal (day & night) for irrigation. Normally in most of the irrigation projects farmers are hesitate or not taking to much care for efficient water use during right time but in Uben Project such problems not observed since last 28 years.

RESULT & DISCUSSION :

(a) **Area covered:** During rotation period, 35.94 Mcft water was released from reservoir and 829 ha. Area could be irrigated in which 70 % area under Cotton crop & 30 % area under Groundnut crop.

(b) **Crop productivity :** Crop productivity data given in Table 3 indicates that crop yield could be increase just double. 1500 Kg/ha. Groundnut could be produced with one irrigation against 625 Kg/ha without irrigation. 1250 Kg/h. Cotton could be produced with one irrigation against 700 Kg/ha. without irrigation. By this way farmers of 6 villages got additional benefits of Rs. 20385625 = 00 against water rates of Rs. 284538. That means by only paying 1.39% water rates additional amount gained by farmers about Rs. 2 crores.

(c) **Water Productivity :** Water Productivity is a ratio of Rs. gained to water release from HR. In this case 35.34 Mcft water i.e. 1000850 M^3 water was released for irrigating the crop in area of 829 ha. which produced addition income of Rs. 20385625=00 over un-irrigated crop. Data given in Table 4 shows that water productivity comes about Rs. 20.37 / M^3 of water which is a very high as compare to other irrigation project where it will comes harly about 10-12 Rs./ M^3

(d) **Water Use Efficiency :** It is a ratio of water supplied to field against released from HR. The data given in Table 4 indicates that the duty comes about 23.46 ha

Table 1 : The details of water demand & water collection rates.

Sr. No.	Name of village	No. of Irrigator	Area in ha. as per		Amount of water charge paid by farmers in advance (in Rs.)		
			7/12 record	Sanctioned area	Water rates	Local fund	Total Amount
1	Bava Piplava	70	82.45	82.45	23581	4717	28298
2	Arab Timdi	211	398.50	394.24	113033	22602	135635
3	Piplava	158	229.86	220.63	63093	12625	75718
4	Dedrava	4	9.90	9.90	2831	566	3397
5	Akala	88	119.70	118.89	33998	6798	40796
6	Choki	1	2.02	2.02	578	116	694
7	Ishapur	0	0	0	0	0	0
8	Kathrota	0	0	0	0	0	0
	Total	532	842.43	829.13	237114	47424	284538

Table 2 : The time allocation schedule for tail minor No.10.

Sr. No.	Name of Irrigators	Survey No.	Land area as per 7/12 record	Land area sanct-ioned	Allotted time in Hrs.	Rotation period (date & time)			
						Water supply started		Water supply closed	
						Date	Time	Date	Time
1	Nanduben Popatbhai	63/2	0.88	0.88	10=35	14-10-14	14=00	15-10-14	00=35
2	Savitaben Govindbhai	24	0.70	0.70	08=25	15-10-14	00=35	15-10-14	09=00
3	Arjanbhai Vallabhbhai	243/1	1.41	1.41	16=55	15-10-14	09=00	16-10-14	01=55
	-	Total	2.99	2.99	35=55	-	-	-	-

Table 3 : Crop productivity& Income

Sr. No.	Name of crop	Irrigated area in ha.	Crop productivity Kg/ha.			APMC Market price Rs/Kg.	Additional yield & income due to irrigation	
			Without Irrigation	With Irrigation	Additional Productivity due to irrigation		Total yield in Kg.	Additional Income in Rs.
1	*2*	*3*	*4*	*5*	*6=5-4*	*7*	*8=3x6*	*9=7x8*
1	Groundnut	249	625	1500	875	35	217875	7625625
2	Cotton	580	700	1250	550	40	319000	12760000
	Total	829	-	-	-	-	-	20385625

Table 4 : Water Productivity & Water Use Efficiency

Water release at HR		Area irrigated in ha.	Duty = Area/ volume of water	Delta at HR in mm.	Delta at field in mm with 67 % conveyance efficiency	Additional income in Rs. due to irrigation	Water productivity in Rs/M3 at HR
Mcft	M3						
1	*2*	*3*	*4=3/1*	*5=2832/4*	*6=5x0.67*	*7*	*8=7/2*
35.34	1000850	829	23.46	120	80	20385625	**20.37**

/ Mcft of water release from HR.120 mm. water delta received by farmers at HR and it will reach hardly 80 mm. depth at field considering 67% conveyance efficiency. Any Irrigation Engineer / Agronomist can justify that even after longer dry spell in medium black soils of Uben command area minimum 3 inches water depth is needed to irrigating the field. That means water use efficiency is very high in this project.

CONCLUSION & LESSON LEARNED BY fARMERS IN THIS SITUATION

Now farmers has realized that crop should be irrigate with the help of alternate furrow irrigation or Drip irrigation and day by day area under drip irrigation has been increased particularly in Cotton crop and sprinkler in Groundnut crop. If farmers of canal irrigated area having uniformity, co-ordination and co-operation anybody can convenience to take right decision at right time.

It is a rewards from Right Decision at Right Time.

A drop of water is worth more than a sack of gold to a thirsty man

Assessment of Groundwater Vulnerability to Pollution by using GIS based DRASTIC Model in Delhi Region

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INTRODUCTION

Ground water is the principal resource of water for drinking, agricultural, and industrial requirements. Increasing population and rapid industrialization particularly in developing countries like India, has affected the availability and quality of ground water due to over utilization and inappropriate waste management in urban areas [1] [2]. The demands of the growing population have also necessitated developing new methods and plans to conserve the available groundwater resource [3]. In this perspective, scientists and resource managers have sought to develop aquifer vulnerability assessment techniques for projecting which areas are more likely to become contaminated due to activities at or near the land surface[4].

In general, groundwater vulnerability is the tendency or likelihood for the contaminants to reach a specific location in the groundwater system after release at some location above the uppermost aquifer [5]. The concept of groundwater vulnerability relates to the fact that certain physiographic settings are inherently more vulnerable or sensitive to having contaminants migrate from surface to impact ground water quality. If these areas of higher vulnerability can be identified, then land use developments that pose a higher risk to the groundwater system can be redirected to less sensitive areas.

After rigorous research, a variety of methodologies for the assessment of groundwater vulnerability to pollution have been devised worldwide with different sets of hydrogeological parameters and variability of parameters produces different results. The most widely applied model is DRASTIC [6] which was developed by US EPA (United States Environmental Protection Agency) as a standardized system for assessing the intrinsic vulnerability of groundwater to contamination. In the same year, Foster (1987) developed GOD model [7], a classical system for quick assessment of aquifer vulnerability to pollution. Van Stempvoort et al. (1993) employed AVI model [8] by using the thickness of aquifers and hydraulic conductivity and later Civita (1994) developed a new model SINTACS [9] by modifying DRASTIC. Thereafter, various improved versions of vulnerability index were formulated and applied by various researchers. In this study, DRASTIC was adopted for vulnerability assessment. DRASTIC model was developed for groundwater vulnerability in USA, however, it has been applied in many countries including Japan [10], China [11], Tunisia [12], and Ecuador [13]. In India, DRASTIC was employed in Kapgarhi catchment, West Bengal [14], central Ganga plains, Uttar Pradesh [15], Loni, Maharashtra [16] and Mewat district, Haryana [17].

The present case study is related to categorization of Delhi into different pollution vulnerability zones. Since the city has limited surface water allocation for drinking purposes, it is completely reliant on the groundwater to fulfill the industrial, agricultural and domestic requirements. As the groundwater supports major anthropogenic activity in the region, water resource management is of prime importance. This can be achieved through vulnerability maps which demarcate zones where it is susceptible to receive and transmit pollution, so that they can be prevented from future contamination. This study aims to achieve two objectives of studying groundwater vulnerability to pollution through DRASTIC model.

OBJECTIvES

1. Identification of potential contaminant zones by using vulnerability index.
2. Integration of data in GIS to prepare vulnerability maps

METHODS

DRASTIC model was used to assess the aquifer vulnerability to pollution in Delhi region. The information about the layers of the model was provided via geographic information system (GIS). Arc GIS 10.2.2 software was used to generate an interactive geodatabase, compile the geospatial data, compute the DRASTIC index and to generate the final vulnerability map. The methodology followed during the study is given in Figure 1.

DRASTIC MODEL

The DRASTIC model was developed by the United States Environmental Protection Agency in 1985 [6] to evaluate pollution potential of groundwater for entire U.S.A. DRASTIC is based on the hydrogeologic setting and the acronym DRASTIC stands for the seven parameters used to compute vulnerability index. The parameters are Depth to water table, net Recharge, Aquifer media, Soil media, Topography (slope percentage), Impact of the vadose zone and hydraulic Conductivity of the aquifer. The

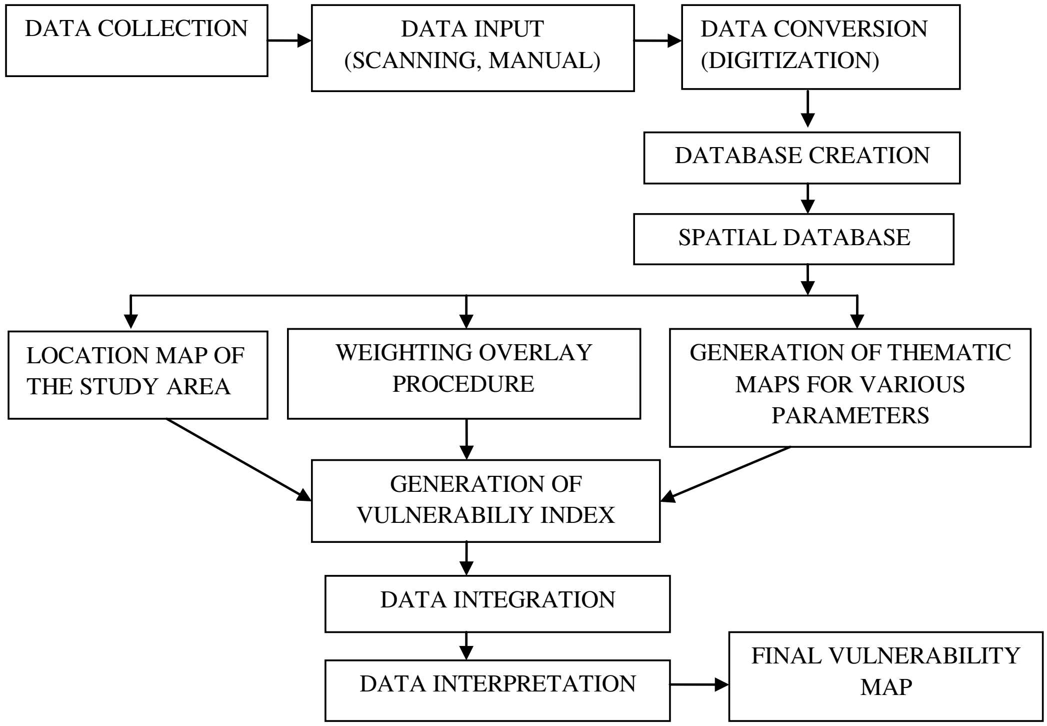

fig. 1 : Flowchart of overall methodology for groundwater vulnerability analysis using DRASTIC model in GIS.

model employs a numerical ranking system that assigns relative weights and rates to various parameters that help in the evaluation of relative groundwater vulnerability to contamination [18]. The numerical relative rating varies from 1 to 10 and weights from 1 to 5 [2]. Table 1 indicates DRASTIC rating and weighting values according to the various hydrogeological settings in the study area. The final vulnerability is a weighted sum of the above seven parameters and can be computed using the following additive equation:

$$D_i = D_rD_w+R_rR_w+A_rA_w+S_rS_w+T_rT_w+I_rI_w+C_rC_w \quad (1)$$

where w is weight factor for parameter and r is rate for parameters

Table 1 : Assigned weights and rates of DRASTIC Parameters

Parameters	Rates	Weights
Depth to water level (D)	1,3,5,7,9 and 10	5
Net Recharge (R)	6,8 and 9	4
Aquifer Media (A)	3, 5 and 6	3
Soil Media (S)	4,5,6 and 8	2
Topography (T)	1 and 9	1
Impact of the Vadose Zone (I)	4 and 6	5
Hydraulic Conductivity (C)	2, 4 and 10	3

Source: Aller et al. (1987)

RESULTS

The final vulnerability map was generated by overlying seven hydrogeological thematic layers in ArcGIS software and then resultant map was reclassified into four classes according to the degree of vulnerability. The DRASTIC index obtained varies from 85 to 157 (Table 2).

Table 2 : Area under vulnerability to groundwater pollution in the study area

Sl. No.	DRASTIC index	Area(in sq km)	Area (in %)	vulnerability zones
1	85-103	323.17	21.79	Low
2	104-121	506	34.12	Medium
3	122-139	381.08	25.70	High
4	140-157	272.75	18.39	Very high
	Total	1483	100.00	

The results of this model revealed that about 21.79% area was in the "low" vulnerable zone with a DRASTIC index ranging between 85 to103 and 34.12% stretch was in the "moderately" vulnerable zone with a DRASTIC index of 104 to 121. 25.7% area was covered under "high" vulnerability zone with a DRASTIC value between 122 to 139 , while 18.39% of area was under "very high" vulnerability category with a DRASTIC index ranging between 140 and 157. This indicates that about 45% of the NCT, Delhi was at very high to high risk regarding pollution potential. These areas were mainly in the

North-West, North, North-East, East, Central, New Delhi and some part of Western districts of Delhi wherein the physical factors like gentle slope and high water table were supporting the chances of shallow aquifer getting polluted. The areas under the 'Very high' vulnerability category mainly lie in the region near River Yamuna, Bhalaswa landfill and Gazipur landfill. The areas, under the 'High' vulnerability were mainly in the North-West and West region of the city like Kanjhawala, Rohini, Mangolpuri, Kingsway camp and Nangloi. The findings suggested that areas in the South, South-West, West and a small part of North-West and East districts of Delhi including Najafgarh, Dwarka, Vikas Puri, Bawana, Ashok Vihar and Mayur Vihar have 'Moderate' vulnerability (Fig 2). On the other hand, a major part of South-West and South Delhi district has 'Low' pollution potential that includes the area along the southern part of Delhi ridge like Hauz Khas, Shekhawati lines and Aaya Nagar. Thus, DRASTIC analysis finally suggests that area along the Yamuna Floodplain is more prone to contamination while potential of groundwater contamination in Delhi ridge area is minimal.

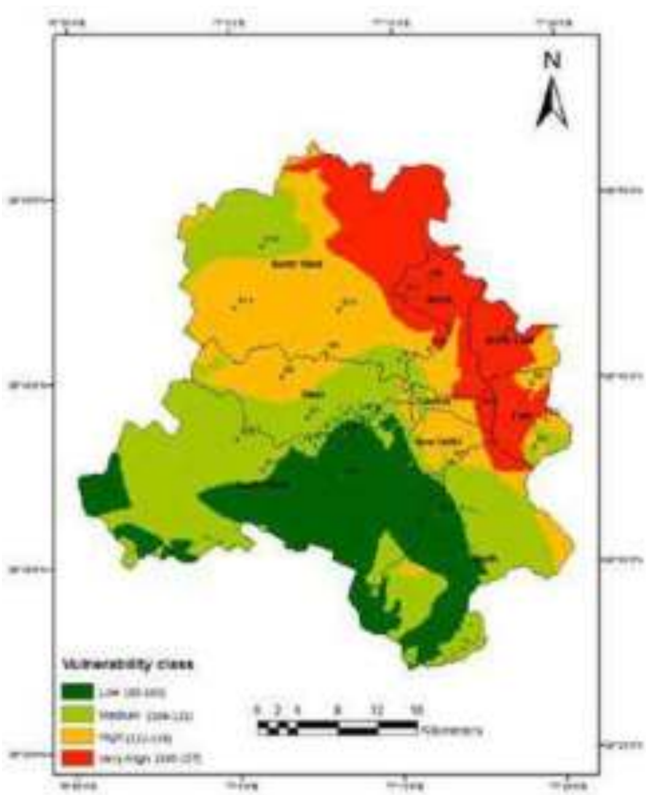

fig. 2 : Groundwater vulnerability map using DRASTIC model

CONCLUSION

The DRASTIC analysis indicated that areas along Yamuna floodplain such as Bhalaswa, Burari, Gokalpuri and Rajghat were more prone to groundwater pollution. This could be credited to its sandy and gravel lithology. Areas along Delhi ridge including Hauz Khas, Aaya Nagar, Mayapuri and Shekhawati lines were found to be least prone to groundwater contamination which could be attributed to the less recharge and deep water table at the given area.

The study exhibits a methodology to assess vulnerability that could be used for various districts in coherence with index mapping techniques to evaluate and identify contamination potential zones. This could be further used by all the stakeholders including private and public agencies to increase awareness and knowledge of groundwater pollution and potential pollution zone.

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Bioremediation of Textile Dye Effluent – A Sustainable Approach

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ABSTRACT

Excessive, inefficient and indiscriminate use of water by textile industry is a major contributor to the degradation of environment. Despite the adverse impact on environment, this sector generates large-scale employment for the skilled as well as unskilled workforce. Much attention has been given on the remediation of contaminants due to the growing awareness and concern of the global community about the discharge of synthetic dyes into the ecosystem and their persistence. Several physico-chemical decolorization methods have been reported over the past two decades, but few have been implemented by the textile manufacturing industry. This has been largely attributed to high costs, low efficiency and poor performance, over wide range of dyes. Bioremediation of synthetic dyes by various microbes is emerging as an effective, innovative and sustainable solution among other emerging pollution control technologies. In this article, we discuss ill effects of textile dye to environment, different methods used for dye decolorization, their progress and limitations.

INTRODUCTION

The textile industry does not only provide clothing to people but also plays a significant role in employment generation and economic growth. The dyeing process is water intensive and the amount of water used depends on various factors, such as the materials being dyed and the equipment used. For example, wool and cotton fabric use more water than polyesters or nylon. During the dyeing process, color is applied to the fabrics, andvarious chemicals are used to enhance the process of adsorption between color and the fibers. When the final product is ready, some of these dyes and chemicals become part of the effluent of textile industry.

This not only exerts pressure on freshwater sources, but also contributes to the pollution load and resists degradation. The effluents can contaminate the surrounding soil, surface water, sediments, degrade the environment and impacthuman and ecological health. To protect the environment, textile effluent treatment is essential which allows subsequent recycling and reuse in textile factory processes or for other suitable purposes.

STATUS AND COMPOSITION Of TEXTILE WASTEWATER

The composition of textilewastewatervaries, depending mainly on the fabric, chemicals, technology and machinery. It is also dependent on the season and fashion trends[1]. The dyes can be divided into two forms - natural and synthetic. Synthetic dyes are widely used because they come in varied bright colorsand are easyto handle. Based on the chemical structure, synthetic dyes are classified into azo, anthraquinone, sulfur, phthalocyanine, and triarylmethane. Based on the application acid, they are classified as basic, direct, disperse, and vat dyeing. Dye effluents are high in color, suspended solids, chemical oxygen demand (COD), biochemical oxygen demand (BOD), pH, temperature and metals. The latter is due to the presence of additives like caustic soda, sodium carbonate. Metals such as mercury, zinc, iron, chromium, and lead cause environmental damage, which makes it crucial to check the effluent with standard concentration before dischargingit to any water stream[2].

THE LEGAL fRAMEWORK Of MANAGING DYE EffLUENTS

In 2015, India was the third-largest exporter of textiles in the world, and more than 45 million people are directly employed by the textile industry. Despite the existing environmental legislation and principles being implemented in the early 1970s, the progress in minimizing and regulating emissions has been limited due to inadequate monitoring and surveillance by the concerned State Pollution Control Boards (PCBs). One of the glaring reasons behind this is low or simple penalties for non-compliance of environmental norms under the existing environment legislations, growing number of small textile industry units lacking any technological, economic, and managerial capacity to handle their waste, corruption and lack of accountability.

In 2014, the 'Circular Economy' approach started taking shape and the narrative towards waste management made a paradigm shift. At the end of 2015, the Ministry of Environment, Forest and Climate Change (MoEF&CC), Government of India, issued guidelines on standard for effluents released from the Textile Industry[1], which proposed that all cotton and woolen processing units must achieve zero liquid discharge (ZLD). Following the Draft notification, the Environment (Protection) Fifth Amendment Rules, 2016 (Table 1) was notified that specify the standards for effluents from textile industry. It mandates ZLD for large units in ecologically sensitive areas. As a result of judicial intervention development which aimed at driving polluters to build wastewater treatment plants and increase the quality of the inputs/ raw materials under the Precautionary and Polluter Pays Principle, the legislature acted promptly by pressuring the Central Pollution Control Board (CPCB) and state authorities to issue directions and take steps to address the environmental pollution by textile industry. In India, he Tirupur region in Tamil Nadu became the first textile industry cluster to systematically practice ZLD. In February 2015, the CPCB by exercising its power under the Water (Prevention and Control of Pollution) Act, 1974, the Environment (Protection) Act, 1986 and the Environment (Protection) Rules, 1986, stipulated stringent standards for the textile industry for discharging pollutants. Directions were issued to the wet processing textiles sector in nine Gangetic states to implement ZLD-based CETPs (Common Effluent Treatment Plants) and IETPs (Industrial Effluent Treatment Plants). This was done as attempt to achieve the wider goal to pursue the installation of ETPs (Effluent Treatment Plants) and decrease the impact on the river's water quality. Those Textile units which released more than 25,000 L/day (25 KLD) were given 16 months (till the end of December 2016) to put in place the required infrastructure and ensure that the technique worked well. Abstraction of groundwater, surface water or the municipal water supply was prohibited for regular industrial process. However, use of reused water was incentivized and fresh water could only be used as makeup water along with reused water.

ISSUES AND CHALLENGES fACED DURING REMEDIATION

As water is the key component in the dyeing process, the textile industry has been one of the major producers of waste water. Approximately 100 L of water is expected to be required for processing of 1 kg of textile chemicals[3]. Every year all around the world, almost 2,80,000 tons of textile dyes get released into industrial wastewater.

Table 1 : Standards for discharge of effluents from textile industry and real textile effluent from different sources

Parameter	**Standard (applicable for all modes of disposal)**	**India** [35]	**Pakistan** [36]
pH	6.5 to 8.5	10.7	8.8
Colour P.C.U (Platinum Cobalt Units)	150		66
Suspended Solids	100	6438	
Bio-Chemical Oxygen Demand (BOD)	30	1478	201
Chemical Oxygen Demand (COD)	250	1734	513

Wastewater from the textile industry has many polluting substances, like organochloride pesticides (OCPs), heavy metals, etc. [4]. Synthetic dyes are modeled in such a manner that they are recalcitrant and resist fading on treatment with water, soap, sweat, light, or any type of oxidizing agent.

The appearance of color in the effluent is the first sign that water has been polluted, and the release of this colored effluent negatively affects the main water stream. Even at a concentration of 1 mg/L, some of the dyes could be observed in water. These water streams, when used in agriculture, can potentially cause bioaccumulation of contaminants in the edible crops which gets in to the food chain and adversely impacts human health and ecology. These colored effluents, when mixed with water bodies, reduce its light penetration capacity and thereby negatively impact the aquatic flora and fauna.

ENvIRONMENTAL AND HEALTH IMPACTS Of TEXTILE WASTEWATERS

Dye-containing effluent also has been shown to increase the BOD of contaminated water. Azo dyes are largest group of synthetic dyes of all the defined dyes and are extensively used. Textile effluent has been characterized by undefined organic pollutants, dyes, increased chemical oxygen demand (COD)and high conductivity due to a high amount of dissolved salt, high amount of sulfide, halogen, and heavy metals. Most of the dyes pose health risks to all kinds of life forms because of their non-biodegradable nature. Azo dyes have been known as potential health hazards. Several azo dyes have also been the cause

1. Draft Notification for Amendment Rules on Standards for Effluent from the Textile Industry

of DNA damage, which leads to malignant tumors[5]. When azo compounds enter the human body through skin contact or injection, they are metabolized intofree radicals and aromatic amines in the gastrointestinal tract and the mammalian liver via azo-reductase. Azo dyes are known as relatively persistent contaminants asunder aerobic conditions, they are not readily degraded. In anaerobic conditions, intestinal bacteria and some environmental microorganisms can reduce azo dyes to colorless amines,which can be mutagenic, carcinogenic and toxic to humans and animals. Three specific forms of carcinogenic activation pathway are available for azo dyes: (1) oxidation of azo dyes with structures containing free aromatic amine groups; (2) reduction and cleavage of the azo bond to produce aromatic amines; and (3) activation of azo dyes via direct oxidation of the azo linkage to highly reactive electrophilic diazonium salts.

REMEDIATION Of TEXTILE WASTEWATER

The textile industry is under immensestress to cut down the application of harmful chemicals, particularly mutagenic, carcinogenic, and allergenic substances. The remediation of textile dye effluent is focused not only on the removal of color (deolorization) but also on the dye molecule’s degradation and mineralization. Physical and chemical processes are used to decolorize colored effluent and were subjective to physio-chemical factors like dye interaction, particle size, sorbent surface area, temperature, pH, and contact time[2]. Conventional treatment methods for effluent treatment have been ineffective in dealing with effluents containing synthetic dyes, which are highly unstable chemical pollutants. (Table 2) presents and array of treatment methods and associated demerits. In order to overcome these challenges, in recent years biotechnological methods have been used, which have shown remarkable achievements.

The drawbacks of all these processes have been mainly due to low efficiency, high cost, disposal problems, and limited versatility. Thus, most of the chemical and physical methods for the treatment of colored wastewater are not widely used in textile industry sites or plants [6].

BIOLOGICAL METHODS Of TEXTILE DYE DEGRADATION

In the last few years, awareness among the scientific community about biological techniques has increased tremendously. These techniques have various benefits over the conventional ones such as low cost, environment-friendly, safe operation, and less sludge production. Biotransformation, biodegradation and bioremediation are regarded as remediation or treatment processes achieved by the use of simple biological systems. Bioremediation is now being considered as an upcoming treatment option for dye removal in diverse conditions. For the complete elimination of toxins and /or harmful substances from the atmosphere, bioremediation utilizes biological components (microorganisms or enzymes). In contrast, biotransformation is referred to as conversion of contaminants from highly toxic to harmless form by chemical modification brought about by living organisms. Flexibility in this technique is understood by the fact that they can be employed ex-situ (off-site) or in situ (on-site), and even plants can be used (phytoremediation).

Table 2 : Different chemical and physical methods for treating dyes with their associated demerits (Alabdraba and Bayati 2014).

Treatment methods	**Demerits**
Fenton's reagent	Sludge generation
Ozone treatment	Short shelf life
Photochemical oxidation	The formation of byproducts is a major drawback.
Sodium hypochlorite	The generation of toxic chlorinated compounds which are considered dangerous for the environment as well as human health
An electrochemical	A high amount of electricity is required.
Membrane filters	Concentrated sludge production is a major disadvantage.
Ion exchange	Regeneration is a possible economic constraint, not useful for dispense dye.
Coagulation/ flocculation	Sludge generation, poor result with acid dyes
Radiation	Radiation is very expensive, which makes it less feasible to use

Until now maximumstudies have focusedon the utilization of microbial species for the treatment of dye wastewater but now the scientific community has recently recognized that plants developing near polluted sites are equipped with transport systems (facilitating the removal of contaminates from water and soil systems within plants) have the inherent metabolic and extractive ability that allows them to dealefficientlywith accumulated pollutants[7], [8]. Studies have shown that plant species genetically adapt withtime to survive and evolve to metabolize or detoxify toxins on highly polluted substrates to overcome environmental stress[9], [10].

Phytoremediation has begunto develop as an energy-efficient and environmentalsustainable remediation technology for air, soil, surface, and groundwater. Basically, it is a collection of techniques that emphasize the effective application of plants, their associated enzymes, and accompanying microbes for the isolation,transport, detoxification, sequestration and mineralization of toxicants through complex natural biological, physiological, and chemical processes/ activities of plants and their microbes.Plants like Lemna minor, Scirpusgrossus, Eichhorniacrassipes, Spirodelapolyrrhiza are used for removal of different types of dyes[11]–[14]. Such plants can then be safely harvested, processed, or disposed of.

fungi are most effective in breaking down or sometimes complete mineralization of synthetic dyes. These degradation properties are attributed to the presence of a powerful extra-cellular and intracellular enzyme system comprising of lignin peroxidase, laccase and manganese peroxidase, robust morphology, and various metabolic activities. The benefit of fungal mycelia over unicellular species is that they produces enzymes which solubilizes the insoluble material. They have a high cell to the surface ratio, which allows them to have greater interaction with contaminants, both physically and enzymatically. In tolerating a high concentration of toxicants, extra-cellular fungal enzyme are also beneficial. Some of the examples are Alternaria alternate, Aspergillusniger and Phachrysosporium[15]–[17].

Bacteria have many advantages as compared to filamentous fungi, such as faster growth rate, higher hydraulic retention time, and could be efficient in treating high-strength organic wastewaters.Generally, azo dyes decolorization occurs under conventional anaerobic, facultative anaerobic, and aerobic conditions by different groups of bacteria. Wide variety of bacteria are used for remediation of dyes they are Nocardiopsis alba, Pseudomonas sp., Bacillus cereus and Klebsiella sp.[18]–[21].

Yeast is able to grow fast and withstand adverse environmental conditions [22]. Limited literature is available on the study of the decolorization effectiveness of yeast. Some groups of microorganisms have not been extensively studied for their degradation abilities with respect to synthetic dyes and other organic xenobiotics. For example, cyanobacteria (blue-green algae) have a ubiquitous distribution, but there is scant information about their role in the functioning of ecosystems, including degradation of recalcitrant compounds such as dye and dyestuffs. Chroococcus minutes, Gloeocapsapleurocapsoides, Phormidiumceylanicum are some of the algae reported on dye decolorization [23].

ENZYMES fOR DYE REMOvAL

The plant and microbial systems possess efficient enzymatic systems which can be used for bioremediation. Therefore, it is important to find out the mechanism of biotransformation followed by the organism and probable enzymes involved in complex biochemical reactions. The enzymatic treatment methods positively influence the environment as they pose a low chance of biological contamination. Enzymes of both bacterial and fungal origin, such as lignin peroxidase, manganese peroxidase, and laccase, can metabolize xenobiotic compounds [19], [24], [25].

Laccase belongs to the multicopper oxidases group, which has low substrate specificity and is highly capable of degrading the spectrum of xenobiotic compounds and aromatic and non-aromatic substrates.The enzyme can degrade phenolic compounds and aromatic azo compounds. Cu^{2+} is used as a mediator to oxidize aromatic amines[26], [27]. Laccase enzyme produce by Fungal strain Podoscyphaelegans is able to decolorize five azo dyes (Congo Red, Orange G, Direct Blue 15, Rose Bengal, Direct Yellow) efficiently [27].The versatile laccase enzyme produce by Streptomycetes sp. has opened a new door for its commercial use.

Azoreductase, also known as azobenzene reductase, is a reducing enzyme. These catalysts can degrade azo dyes into colorless amines via the process of reductive cleavage. The whole process requires Nicotinamide Adenine Dinucleotide (NADH) or Flavin Adenine Dinucleotide (FADH), which acts as an electron donor in a redox reaction[28]. Microbes like Staphylococcus aureus, Bacillus subtilis and Pseudomonas sp. have been found to decolorize azo dyes (Methyl Red, Disperse Blue and Acid yellow) through the production of azo reductase [29]–[31].

Peroxidase isrelated to the group of oxidoreductases, which work on peroxide acting as the electron acceptor. Knowledge of such factors will influence the degradation activity, facilitating the development of bioreactors for the bioremediation of industrial waste. These enzymes have a heme group attached to the active site. Both lignin and manganese peroxidases have same reaction mechanism (catalytic enzyme causes oxidation of H2O2 to an oxidized state) (Durán and Esposito 2000). Various microorganisms involved in dye decolorization with peroxidases activity includes Thermomonosporacurvata[32], Bacillus subtilis[33], Enterobacterignolyticus[34].

CONCLUSION AND WAY fORWARD

At present, wastewater from textile dyeing is one of the significant sources of water pollution. This type of wastewater has the characteristics of high color, COD and BOD value, complicated structures, which makes it difficult to degrade. Textile effluent mainly consist of hard to treat waste and toxic wastes,each of which requires different pollution prevention and treatment approach. Individual waste/waste stream signify an individual problem which can be solved by considering the facts like,

1. Region

2. Local Condition
3. Local drainage conditions
4. Main sewage channel
5. Quantity and composition of waste water

Our main focus should be in adopting technologies which enableminimum environmental pollution. Unfortunately, none ofthe treatment method is efficient or universally accepted for effluent treatment. Therefore, treatment of effluent is done by application of various methods, which includes physical, chemical and biological treatment depending upon pollution load. The class of life directly dependent on ability to manage water in interest of the people. Minimization of waste has great significance in lowering the emission load and cost of production. The main purpose of wastewater treatment process is water can either be reused or returned to the water cycle, but never be wasted. Moreover, it reduces the cost of buying more water for industrial purposes. With the improvement of the environmental protection laws, and the growing awareness on environmental protection and compliance, the pollution of dyeing enterprises, and the treatment of textile dyeing wastewater have caught the attention of stakeholders. The enhancement of knowledge of wastewater treatment technology, and the improved understanding of microbial ecology and the web of intra-species linkages, are the need of the hour. Combined efforts are required by textile industry specialist and water technologists to cut down the water intake in the industry. Our main focus should be to save life and its environment. Thus we should minimise using chemicals and dyes, which are harmful to our ecosystem.

Conflict of interest : The authors declare that they have no conflict of interest.

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Common and Emerging Aspects of Water Quality and its Public Health Impacts

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INTRODUCTION

Water is most essential for life to exist.Clean, safe water for drinking, cooking, and for other potable purposes is a basic requirement. In 2011, the per capita water availability in India was 1545 cubic metres per year, which is likely to go down to 1140 cubic metres per capita per year in 2050. Water quality can have significant impacts on public health.Some 1.8 million people die every year of diarrheal diseases like cholera. The United Nations' Sustainable Development Goal (SDG) 6.3 reiterates the importance of clean water by setting out to improve ambient water quality.

Majority of drinking water supplies in the developing world are contaminated. Water pollution is the single largest threat to human health and food security. Water-borne disease are increasing due to the uncontrolled release of pesticides, heavy metals, and pathogens in water. Food safety is also linked with safe water because fresh vegetables and fresh meat when washed with poor quality water can lead to various health concerns.

Also, water-related ecosystems, such as lakes, rivers and wetlands, are among the world's most biologically diverse environments and provide numerous products and services. Despite the values and benefits of water-related ecosystems, they face considerable pressures to meet short-term demands of socioeconomic development, thereby putting human sustainability at risk. Soil salinity levels are increasing due to poor irrigation practices, high evaporation rates, and increase in groundwater salinity levels.

Water Pollution is the presence in water of unsafe or objectionable material enough to degrade water quality. The different attributes of water in the natural state include the following:

- Physical aspects related to colour, smell, and temperature of water
- Chemical aspects including pH, DO (Dissolved Oxygen), BOD (Biological Oxygen Demand), Emerging contaminants such as: Persistent Organic Pollutants (POPs), Endocrine Disrupting Chemicals (EDCs), Polyaromatic Hydrocarbons (PAHs), Pharmaceuticals and Personal Care Products (PPCPs), Heavy metals, Arsenic, Fluoride, and high load of Nitrates, Phosphates, etc
- Biological attributes determined by the presence or absence of microorganisms in water.

The natural sources of water pollution include surface run-off, seepage from ground water and swamp drainage, reaction between water droplets and atmospheric oxides of Sulphur and Nitrogen, and leachatefrom organic sources that can be further strengthened with respect to toxicity induced by POPs, EDCs, and others. The anthropogenic sources of water pollution include industrial, domestic, agricultural, and mining.The point sources of water pollution are piped sewage (municipal), storm water drains and industries. The non-point sources include agricultural runoff, atmospheric pollution, seepage from mines, and unsewered human habitations.

TRANSfER Of POLLUTANTS

In order to understand water pollution, it is important to first discuss about the transfer of various substances within the natural water cycle. The hydrological or water cycle (Figure 1) shows major transfers of water between land and water surfaces. At a deeper level, the hydrological cycle entails a wide range of scales and has a great deal of variability in time and space. Precipitation, which is the source of all freshwater in the hydrologic cycle, falls nearly everywhere on the earth's surface, but its distribution, is highly variable across regions. Similarly, evaporation and transpiration return water to the atmosphere, but evaporation and transpiration rates vary considerably according to climatic conditions of a place. As a result, much of the precipitation never reaches the oceans as surface and subsurface runoff before the water is returned to the atmosphere. The relative magnitudes of the individual components of the hydrological cycle, such as evapotranspiration, may differ significantly even at small scales, as between an agricultural field and/orany other land surface(Winter et al, 1998).

TREATMENT Of CONTAMINATED WATER

Different kinds of pollutants can be treated through different techniques, as indicated below:

- Arsenic removal technologies include oxidation, coagulation, precipitation, adsorption, ion exchange and membrane techniques. Arsenic is removed by co-precipitation and adsorption using iron coagulants. Ferric oxide has a high affinity for adsorbing dissolved metals like arsenic. Activated alumina is an adsorbent

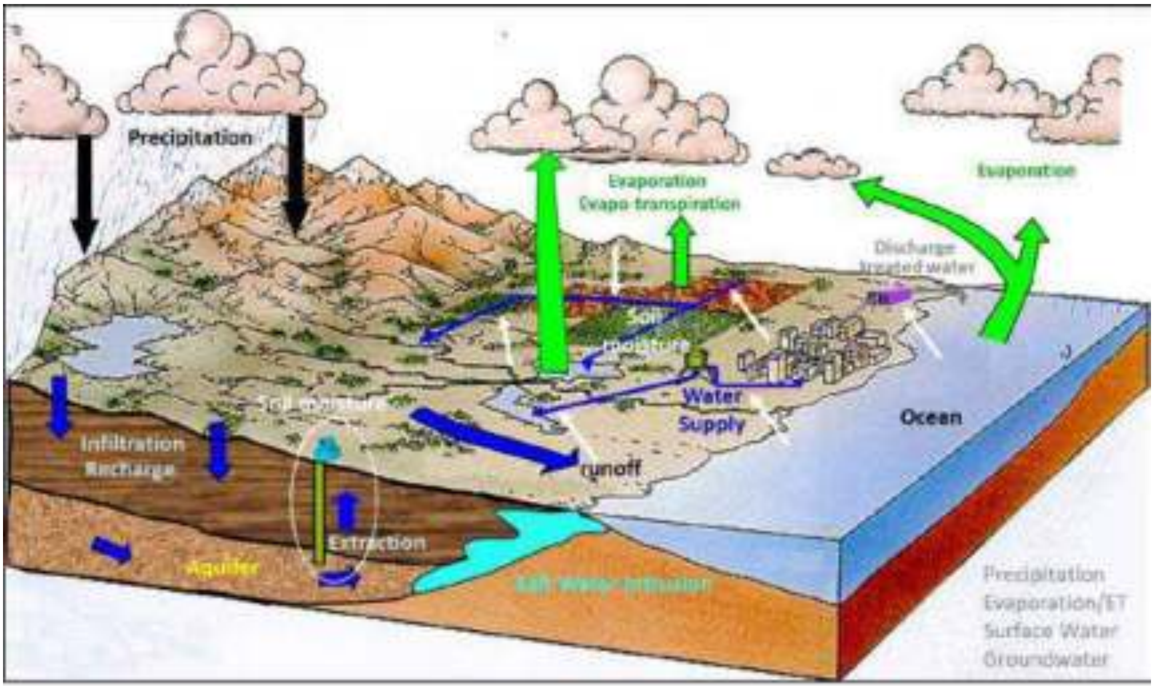

figure 1 : Processes of hydrological cycle determining transfer of pollutants (Source: Winter et al, 1998)

that effectively removes arsenic. Reverse Osmosis (RO) and electrodialysis can remove arsenic with a net ionic charge.

- Fluoride can be removed through RO, Activated Alumina Defluorination Filter, Distillation filter
- Nitrates are removed through Ion exchange and RO
- Perchlorate can be removed through destructive processes such as: biological reduction, chemical reduction, and electrochemical reduction; and Physical removal processes involve Anion Exchange and Membrane Filtration/RO.
- Methyl tert-butyl ether (MTBE) can be removed through air stripping, Granular Activated Carbon (GAC). GAC treatment technique pumps contaminated water through a bed of activated carbon to remove organic compounds. Since MTBE does not sorb well to organics such as carbon, high volumes of the contaminated water must repeatedly pass through a GAC system before MTBE is effectively removed.
- Air stripping is a process in which contaminated water is passed through a column filled with packing material while the upward-flowing air removes chemicals from water but requires high water-to-air ratio.

NEW AND EMERGING CONTAMINANTS

The health concerns in Punjab due to deteriorating water quality is primarily caused by massive and unregulated use of pesticides and other agricultural chemicals. According to an environmental report by the Government of Punjab, the modest-sized State accounts for 17% of India's total pesticide use. The State's water, people, animals, milk and agricultural produce are all getting contaminated with these pesticides.

Emerging contaminants are synthetic or naturally occurring chemicals or any microorganisms that are not commonly monitored in the environment but have the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects. The sources of emerging contaminants include the following:

- Pharmaceuticals and Personal Care Products (PPCPs)
- Detergents and Surfactants including some additions from nonylphenol (NP), a synthetic organic chemical primarily used as abuilding block of nonionic surfactants used in lubrication, defoaming agents, emulsifiers, wetting and de-wetting agents, dyes, etc.
- Nanomaterials
- Flame retardants such as : Poly-Brominated Diphenyl Ethers (PBDEs)
- Disinfectants
- Fragrances
- Pesticides and Repellants
- Plastics and plasticizers such as Bis-Phenol A (BPA)
- Fumigants

With advances in testing and health research, experts are discovering and learning about these new and emergent pollutants in our environment, and its potential hazards in drinking water. In many cases, the possible harms and their pathways are not yet fully known as these are the newly "discovered" contaminants. The complexes formed from these chemicals have the potential for being carcinogenic, mutagenic, or teratogenic responses in mammalian systems.

Figure 2 helps to explain how the body burden of POPs and other chemicals that is built through lifetime exposures. It may start in-utero, through the mother's exposure to POPs in food, water or air. After birth, exposure occurs first through breastfeeding (up to 12–18 months, in general) and afterwards, through contamination in solid foods that are usually introduced after 6 months. The toddler spends much time on the floor, and may be exposed to contaminated soil – through skin or because of ingestion. Occupational exposure starts later in life – usually after late adolescence. Contaminated air, water and the environment continually accumulate to the body burden throughout life.

The timing of exposure of POPs is the most critical factor. Exposure during the "programming" period in the fetal stage may result in permanent changes. Exposure during adulthood tends to be compensated by homeostasis and may not result in detectable effects. Exposure to the same level during different life stages may produce different effects. Timing of exposure will determine both the nature and severity of effects.

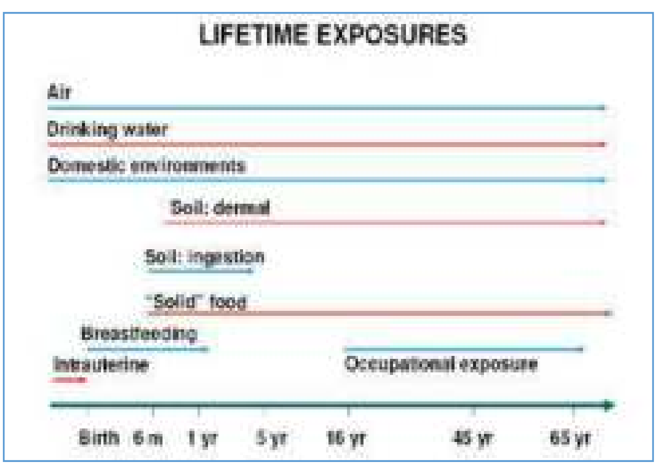

figure 2 : Body burden of POPs and other chemicals built through lifetime exposure

POPs is a set of hazardous chemicals as mentioned in the Stockholm Convention. Research indicates that monitoring is the critical component in the management of POPs,for which both capacity building and implementation should be prioritized in India. Since POPs are found in trace levels in environmental matrices, high-end analytical techniques such as gas chromatography-electron capture detector (GC-ECD), gas chromatography-mass spectrometer (GC-MS), GC-MS/MS, liquid chromatography-MS (LC-MS), and GC-high resolution MS (GC-HRMS) are used for analysis of POPs. Mass spectrometry techniques is an indispensable tool for the determination of new POPs in various matrices, due to its high accurate mass determination and the possibility to couple with separation techniques like LC or GC. However, several challenges need to be carefully handled to achieve successful determination of thePOPs with high accuracy and precision. As newer POPs continue to get added to the Stockholm Convention, more novel methods are expected to complement our understanding of the fate and behavior of POPs, more specifically the 'new' POPs in the environment.

CURRENT GAPS IN LITERATURE

There exist gaps in literature on POPs in terms of environment and human exposure. Common beliefs consider India as a hotspot of POPs contamination. However, not much systematic analysis is available considering past data. Available data are highly fragmentary and typically refer to rural or urban areas, and information on background environment contamination is scarce.

In terms of chemical management framework, there is a fragmentary legislative chemical management framework wherein a shift in paradigm is evolving lately. It involves various jurisdictions, is complex in nature, and follows a retrospective approach for chemical management. It misses a dedicated strategicframework for the management of priority classes of pollutants. Also, there is lack of investments for analytical and emission reduction technology of these pollutants. The concept of "public participation and awareness" is also not adequate. The level of environmental protection between developed and developing countries follow a double standard approach, and needs to follow a systematic path.

Data is abundant for legacy contaminants, but very little information is available on emerging POPs. Most of the studies were generated by different research groups using different sampling and analytical methods. There is lack of inter-laboratory-calibration, which makes it hard to represent a country-level scenario. There is also lack of basin scale or regional scale monitoring. We have conducted a catchment level study on the river Ganga.

Our project 'India-Norway cooperation project on capacity building for reducing plastic and chemical pollution in India' (INOPOL) aims to address the highly interlinked challenges of marine litter, microplastics and POPs. The project focusses on the cities of Vapi (in the Daman Ganga catchment) and Surat (in the Tapi catchment) in the industrial state of Gujarat, India. It investigates the land-based sources, river fluxes and ocean input of microplastics and POPs pollution through a knowledge-based scientific approach that seeks to enhance ongoing efforts by key stakeholders (Ministries, scientific institutions, NGOs) to reduce plastic and chemical pollution in Gujarat. The expected outcomes are to develop increased capacity to reduced marine litter and microplastics pollution in Gujarat, as well as reduced releases of POPs (including new POPs)to support the implementation of the Stockholm Convention.

WATER SAMPLING METHODOLOGIES

Sampling is the act of collecting a portion of water sample for analytical purposes that accurately represents the water being sampled with respect to stated objectives. Sampling strategy for water samples is an easy process. In many cases, because water is mobile, a set number of bulk samples are simply collected from the same point at various time intervals like active sampling from a river. Some of the other water sampling methodologies include high volumeactive water sampling, where water is passed through polyurethane foam (PUF) plugs. Passive air samplers are used for the collection of POPs, EDCs or other emerging contaminants in ambient air. These instruments can be deployed quickly, easily, and in any location. They do not require electricity and are maintenance free and require very little interaction from the user. Passive air samplers house a PUF, which is uniformly porous to allow gaseous chemicals to penetrate. The samplers with the PUF plugs are deployed and collect the pollutants in ambient air. The PUF disks are later removed from the device and transported to a lab for further analysis. Bulk deposition for air samplingis done to collect all wet and dry particles together, depending both on the aim of the study and on the sampling sites (rural, industrial, or urban areas).

The chemical analytical methods of water include series of operations such as the following:

- Isolation (extraction and separation) of the target chemicals from sample matrix (air, water, sediment, soil, biota, etc.).
- Separation and purification of the target chemical from co-extracted, non-target chemicals (sample clean-up).
- Sample concentration.
- Measurement by highly selective and sensitive analytical equipment, such as Gas Chromatography / Mass Spectrometry (GC/MS). Occasionally it is also necessary to derivatise (chemically modify) non-volatile and heat degradable target chemicals prior to analysis by the two most commonly used instrumental methods in environmental analysis, GC or GC/MS.

POPS POLLUTION AND IMPACTS ON PUBLIC HEALTH IN THE HIMALAYAN RIvERINE REGION

The complexity of POPs pollution in the environment can be well-explained by case studies of POPs pollution in the Himalayan Riverine Region.The Ganges River structure and its tributaries in upper Himalayan Reach and middle Gangetic Reach (Figure 3)is one of the largest transboundary perennial rivers supplying freshwater to the northern and eastern states of India. These tributaries include glacial and snowfed, and rainfed streams. ([A]Alakananda, [B]Bhagirathi, [C]Ramganga, [D]Yamuna ([D1]Chambal, [D11]Kali, [D12]Parbati, [D13]Banas, [D2]Sind, [D3]Betwa, [D4]Rind, [D5]Ken, [D51]Banne).

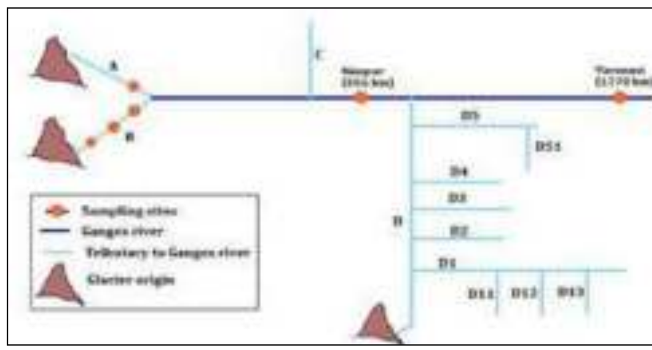

figure 3 : Sketch showing the Ganges River structure and its tributaries in upper Himalayan Reach and middle Gangetic Reach

Melting glaciers are natural redistributors of legacy airborne pollutants, affecting exposure of pristine proglacial environments. Study data shows that melting Himalayan glaciers by legacy atmospheric depositionscan be major contributors of polychlorinated biphenyls (PCBs) and high-molecular-weight polycyclic aromatic hydrocarbons (PAHs) for surface water in the Gangetic plain during the dry season. Glacial emissions can exceed in some cases inputs from diffuse sources within the catchment. The air, deposition and river water in several sections along the Ganges river and its major headwaters were analyzed. The predominant glacial origin of these contaminants in the Himalayan reach was demonstrated using air-water fugacity ratios and mass balance analysis. The proportion of meltwater emissions compared to pollutant discharge at downstream sections in the central part of the Gangetic plain was between 2 and 200% (Goel et al, 2015). By remobilizing legacy pollutants from melting glaciers, climate change can enhance exposure levels over large and already heavily impacted regions of Northern India.

The health and ecological risk assessment of emerging contaminants in surface and groundwater (drinking water) in the Ganges River Basin also shows interesting results (Sharma et al, 2018). At several sites along the Ganges

River, the occurrence and distribution of emerging contaminants including 15 PPCPs (pharmaceuticals, personal care products) and five ASWs (artificial sweeteners) in the river and groundwater (used untreated as drinking water) were investigated. Based on the measured groundwater concentrations, the life-long human health risk from exposure to PPCPs through drinking was estimated. In addition, the risk of exposure to PPCPs and ASWs in the river water for aquatic organisms was also estimated. The sum of detected PPCPs in the river water ranged between 54.7-826 ng/L, with higher concentrations in the severely anthropogenically influenced middle and lower reaches of the Ganges. The highest concentration among the PPCPs in the river water was of caffeine (743 ng/L). The sum of detected ASWs in river water ranged between 0.2–102 ng/L. Similar to PPCPs, the sum of ASWs in the river water was higher in the middle and lower reaches of the Ganges. In groundwater, the sum of detected PPCPs ranged between 34–293 ng/L, whereas of ASWs ranged between 0.5-25 ng/L. Negligible risk for humans was estimated from PPCPs in the drinking groundwater sources along the Ganges river, whereas moderate risks to PPCPs and ASWs (namely: caffeine, sulfamethoxazole, triclocarban, triclosan, and sucralose) were estimated for aquatic organisms in the Ganges River.

Also, perfluoroalkyl substances (PFAS) in river and groundwater (drinking) of the Ganges River basin(Sharma et al., 2015)were also studied. PFAS are ubiquitous environmental contaminants used in production processes and daily-use products or may result from degradation of precursor compounds in products or the environment. In a study to investigate PFAS emission and exposure along steep environmental and socioeconomic gradients, it was found that PFAS concentrations in river and groundwater (used as drinking water in this region) from several locations along the Ganges River and estimates direct emissions, specifically for Perfluorooctanesulfonic acid(PFOS) and Perfluorooctanoic acid (PFOA). 15 PFAS were frequently detected in the river with the highest concentrations observed for Perfluorohexanoic acid (PFHxA) (0.4 e4.7 ng L-1) and Perfluorobutanesulfonic acid (PFBS) (<method quantitation limit (MQL) e 10.2 ng L-1) among perfluoroalkyl carboxylic acids (PFCAs) and perfluoroalkane sulfonates (PFSAs), respectively. Prevalence of shortchain PFAS indicates that the effects of PFOA and PFOS substitution are visible in environmental samples from India. The spatial pattern of C5eC7 PFCAs co-varied with that of PFOS suggesting similar emission drivers. Perfluorononanoic acid (PFNA) and perfluorodecanoic acid (PFDA) had much lower concentrations and co-varied with PFOA especially in two hotspots downstream of Kanpur and Patna. PFOS and PFOA emissions to the river varied dramatically along the transect (0.20e190 and 0.03e150 g d-1, respectively). PFOS emission pattern could be explained by the number of urban residents in the sub-catchment (rather than total population). Per capita emissions were lower than in many developed countries. In groundwater, perfluorobutanoic acid(PFBA) (<MQL e 9.2 ng L^{-1}) and perfluorobutane sulfonate (PFBS) (<MQL e 4.9 ng L^{-1}) had the highest concentrations among PFCAs and PFSAs, respectively. Concentrations and trends in groundwater were generally similar to those observed in surface water suggesting the aquifer was contaminated by wastewater receiving river water. Daily PFAS exposure intakes through drinking water were below safety thresholds for oral non-cancer risk in all age groups.

ENDOCRINE DISRUPTING CHEMICALS (EDCS)

Another cause of public health concern is the presence of Endocrine Disrupting Chemicals (EDCs) in water. EDCs represent a wide and varied range of chemical substances causing disruption on the endocrine system, the organ system producing hormones that regulates many of the body's functions.These endocrine disruptors include diethylstilbestrol (the synthetic estrogen Diethylstilbestrol,DES), dioxin and dioxin-like compounds, polychlorinated biphenyls (PCBs), dichloro-diphenyl-trichloroethane (DDT), and some other pesticides. An endocrine disruptor is an exogenous substance or mixture that alters function(s) of the endocrine system and consequently causes adverse health effects in an intact organism, or its progeny, or (sub) populations (World Health Organization - International Programme on Chemical Safety (WHO-IPCS), 2002). As indicated in the Figure 4, when absorbed in the body, an endocrine disruptor can decrease or increase normal hormone levels (left), mimic the body's natural hormones (middle), or alter the natural production of hormones (right)(National Institute of Environment Health Sciences, n.d.).

Table 1 : Endocrine Disruptors and their sources

Endocrine Disruptor	Sources
BPA (Bis-Phenol A)	Plastics and Thermal receipts
Phthalates	Plastics and Fragrances
PCBs	Electrical coolant
PBDEs	Flame retardants
Lead	Drinking water, paint, gasoline
Mercury	Burning coal, seafood
Dioxin	Formed in industrial processing
DDT/DDE	Pesticides
Arsenic	Drinking water, animal feed, herbicides, fertilizers
Cadmium	Tobacco smoke, fertilizers
Atrazine	Herbicide
Alkylphenols and p-Nonyl-phenol	Detergents, additives

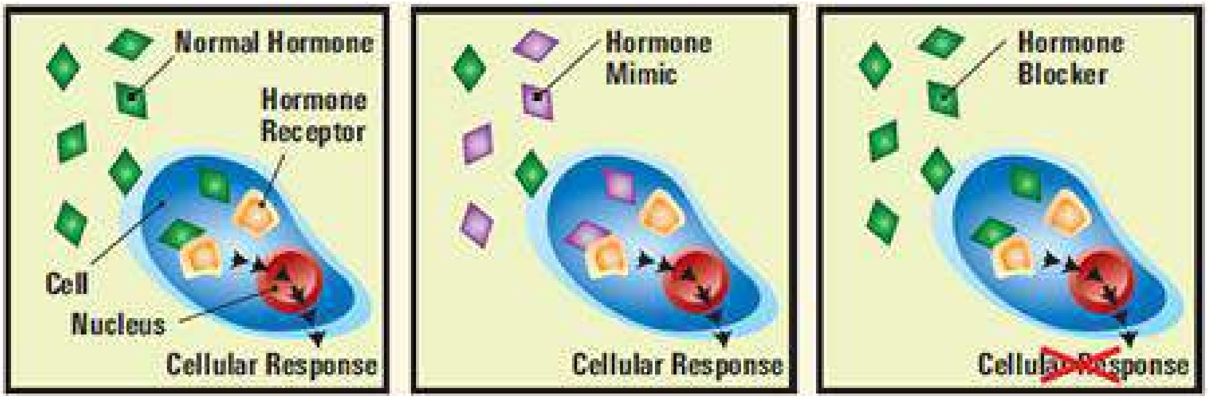

figure 4 : Effects of EDCs on human health

The important factors of endocrine disruption include latency from exposure, age at exposure, importance of mixtures, non-traditional dose-response dynamics, and trans-generational, epigenetic effects. The adverse health effects of EDCs include breast/prostate and other kinds of cancer, birth defects and premature births, thyroid disruption, neurological issues, kidney disorders, asthma, and immune suppression(Schugg et al., 2016).

Another substance that needs to be discussed is Triclosan. It is an antibacterial and antifungal agent present in some consumer products, including toothpaste, soaps, detergents, toys, and surgical cleaning treatments. Triclosan has been found to be highly toxic to different types of algae, keystone organisms for complex aquatic ecosystems, and has been detected at high concentration in earthworms. Triclosan can combine with chlorine in tap water to form chloroform, which is listed as a probable human carcinogen. Over 95% of the uses of Triclosan are in consumer products that are disposed of in residential drains. As a result, widespread use of Triclosan and other antibacterial compounds result in contamination of the waterbodies, with Triclosan being the most prevalent contaminant not removed by typical wastewater treatment plants (Figure 5).

At present, disease risk due to EDCs is significantly underestimated.The key concerns over endocrine disruptors include the high incidence and the increasing trends of many endocrine-related disorders in humans, observations of endocrine-related effects in wildlife populations, and the identification of chemicals with endocrine disrupting properties linked to disease outcomes in laboratory studies.

There are various actions that may be taken to manage EDCs. The first step will be to increase understanding of effects of EDCs, including enhancing and strengthening basic and clinical research and knowledge of EDCs, and advocating involvement of individual and scientific society stakeholders in communicating and implementing

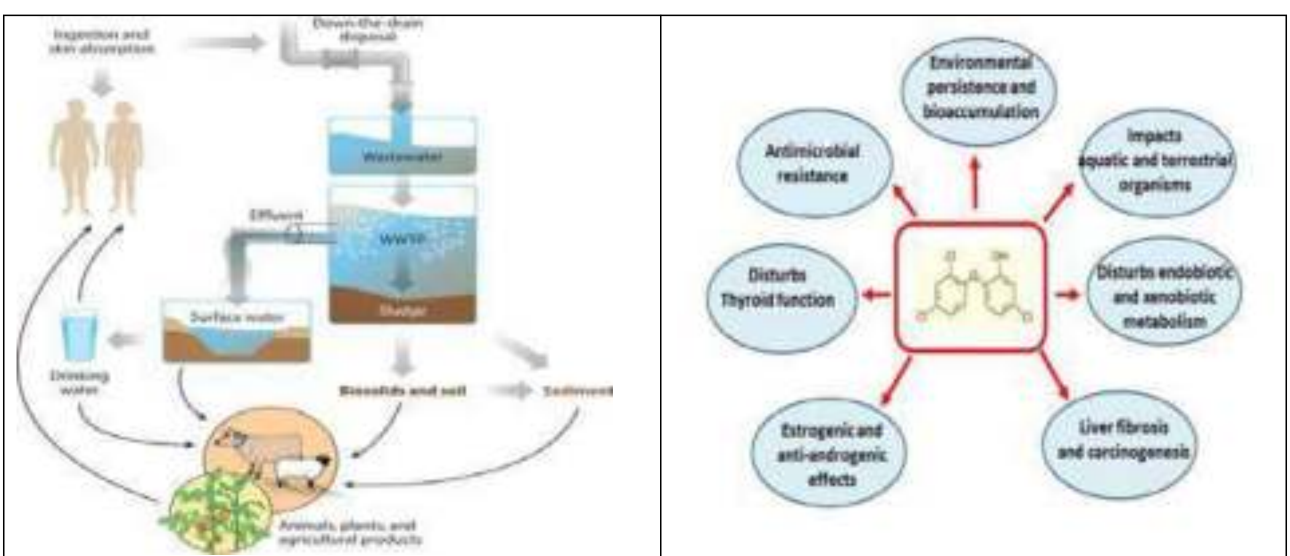

figure 5 : Fate and effects of Triclosan in the environment (Celebi et al., 2018)

changes in public policy and awareness. Also, it is crucial to look at improved testing for EDCs, identifying EDCs for reducing exposures and thereby vulnerability to diseases. It is also important to create an enabling environment for scientific advances, innovation and disease prevention.

CONCLUSION AND RECOMMENDATIONS

While the supply of available freshwater is adequate to meet global water demands, there are concerns related to water quality as well as with the spatial and temporal distributions of water across regions. There are many regions in India where the freshwater resources are inadequate to meet domestic, economic and environmental needs. In such areas, the lack of adequate, clean and safe water to meet the drinking and potable uses of water is a constraint on human health and productivity, and also on economic development and sustainable ecosystems. The need of the hour is therefore to help remove these constraints. We face multiple challenges in the process, especially in the current scenario of changing climate, rapidly growing population, increased social and economic development, and unplanned urbanization. Meeting these challenges requires improved research, awareness, partnership and various other concerted efforts in all aspects of water resources management. This paper is believed to contribute in reporting and disseminating current knowledge, and communicating important information on water quality management. This paper also identifies the issues facing present and future water resources management that is needed to better inform those who strive to create a more sustainable and water-secure future. Some of the key recommendations for water sustainability opportunities to combat the current management challenges are as below:

- Irrigated agriculture plays a fundamental role as a supplier of food. It is however, also the world's largest water user. It is therefore important to analyze agricultural irrigation from the perspective of sustainability with a focus on its environmental, economic, and social impacts. The need of the 21stCentury will be to design innovative sustainable irrigation systems to increase its water use efficiency. The new draft National Policy on Safe Reuse of Treated Water (SRTW) that will soon be introduced by the Government of India is aimed to facilitate the development of water reuse by serving as a valid reference on water reuse practices.It will include guidelines for the utilization for Treated Used Water (TUW) in agriculture and aquaculture by following the required water quality compliance to protect food safety.
- Innovations for designing water saving devices and concepts, and product/model designs must be developed to improve water use efficiency, conserve the environment as well as to save money.
- Water conservation technologies must be developed. These technologies must cover all methods of conserving water through increasing water use efficiency, enhancing capacity to retain runoff water, and eliminating water pollution.
- Water technologies and systems should be designed in such a manner that it protects and cleans degraded water supplies. Such systems will help support development and implementation of risk management strategies to ensure safety of drinking-water supplies through control of hazardous constituents in water.
- Recycling and Reuse of water must be encouraged as much as possible. For example, reuse of wastewater, along with simple water conservation technologies for urban areas (i.e. more efficient toilets, showers and in-house wastewater recycling) can make water conservation more affordable. It can reduce the opportunity cost of selecting sustainable options at individual and community scale (efficient options for urban planning/green building design).
- Nanotechnology for urban water produce may contribute to pollution reduction and accelerates filtration, making water re-use possible and affordable.
- Polluter-pay-principle should be applied on industries and municipalities responsible for dumping industrial and municipal effluents into the rivers and water bodies.
- Information Technology must be used as an effective platform for bringing in behavioral change amongst people by making them aware about reducing wastage of water and managing wastewater. Awareness must be raised in all levels of society about the importance of saving water to cope with its scarcity and ensure sustainability. The aim should be to change citizen attitudes and behaviour to improve water use efficiency.The concept of IoT (Internet of Things) for Smart Water Management must be introduced through implementation of smart devices and sensors that can make water management more efficient and safer for consumers and workers through real-time data collection, forewarning and actions to prevent future problems.
- Watershed management and planning should identify and include the partners, or stakeholders in the watershed. Development of local partnerships can lead to greater awareness and support from the general public. Once the general public becomes aware of and interested in their watershed, they become more involved in decision-making as well as hands-on restoration efforts. Through such involvement, watershed management builds a sense of community, helps reduce conflicts, increases

collective commitment to sustainable actions, and thereby improves the likelihood of success for the watershed management plan.

- Hydrological modelling is an indispensable component of water resources research and management in river basins, and helps in effective policy development and management.
- In order to address the 21stcentury water issues and challenges, it is important to develop innovative curricula, which will give studentsand practitioners tools to create innovative solutions. Students will develop creative confidence to become active problem solvers in innovative ways that will help them confront the water-related challenges and possibilities that surround us in the 21stcentury.
- Capacity building of NGOs (non-governmental organizations), CSOs (civil society organizations)and SHGs (self-help groups) to be undertaken for training and building the capacities of farmer groups for limited use of pesticides, fungicides and weedicides. These programmes to be conducted regularly for mass awareness generation campaigns.
- Pollution of sources of water and water bodies should not be allowed. Water bodies should be periodically inspected by a third party under a mechanism devised by the Water Resource Agency (WRA), which should levy penalty and issue directions to undertake rectification.
- A survey should be conducted for inter-state Rivers and large water bodies to identify polluted or dying rivers/water bodies and a systematicarea-based rejuvenation mission needs to be launched to restore these river stretches/ water bodies to maintain its ecological flow and quality.
- It is imperative to develop value-chain partnerships with organizations having varied skill sets and experiences but shared objectives,to be able to solve regional and local water problemsby drawing various innovative and sustainable solutions, such as:appropriate technology transfer, collection and use of data.

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Climate Changes Impact on Southwest Monsoon Rainfall Pattern Over River Basins of India

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1. INTRODUCTION

Indian southwest monsoon has significant role on the economy of the country as the agricultural production the Khariff crops are purely dependent on rainfall. In addition all other sectors as well as human life and society are also directly or indirectly dependent on rainfall. However rainfall has high spatial and temporal variability and during the southwest monsoon almost 95% of annual rainfall received over Gujarat region to around 45% of annual rainfall received over Tamilnadu region. In the distribution of water over different parts of country various rivers play crucial role.

There are several studies on observed variability and trends over India in different spatial scales viz. meteorological subdivisions (Guhathakurta and Rajeevan, 1998; Guhathakurta et al., 2011, Guhathakurta et al, 2018 etc), districts (Guhathakurta and Saji, 2013, Guhathakurta and Ray, 2019etc). However for water management and in studying hydrological cycle information on mean rainfall patterns and their variability as well as changes in the rainfall pattern in view of climate changes and its impact on water resources is very crucial. Though the country has several river basins but there are high temporal and spatial variability of rainfall. It is very important for water resource management to have an idea of up to date rainfall pattern over river basins and sub basins.

Central Water commission of India has classified the country in to 25 major river basins and these 25 major basins have been further classified as 101 sub basins. Out of these 99 sub basins are in the main land (Table 1). In the present paper we have analyzed monthly mean rainfall pattern and its variability for the four monsoon months and for the cumulative period of June – September. The long term trends and also decadal variability have been investigated to identify the impact of climate change on the river basin rainfall.

2. DATA AND METHODOLOGY

High resolution 0.250X 0.250 daily rainfall data from India Meteorological Department has been considered for the period 1901-2019 for the analysis and river basin and sub basin rainfall series construction. From the daily rainfall series monthly rainfall series for the monsoon months June, July, August and September and also for the cumulative period of four months of the southwest monsoon season have been prepared for each of river sub basins. From the grid point data using GIS, rainfall series for each of the 99 river subbasins are being computed for analysis. Also using area weighted method monthly and seasonal rainfall series of all the 25 major river basins are computed for analysis.

BA_NAME	SBCODE	SUB_BASIN
Indus (Up to border) Basin	BAM	Barmer
Indus (Up to border) Basin	BEA	Beas
Indus (Up to border) Basin	CHA	Chautang and others
Indus (Up to border) Basin	CHE	Chenab
Indus (Up to border) Basin	CHR	Churu
Indus (Up to border) Basin	GHO	Ghaghar and others
Indus (Up to border) Basin	GIL	Gilgit
Indus (Up to border) Basin	JHE	Jhelum
Indus (Up to border) Basin	LIN	Lower Indus
Indus (Up to border) Basin	RAV	Ravi
Indus (Up to border) Basin	SHY	Shyok
Indus (Up to border) Basin	SUL	Sutlaj Lower
Indus (Up to border) Basin	SUU	Sutlaj Upper
Indus (Up to border) Basin	UIN	Upper Indus
Godavari Basin	GDL	Godavari Lower
Godavari Basin	GDM	Godavari Middle
Godavari Basin	GDU	Godavari Upper
Godavari Basin	IND	Indravati
Godavari Basin	MAJ	Manjra

Godavari Basin	PRA	Pranhita and others
Godavari Basin	WAR	Wardha
Godavari Basin	WEI	Weinganga
Krishna Basin	BHL	Bhima Lower
Krishna Basin	BHU	Bhima Upper
Krishna Basin	KRL	Krishna Lower
Krishna Basin	KRM	Krishna Middle
Krishna Basin	KRU	Krishna Upper
Krishna Basin	TUL	Tungabhadra Lower
Krishna Basin	TUU	Tungabhadra Upper
Cauvery Basin	CAL	Cauvery Lower
Cauvery Basin	CAM	Cauvery Middle
Cauvery Basin	CAU	Cauvery Upper
Subernarekha Basin	SUB	Subernarekha
Brahmani and Baitarni Basin	BAI	Baitarni
Brahmani and Baitarni Basin	BRA	Brahmani
Mahanadi Basin	MAL	Mahanadi Lower
Mahanadi Basin	MAM	Mahanadi Middle
Mahanadi Basin	MAU	Mahanadi Upper
Pennar Basin	PEL	Pennar Lower
Pennar Basin	PEU	Pennar Upper
Mahi Basin	MHU	Mahi Upper
Mahi Basin	MHL	Mahi Lower
Sabarmati Basin	SAL	Sabarmati Lower
Sabarmati Basin	SAU	Sabarmati Upper
Narmada Basin	NAM	Narmada Middle
Narmada Basin	NAU	Narmada Upper
Narmada Basin	NAL	Narmada Lower
Tapi Basin	TAM	Tapi Middle
Tapi Basin	TAU	Tapi Upper
Tapi Basin	TAL	Tapi Lower
West flowing rivers South of Tapi Basin	BHT	Bhatsol and others
West flowing rivers South of Tapi Basin	NET	Netravati and others
West flowing rivers South of Tapi Basin	PAR	Periyar and others
West flowing rivers South of Tapi Basin	VAR	Varrar and others
West flowing rivers South of Tapi Basin	VAS	Vasishti and others

East flowing rivers between Mahanadi and Godavari Basin	NAG	Nagvati and other
East flowing rivers between Mahanadi and Godavari Basin	VAM	Vamsadhara and other
East flowing rivers between Godavari and Krishna Basin	GTK	East flowing rivers between Godavari and krishna
East flowing rivers between Krishna and Pennar Basin	KTP	East flowing rivers between krishna and Pennar
East flowing rivers between Pennar and Cauvery Basin	PAL	Palar and other
East flowing rivers between Pennar and Cauvery Basin	PON	Ponnaiyar and other
East flowing rivers South of Cauvery Basin	PAM	Pamba and others
East flowing rivers South of Cauvery Basin	VAI	Vaippar and others
West flowing rivers of Kutch and Saurashtra including Luni Basin	BHA	Bhadar and other west flowing rivers
West flowing rivers of Kutch and Saurashtra including Luni Basin	LUL	Luni Lower
West flowing rivers of Kutch and Saurashtra including Luni Basin	LUU	Luni Upper
West flowing rivers of Kutch and Saurashtra including Luni Basin	RAN	Drainage of Rann
West flowing rivers of Kutch and Saurashtra including Luni Basin	SAR	Saraswati
West flowing rivers of Kutch and Saurashtra including Luni Basin	SHE	Shetranjuli and other east flowing rivers
Minor rivers draining into Bangladesh Basin	KPO	Karnaphuli and Others
Minor rivers draining into Bangladesh Basin	MHO	Muhury and Others
Minor rivers draining into Myanmar Basin	IMP	Imphal and others
Minor rivers draining into Myanmar Basin	MAN	MangpuiLui and others
Area of North Ladakha not draining into Indus Basin	SHK	Shaksgam

Area of North Ladakha not draining into Indus Basin	SUM	Sulmar
Drainage Area of Andaman and Nicobar Islands Basin	DAN	Drainage Area of Andaman and Nicobar Islands
Drainage Area of Lakshadweep Islands Basin	DAL	Drainage Area of Lakshadweep Islands
Ganga Basin	ARA	Above Ramganga Confluence
Ganga Basin	BAN	Banas
Ganga Basin	BHG	Bhagirathi and others (Ganga Lower)
Ganga Basin	CHL	Chambal Lower
Ganga Basin	CHU	Chambal Upper
Ganga Basin	DAM	Damodar
Ganga Basin	GAN	Gandak and others
Ganga Basin	GHA	Ghaghara
Ganga Basin	GHG	Ghaghara Confluence to Gomti confluence
Ganga Basin	GOM	Gomti
Ganga Basin	KAS	Kali Sindh and others up to Confluence with Parbati
Ganga Basin	KOS	Kosi
Ganga Basin	RAM	Ramganga
Ganga Basin	SON	Sone
Ganga Basin	TON	Tons
Ganga Basin	UGO	Upstream of Gomticonfluece to Muzaffarnagar
Ganga Basin	YAL	Yamuna Lower
Ganga Basin	YAM	Yamuna Middle
Ganga Basin	YAU	Yamuna Upper
Brahmaputra Basin	BRL	Brahmaputra Lower
Brahmaputra Basin	BRU	Brahmaputra Upper
Barak and others Basin	BAR	Barak
Barak and others Basin	KYN	Kynchiang and other south flowing rivers
Barak and others Basin	NAO	Naochchara and others

3. MEAN RAINfALL PATTERN Of RIvER SUB BASINS Of INDIA

Both monthly and seasonal rainfall over sub basins of India has high temporal and spatial variation. Mean rainfall for eachof four monsoon months and also for the southwest monsoon seasons are shown in Fig. 1 and 2 respectively. In June rainfall maximum rainfall around 400-800 mm received over sub basins of West flowing rivers South of Tapi Basin and also sub basins over north eastern parts of India. In July maximum rainfall touches to 1200mm in sub basins of West flowing rivers South of Tapi Basin.

In southwest monsoon season rainfall varies from less than 200 mm to around 3000mm. During the southwest monsoon rainfall received over three sub basins of West flowing rivers South of Tapi Basin viz. Bhatsol and others, Vasishti and others and Netravati and others receive rainfall between 2400mm to 3000mm along with the only sub basin viz. Kynchiang and other south flowing rivers of Barak in north eastern parts of India. Mahanadi Middle, Indravati, Bhagirathi and others (Ganga Lower) along with most of the sub basins of north eastern parts of the country receive rainfall between 1200-1800mm. The sub basins Vaippar and others in extreme south, Barmer in west and extreme northern basins receive rainfall less than 200mm.

4. LONG TERM TRENDS IN SUBBASIN RAINfALL

Fig. 3 shows the observed trends of in monthly rainfall of the sub basins based on 1901-2019 data period. In all the first three months, most of the sub basins of the eastern, central and north eastern parts show significant decreasing trend in rainfall. In July even some sub basins of southern peninsular India have also shown significant decreasing trend. The August month is however very good where most of the western, central as well as south peninsular India show significant increasing trend. Also in June month many sub basins of western and southern parts show significant increasing trend in rainfall. Rainfall has shown significant increasing trend for the months June, July, August and September in 44, 26, 42 and 21 number of sub basins respectively while significant decreasing trend in 15, 26, 26 and 16 number of sub basins but the spatial variability in observed trend in months is clearly noticed.

Observed trend in southwest monsoon rainfall over the sub basins of India is shown in Fig. 4. It can be seen that most of the sub basins of Ganga basin and Brahmaputra Basin are showing significant decreasing trend in southwest monsoon rainfall while Godavari, Narmada and some other basins are showing significant increasing trend in southwest monsoon rainfall.

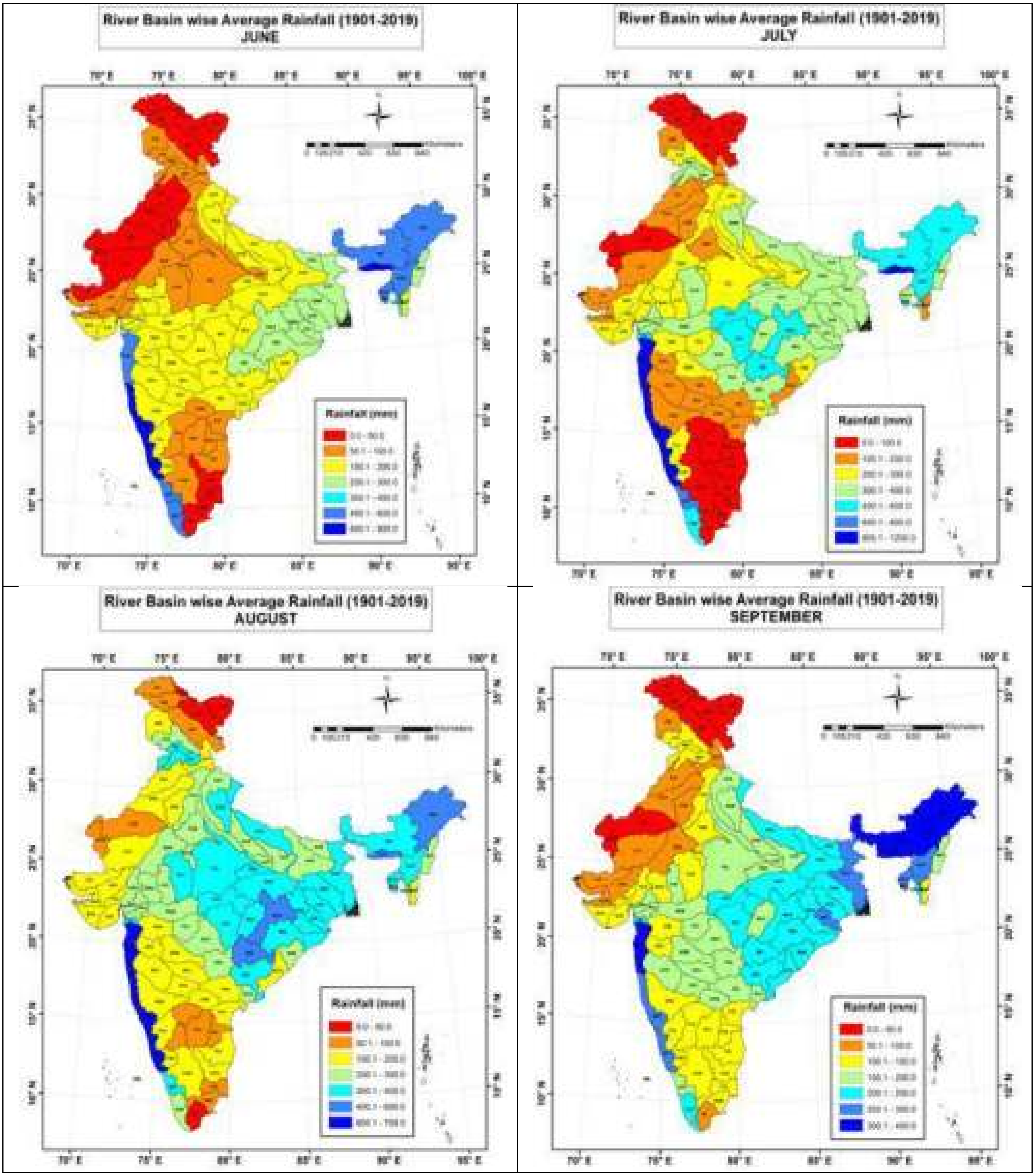

fig. 1 : Average rainfall during the four monsoon months in sub basins of India

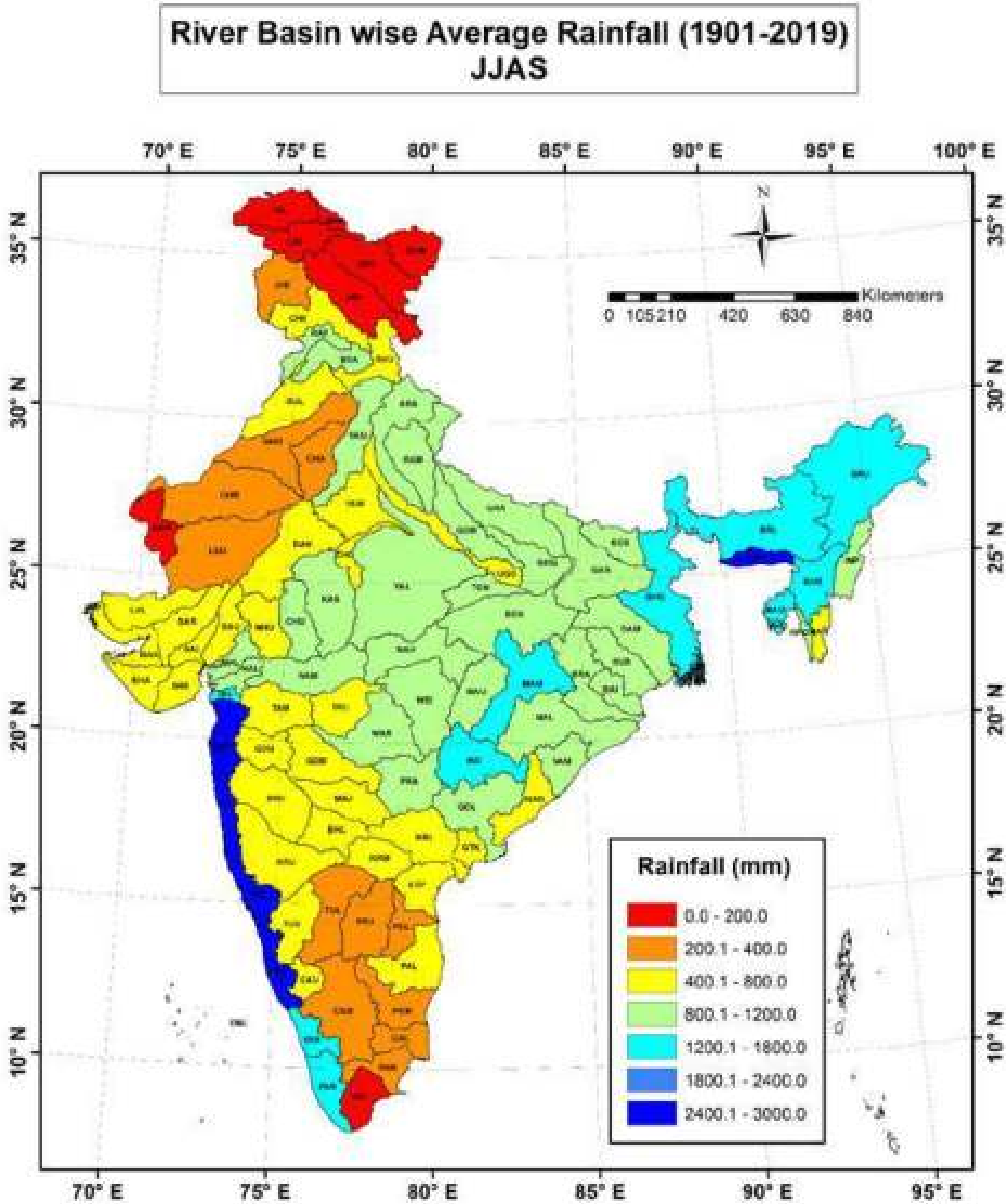

fig. 2 : Average rainfall during the southwest monsoon season (June-September) in sub basins of India

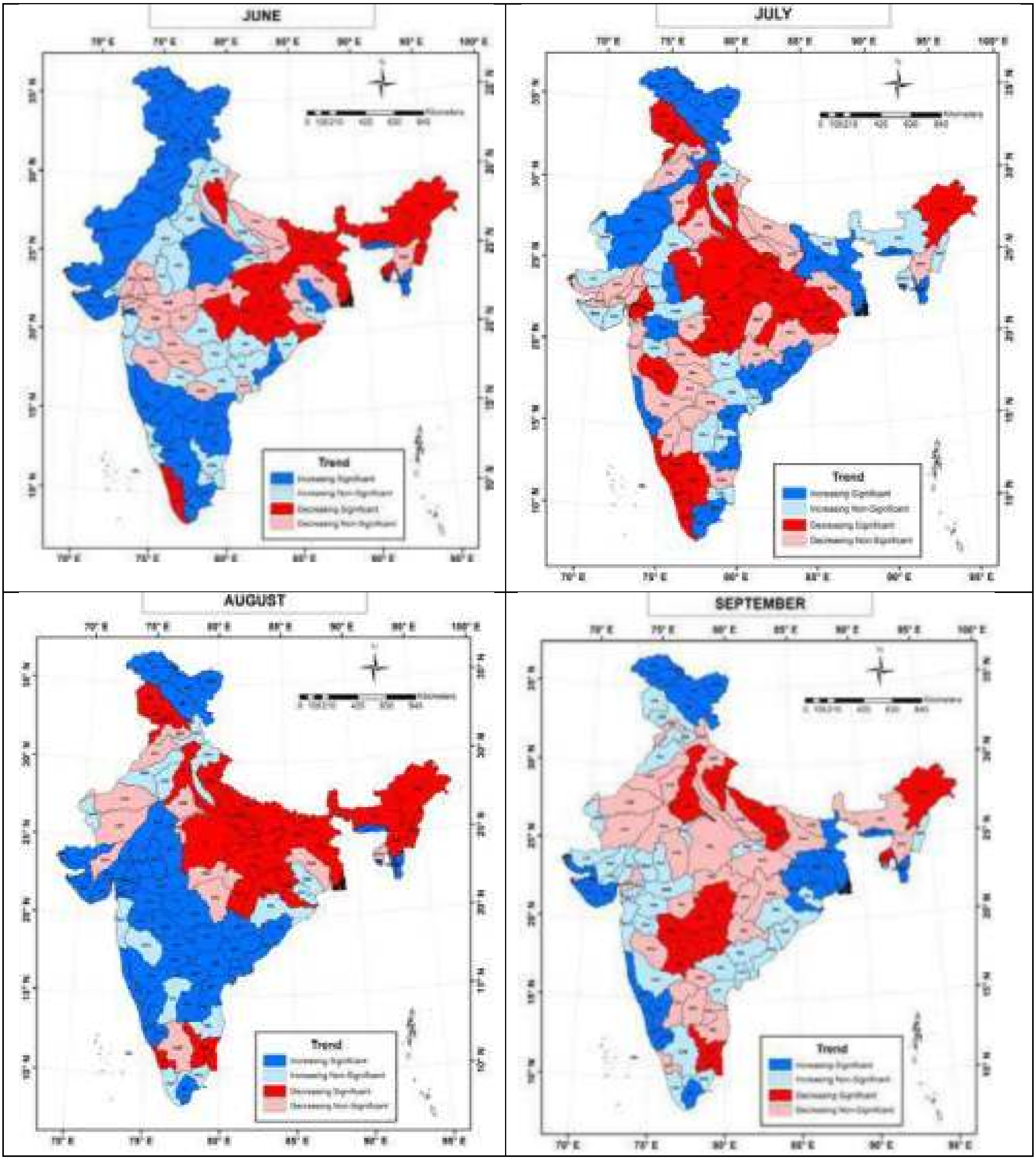

fig. 3 : Observed rainfall trend in monthly rainfall

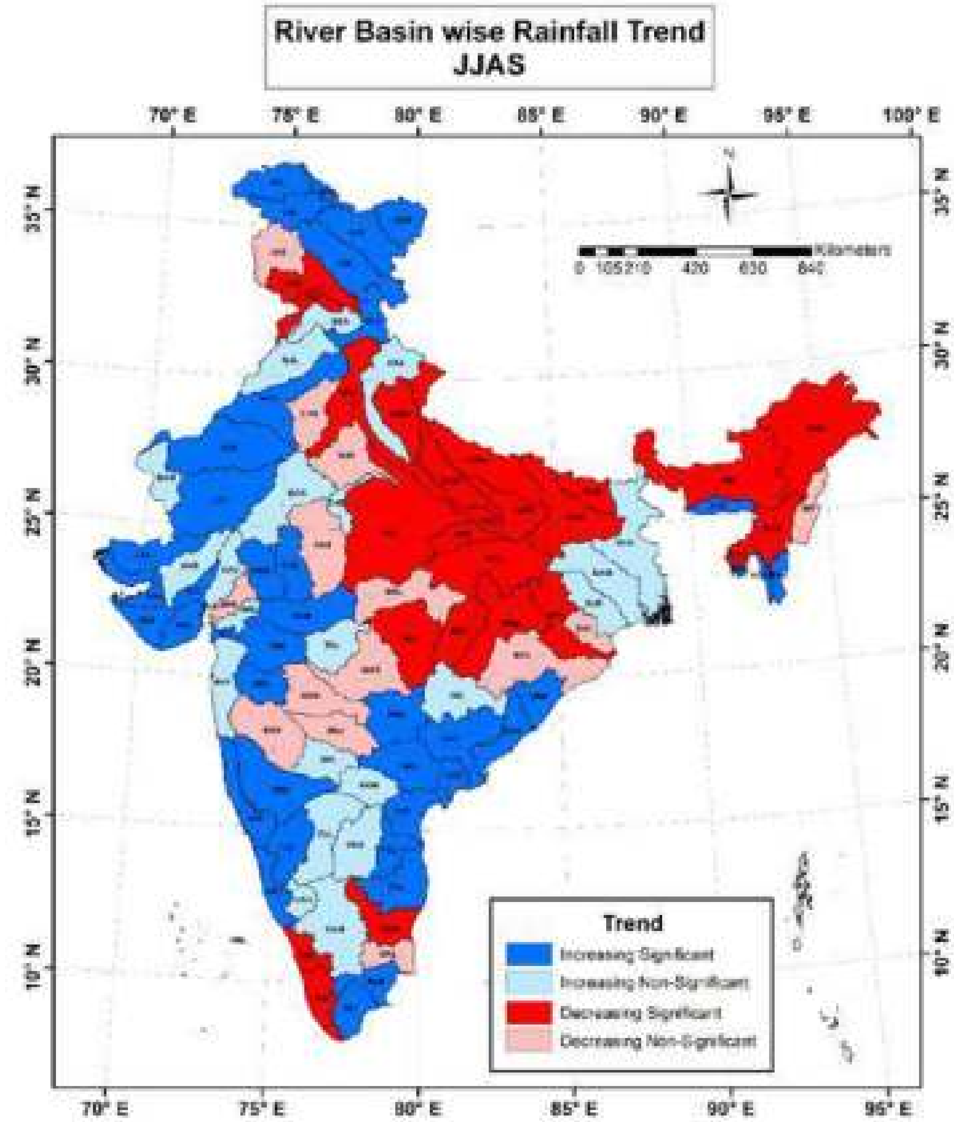

fig. 4 : Observed trend in southwest monsoon rainfall over the sub basins of India

5. CONCLUSIONS

The monthly rainfall long period rainfall series for the river sub basins has been generated for the first time from the India Meteorological Department high resolution gridded data for the climate services to the water sectors. The analysis of the 119 years past data for the rainfall variability, trends and mean pattern is useful for the water resource managements.

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Impact Assessment of On-site Sanitation System on the Quality of Groundwater in Sandysoil of Periurban Area of Bangalore City, Karnataka, India - A Case Study

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ABSTRACT

Due to inadequate sanitation and practice of onsite sanitation like pit latrines and septic tanks in Periurban areas, the contaminant levels are exceeding permissiblelevels in ground water drinking sources resulting in water borne diseases, causing widespread morbidity and mortality.Contamination of groundwater sources by pathogenic bacteria and nitrate are two major public health risks due to onsite sanitation systems. A field study was carried out for two year in a peri urban area of Bangalore rural district. During the study bore well water samples were collected at eleven sampling stations near onsite sanitation systems.The collected bore well water samples were analysed for critical onsite parameters and analysis of bore well water samples indicates that groundwateris unfit for drinking purpose. Higher concentration of nitrates and chlorides in bore well water samples show that ground water is getting contaminated with onsite sanitation. The regression graphs are plotted to study variation of nitrate and total count, with depth, distance and years of usage. The regressiongraphs indicatethat the 10m distance between public borewell and septic tank is sufficient to prevent groundwater contamination for present days. Appropriate legislation on zoning, specification, siting, designing, construction and maintenance of onsite sanitation system are necessary to protect groundwater aquifers in future.

***Key words** : Onsite sanitation system; Nitrates; Chlorides, E-coli; Total coli forms; regression*

1. INTRODUCTION

Due to the absence of central water supply and sewerage system the people in the fringe of periurban/ semiurban areas are adopting onsite sanitation as a mode of sanitation and groundwater as a source of water. In semiurban area people are not following any guidelines in locating onsite sanitation like septic tank, soak pits near groundwater source. This may cause groundwater contamination through infiltration of chemical and microbial contaminants which ultimately results in mortality and morbidity. The existing septic tank system, developed nearly a century ago has many functional inadequacies and their performance depends on its design, construction, nature of wastes, climate, regional geology, topography, physical and chemical composition of the soil mantle, and care taken in periodic maintenance. This problem is still exists in many urban and periurban areas due to lack of willingness of citizens to observe neighborhood water and onsite sanitation system or due to poor coordination between households. Sufficient depths of unsaturated soil and adequate horizontal separation distances between an onsite system and water supply wells or water bodies are required to protect public health from pathogen contamination. In addition to this many government agencies are not giving much importance in assessing risk of onsite sanitation. It is reported by government agencies that onsite sanitation is responsible for groundwater contamination. The impact of onsite sanitation systems in developing countries with different soils and hydro geological conditions is not carried out compared to developed countries NEERI (2005).Hence the present study is undertaken to assess the impact of onsite sanitation on sandy soil environment. An objective of the present research work is to predict the impact of low cost onsite sanitation system on subsurface water andto establish the minimum safe distance between onsite sanitation systems and groundwater resources.

2. LITERATURE REvIEW

The practice of onsite sanitation is most common in developing and underdeveloped countries.The septic tank/cesspools/pit latrines are used as an onsite sanitation system by in densely populated periurban areas in India. Septic tanks, and pit latrines without any lining permits the leaching of effluents to surrounding soil. The effluents like chloride, pathogens and nitrate percolate to the surrounding soil may cause groundwater contamination, and water borne diseases. This type of onsite sanitation has potential danger of polluting groundwater sources, which is common in many under developed and developing countries. The close location of groundwater sources and onsite sanitation is common in densely populated periurban areas in India is responsible for groundwater contamination. Most of the studies related to onsite sanitation are used nitrate, chloride and feacal coli forms/E-coli as indicator parameters to assess the effect of onsite sanitation systems on groundwater.

The various researchers are worked on onsite sanitation systems to assess its effect on groundwater quality. (Kligler 1921, Caldwell and Parr 1937, Dyer1941, Chidavaenzi 1997, Ahmed 2002, Still and Nash 2002,Ramaraju.H.K. et al. 2005, Dzwairo 2006, Banerjee 2011, Pujariet al. 2012, Vingeret al. 2012, P.S. Hari Kumar 2013, Sudhakar.M.Rao 2014. Michael R.Templetonet al., 2015,Jangam.Cet al.2015, Bruce Roy ThulaneVilane 2016, Pantaleo et al.2018,Rafat Quamaretal.2018). In all the studies the health hazards due nitrate and feacal coli forms/E.coli are highlighted. In India elevated levels of nitrate hazards due to nitrate contaminant from onsite sanitation is reported by Pujariet al.(2012) andSudhakar.M.Rao(2014). The hazards due to feacal coli forms/E.coli from onsite sanitation are reported by Banerjee (2011). Hence at locations of onsite sanitation practices data management of water quality monitoring along with health studies will be useful in mitigating the impacts due to onsite sanitation on groundwater.

3. STUDY AREA

A Field investigation was carried out in Ramanagaram district of Karnataka where sewerage system is absent. The study taluk from theRamanagara District is Kanakapura. The types of on-site sanitation systems(Pit or borehole latrine/leach pit/septic tank/ventilated improved pit latrine/ twin pit latrine/ pour flush toilet/ eco-san services) adopted by the community, and their performance has been studied. Mitigative measures are suggested to the concerned authorities for speedy implementation. The geology of the Kanakapura area consists of pink and gray granites, granite gnesises and granodiorite. The Kanakapura soil consists of red loamy sandy soils, which are moderately porous, medium permeability, and favorable for groundwater recharge. The average annual rainfall of Kanakapura is 750mm (CGWB2013). In this periurbanarea people are dependent on their own bore wells and public bore wells installed by the municipal council. No sewerage facilities are existing in this town and septic tanks/soak pits are common mode of sanitation used in the residential areas. The study area is located in hard rock terrains with secondary porosity in the form of fracture and cracks. The leachate moves faster at the rate of few meters/day to tens of m/day. Hence chance of leaks from septic tank reaching the saturated zone is very high. The soil of study area issandy in nature and permeability of soil in the study area varied from 0.107 to 0.112 m/day.

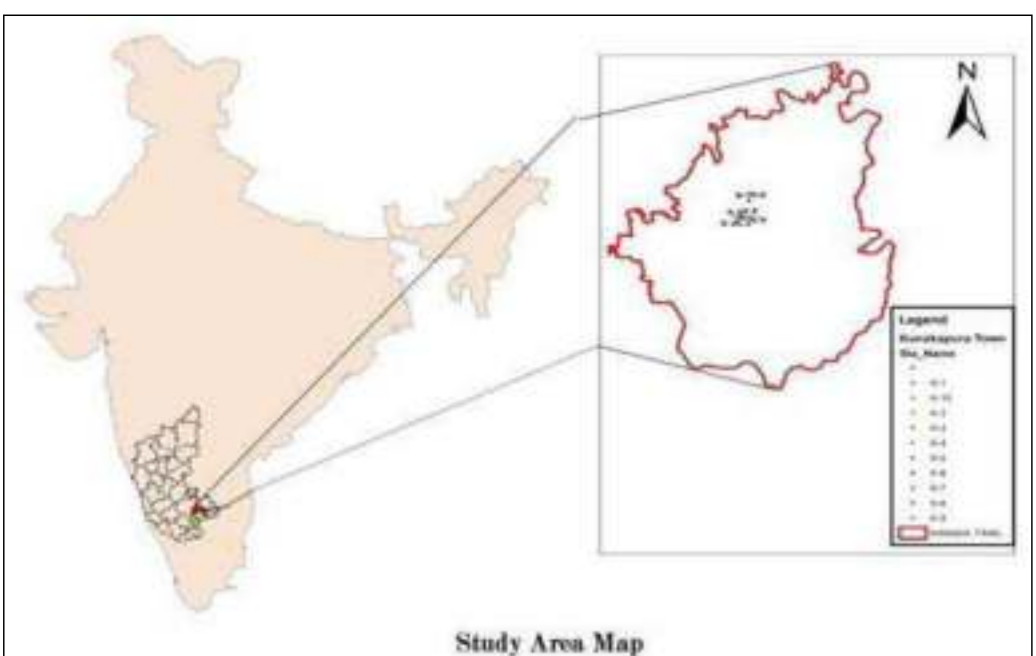

fig. 1 : Study area map with sampling stations

4. METHODOLOGY

A reconnaissance survey of the study site was carried out using questionnaire to know the water supply and sanitation conditions along with other technical and socio-economic data from the house owners in the periurban area. The samples of water from 11 bore wells located in individual houses having their own sources of water supply (located down gradient), were collected, based on their nearness to the septic tanks/cess pools/ soak pits latrines within the homestead. Out of 11 bore wells one wellwas used as control point. Sampling and analysis of water from borewells were done as per standard methods for physical, chemical and bacteriological parameters. Infiltration studies in the same locations (around the septic tank) are also carried out. The regression graphs are plotted to study variation of nitrate and total count, with depth, distance and years of usage.

5. RESULTS AND DISCUSSIONS

The results of analysis of bore well water samples collected near the onsite sanitation systems in the study area (Kanakapura) contain the nitrate concentration varied from 03 to 68 mg/l. The chloride concentration varied from 62 to 800 mg/l. Higher concentration of nitrates and chlorides in bore well waters in the study area show that the ground water is getting contaminated with onsite sanitation effluents. Among these chloride, is very high and is exceeding the permissible limit. The bore well water is not fit for drinking purpose and is unpalatable too. In study area, except two stations all other stations are having chloride values above permissible limit of 250 mg/l. Nitrate exceeds 45mg/l infour sampling stations. E-coli are observed in only one sampling station.Microbiological analysis of borewell water samples show positive results (presence of E.Coli) in 01 sampleand 10 samples were free from E.Coli contamination. It is found that presence of total coli is observed in all stations of the town.The total count concentration varied from 2 to 26/100ml in study area. It exceeds the permissible limit of 10/100ml.It is observed that bore wells both near and far away from onsite sanitation system show increased total count and E-coli due to closeness to public toilets and due to their location near open drains. The infiltration rate in the study area varied from 5.4 cm hr-1 to 9.78cm hr-1. From the field infiltration tests data it is found that soils near community toilets septic tank is having medium permeability and infiltration rate. These results are reflecting that migration of pollutants might be more in study area.

The distance between the soakpit/septic tanks to bore wells varied from 3.34-50 m in study area. Most of the borewells are located within 10 m distance.In thestudy area thickness of weathering in major parts is 5-10m and more than 10m in rest of the area. The groundwater is drawn from unconfined and semi unconfined aquifer system. The study area is located in hard rock terrain with secondary porosity in the form of fracture, and cracks (CGWB2013). The leachate moves faster at the rate of few meters/day to tens of meters/day. Hence, the chance of leakage from septic tank reaching the saturated zone is very high.

To study variation of nitrate with depth, distance and years of usage regression graphs (Fig. 2 to Fig. 4) are plotted for Kanakapura study area. The findings indicate a positive relationship between distance, years of usage and depth. The nitrate increases with increase of years of usage of onsite sanitation system. The nitrate concentration decreases with distance and depth of bore

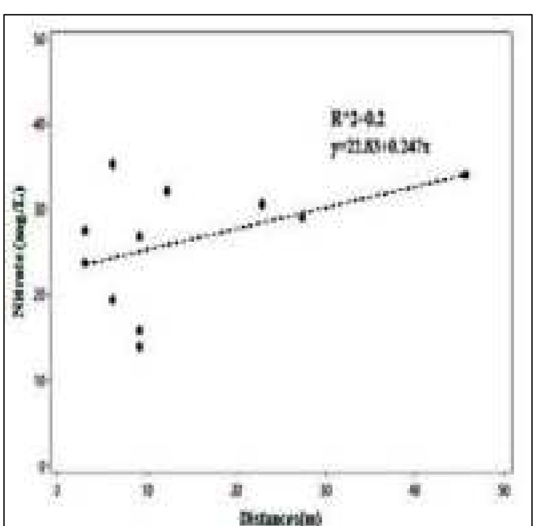

fig. 2 : Regression graph of Nitrate vs. Distance (Kanakapura study area)

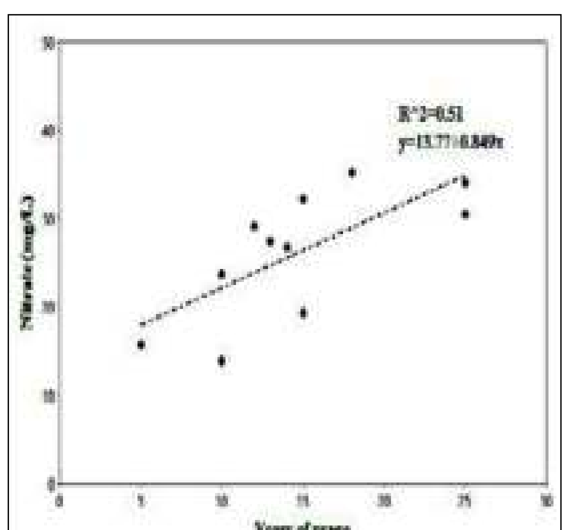

fig. 3 : Regression graph of Nitrate vs. Years of usage (Kanakapura study area)

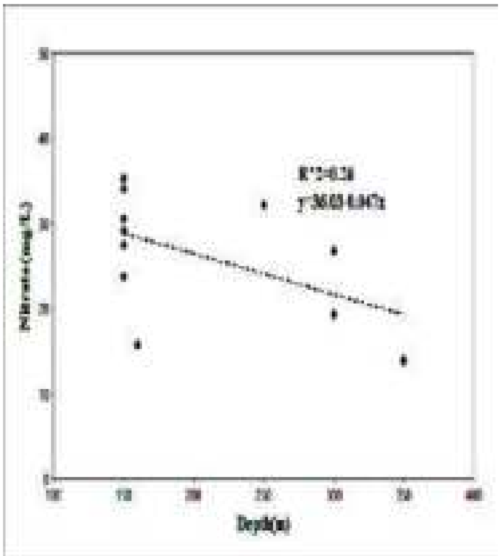

fig. 4 : Regression graph of Nitrate vs. Depth. (Kanakapura study area)

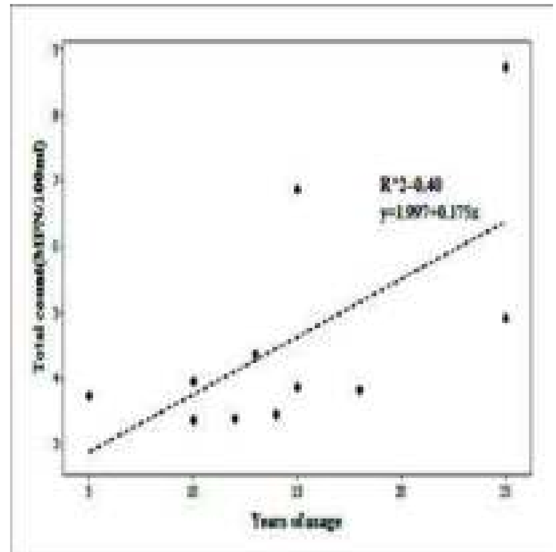

fig. 5 : Regression graph of Total count vs. Years of usage (Kanakapura study area)

well.Regression graphs of nitrate versus distances (Fig. 2) indicate that up to 10 m distance from the source nitrate concentration increases and decreases beyond 10m onwards. A regression graph of nitrate versus depth (Fig.4.) indicates more nitrate content at 50 m and beyond 50 m it decreases. Regression graphs of nitrate concentration versus years of usage (Fig.3.) of onsite sanitation system indicate that increase of nitrate with years of usage of onsite sanitation system. The increase is observed between 10-25 years of onsite sanitation system. A regression graph of nitrate versus chloride (Fig.7.) indicates normal relationship. The chloride and nitrate ratio is greater than one. Therefore it is of faecal origin and both are released from the same source.To study variation of total count with (Kanakapura study area), distance and years of usage graphs (Fig.5. to Fig. 6.) are plotted. The findings indicate a positive relationship between total count and distance, total count and years of usage. The total count varied more between 0-10 years of usage. The decrease in total count with increase in distance (Fig.6.) is due to the ability of soil to filter bacteria as water moves in downward direction.

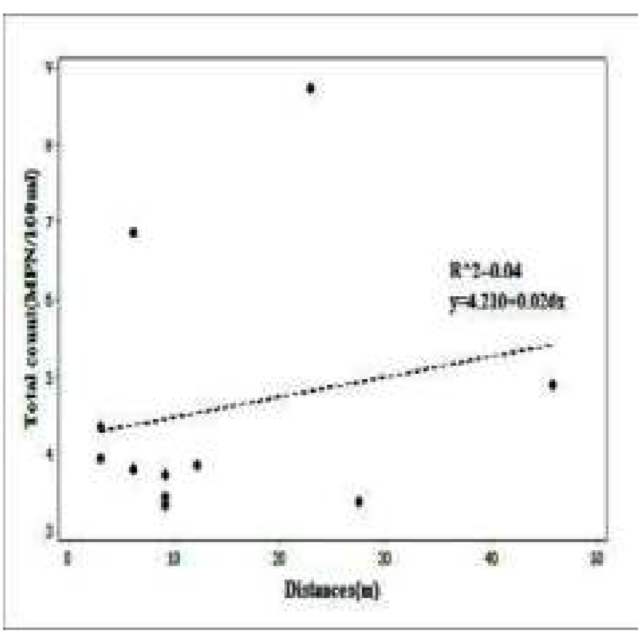

fig. 6 : Regression graph of Total count vs. Distance (Kanakapura study area)

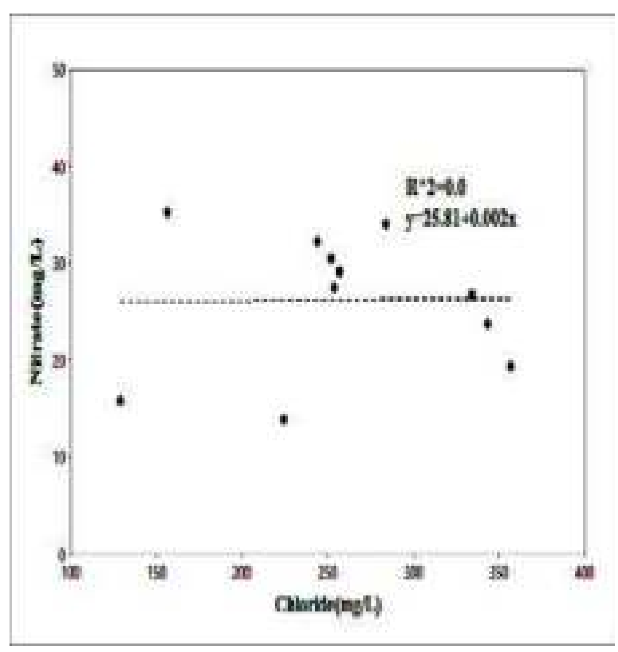

fig. 7 : Regression graph of Nitrate vs. Chloride (Kanakapura study area)

6. CONCLUSIONS AND SUGGESTIONS

In the present study it is observed that a horizontal distance of 10m as safe distance between onsite sanitation system and groundwater source for Kanakapura town. Safe distance between onsite sanitation system and groundwater wells was determined based on findings of field sampling. By considering permissible limit of nitrate of 45mg/l in drinking water as per Bureau of Indian Standards from graph nitrate vs. distance (Fig.2) safe distance between onsite sanitation system and groundwater wells was determined. Vertical distance of 2m between bottom of pit and water table is found to be sufficient as water table is well below the ground surface in the study area. As per Indian national building organization, Government of India, New Delhi (1989), a horizontal distance of 10m distance between onsite sanitation and groundwater source and vertical distance of 2m between bottom of pit and water table is found to be sufficient.

Shallow depth aquifers in study area are more vulnerable to contamination. The present study area results are significant because most of the populations of this town are dependent on groundwater and onsite sanitation system. The populations of this area are at risk of nitrate contamination. Most of the low cost onsite sanitation systems were sited and constructed without sound scientific knowledge and without considering the direction of groundwater flow and seasonal recharge trends.This study really helps to locate groundwater from onsite sanitation in safer zone.The results of bacterial analysis indicate that water should be chlorinated before its use for drinking. The groundwater should be treated before drinking for removal of nitrate, chloride, hardness and pathogens. Best approach in minimizing groundwater contamination in periurban human settlement is through the provision of community onsite waste disposal system. Establishment of settings standards for siting of borewells from onsite sanitation is necessary. Appropriate legislation on zoning, specification, siting, designing, construction and maintenance of onsite sanitation system as well as educating the users are necessary to protect groundwater aquifers.

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NDWI and Hydrogeomorphology in Attaining Optimization of Water Reseources in Pendurthi Mandal, Vishakhapatnam District, Andhra Pradesh, India using Sentinnel Data-2

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ABSTRACT

Pendurthimandal the study area depends on tanks, wells, bore wells and the vagaries of monsoon for the sustenance of living as well as for irrigation purposes. The entire activity is under dug wells, bore well and tanks.In need for water sustenance, to meet the demands of the agrarian economy, the 1,45000 population as per 2011 census data consisting of 23 villages, NDWI of the mandal has been prepared in achieving water optimization. The delineation of hydrogeomorphological units will help in understanding the composition of the material of the landforms, and identifying more potential ground water zones.

Keywords *: Pendurthi,Hydrogeomorphology, NDWI, Meghadrigedda, catchment*

INTRODUCTION

Water monitoring has become one of the prime interests, and more a necessity in any form of water resource management in dealing with water crisis around the world in achieving sustainable development. Assessment and suggestive measures are absolutely important in understanding the requirement for a better decision making towards earth's natural resources and direct dependence of the human resources on the very same.

REvIEW Of LITERATURE

Few studies have been carried out in and around Pendurthimandal and Meghadrigedda, major river that flows through the mandal. Among them are Identification of soil erosion zones with special reference to silt deposition in Meghadrigedda reservoir (UshaChirala, Ph.D Thesis, (2013), Correlation of geometric parameters for the hydrological characterization of the Meghadrigedda watershed, Vishakhapatnam, A GIS approach, UshaChirala et.al., (2012), Nageswara Rao and Narendra (2009&2006), Mapping and evaluating the urban sprawl, Nageswara Rao et., al on the ground water quality of the Meghadrigedda Watershed (2008), Mapping of Hydrogeomorphic features in the Pendurthimandal using IRS data Usha Chirala (2003).

NDWI is being conducted from 1995, Kaplan and Avdan (2016),Yuanzheng, Zhen Guo, Kaipeng, Dan, &Zhouab, (2016), Feyisa, Meilby, Fensholt, & Proud, (2014), Meng, Zhu, Cao, Xsu, & Cao, (2013), Pereira-Cardenal et al., (2011), Xiao, Zhao, & Zhu, (2010), Ding, (2009) Lacaux, Tourre, Vignolles, Ndione, & Lafaye, (2007), Xu (2006), Rogers & Kearney, (2004) and McFeeters (1996) to name a few.

STUDY AREA

Vishakhapatnam is a coastal district, in the north eastern part of Andhra Pradesh and covers an area of 11,161 sqkm, spread over 43 mandals. These 43 mandals are grouped into Narsipatnam with 13 mandals, Paderu agency area 11 mandals and Vishakhapatnam with 15 mandals.

The study area, Pendurthi falls in Vishakhapatnam mandal in between17^0 49' 30" north latitudes and 82^0 12' 13" east longitudes under SOI toposheet 650/1 and 0/2and 3 on 1:50000 scale.

The present study area is 40m above MSL. The total area is 120.19 sqkm, comprising of 23 villages and a population of 1,45000 with 73434 males and 73216 females (2011 census) (Table 1). The mandal headquarters is located 25 km north-west of Vishakhapatnam. It lies on Vizianagaram-Aanandapuram –Pendurthi-Ankapalli road and also has a railway station between Vizinagaram and Vishakhapatnam section of south eastern railway. The mandal extends for a maximum distance of 20 km in the N-S direction and 12 km in east west direction.

The study area "Pendurthi Development block (Fig.1) though close to Vishakhapatnam has agrarian economy. Agricultural crops include Paddy, sugar cane, groundnut, Chodi, Ragi Sesame Horsegram.

Table 1 : List of population in PendurthiMandal

S.No	Name of the village	Area (sqkm)	Population	Male	female	Household	Density per sqkm
1	Cheemalapalle	2.92	746	362	384	187	307
2	Chinamushidivada						
3	Chintagatla	2.28	1602	798	804	413	0
4	Gorapalle	4.94	3716	1866	1850	988	1
5	Gurrampalem	5.35	3727	1898	1829	947	1
6	Jerripothulapalem	3.06	957	491	466	255	0
7	Juthada	1.16	465	204	261	128	481
8	Krishnarayapuram						
9	Lakshmi Puram	2.23	647	312	335	175	348
10	Mudapaka	8.16	1402	670	732	341	0
11	Narava						
12	Pedagadi	9	2279	1111	1168	585	
13	Pendurthi						
14	Pinagadi	6.67	2390	1174	1216	605	0
15	Porlupalem						
16	Pulagalipalem						
17	Purushottampuram						
18	Rajayyapeta	2.23	1774	888	886	437	1
19	Rampuram	3.07	3536	1747	1789	920	1
20	Saripalle	5.25	4404	2217	2187	1107	1
21	SowbhagyaRayapuram	3.46	3025	1477	1548	663	1
22	Valimeraka	4.01	1710	855	855	423	0
23	Vepagunta						

Source : Chief planning Officer (CPO) Vishakhapatnam, Andhra Pradesh, INDIA

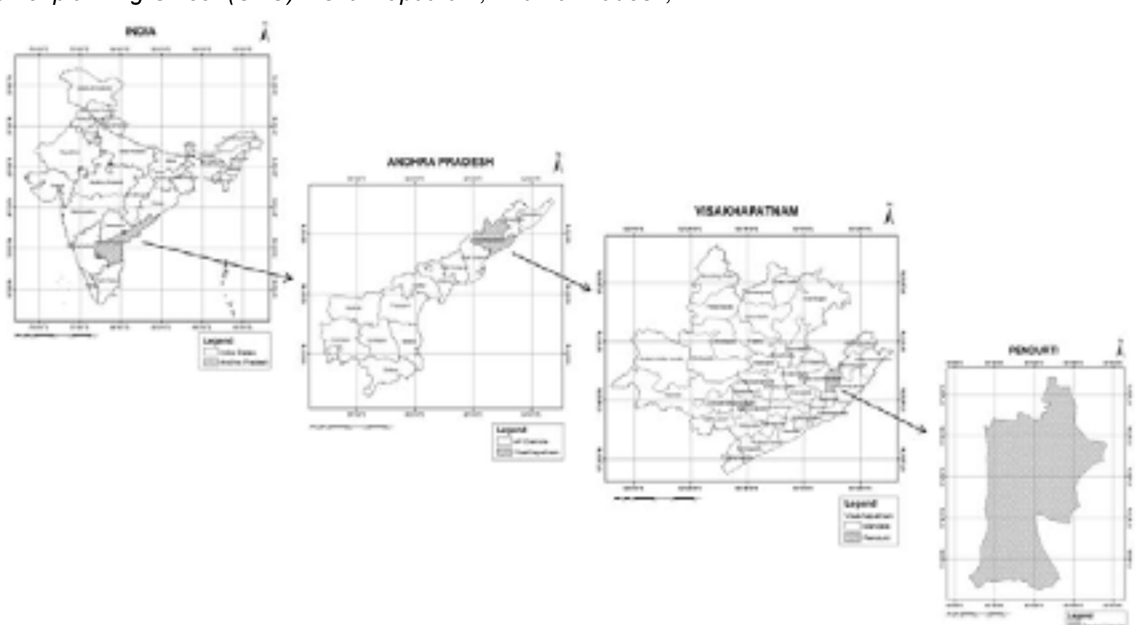

fig.1 : Location Map of the Study Area

PHYSIOGRAPHY

Topography and Drainage

The area is part of the Waltair coastal plains in the Eastern Ghats Physiographic province (NAO 1968). This study area forms part of Vishakhapatnam fold belt and the foliation generally strikes NE-SW. In the central part of the EGGB there are four main tectono thermal events dated at 2600, 2200-1900, 1180-950 625-500Ma (Fonarev et., al, 1998). Majority of the area is plain and under agriculture, with hills in the eastern, northern and southern parts of the mandal. The highest peaks are in the Narava reserved forest (375m). There are also few isolated hills in this area like the residual hills and inselbergs. The predominant rock type is Khondalite, followed by Charnockites, kalonized clay and quartzite. Meghadrigedda is an east flowing river taking its rise in the Eastern Ghats from the Nandikonda hill. It flows south untilkarupavani village and thereafter in south eastern direction until it joins the sea near Dolphins nose, Vishakhapatnam town.

Climate and Rainfall

The study area enjoys sub-tropical climatic conditions and the temperature ranges between min 14^0 -20^0C during the month of December and maximum 33^0 to 42^0C during May. The area receives rainfall during June to December from both south-west and north-east monsoon and the average rainfall is 1110mm per annum (source: Zilla Praja Parishad, Vishakhapatnam). Though the area has 124 tanks, they do not significantly reduce the flood peaks. Most of the rainfall flows to the adjoining sea as runoff. Except Narava which is cool due to the forested area, the mandal is generally warm.

Soils and vegetation

The soils are categorized into alluvial redloams and clays, gravelly loams and shallow skeletal sandy soils. The vegetation type is deciduous comprising mostly of deciduous dry and deciduous scrub. Table 2.0 explains the land utilization in Agriculture in the study area.

METHODOLOGY

Sentinel data 2 has been georeferenced using Survey of India (SOI) topographical maps no, 65O/1 and 65O/2&3 on 1:50000 which cover the study area. The drainage network has been demarcated as a vector layer in *.shp format. Hydrogeomorphology map has been prepared with the aid of Satellite data as well as SOI map of the respective study area.

Normalized difference Water Index (NDWI) has been carried our using ArcGIS software, version 10.1 Vishakhapatnam Handbook of Statistics 2001 has been used for the reference, and the entire study has been validated with ground truth observations.

Table 2: Land Utilization in agriculture in the Pendurthimandal

S.No	Category	Area in sqkm	Percentage of the Area
1	Forest area	10.19	8.47
2	Barren and uncultivable	25.84	21.50
3	Land put to non-agricultural use	40.30	33.50
4	Cultivable waste	1.40	1.20
5	Permanent pastures and other grazing lands	0.28	0.20
6	Fallow land	5.34	4.40
7	Cropped area	33.93	28.20
	Total Geographical area	120.19	100.00

Source : Chief planning Officer (CPO) Vishakhapatnam, Andhra Pradesh, INDIA

HYDROGEOMORPHOLOGY

The hydrogeomorphological interpretation is helpful to understand the nature and potentially of different landforms. The study area is broadly divided into three zones, namely runoff, infiltration and discharge. The hills constitute the runoff zones, because of inclined rock surface and sparse vegetation. The other landforms are zones of infiltration and discharge. Based on the aforementioned data, the study area has been divided into nine geomorphic units.

There are altogether five structural hills (SH) Yerrakonda (370m), Narava (375m), near Vepagunta (263m), near Porlupalem (324m) and near Mudapaka (321m). There are made up of well jointed khondalites. The slope of these hills ranges from 12^0 to 23^0. The Yerrakonda hill range and the Narava hill range are named after the reserved forests respectively. Fig 2(a) and 2(b) display the drainage map and hydrogeomorphology of the study area.

Inselbergs(I) are located at four places lying between the contours of 100m and 200m near Sowbhagyapuram (281m and 211m), Mudapaka (169m) and Chintagatla (211m) and are made of Charnockites. The slope of these inselbergs is between 6^0 to 18^0.

Residual hills (RH) left out by scrap retreat and peneplanation owe their origin to resistance to erosion, consisting of Charnockites lying between the contours of Jerripotulpalem (96)m and Pulagalipalem (98) m, with slope ranging from 12^0 to 18^0.

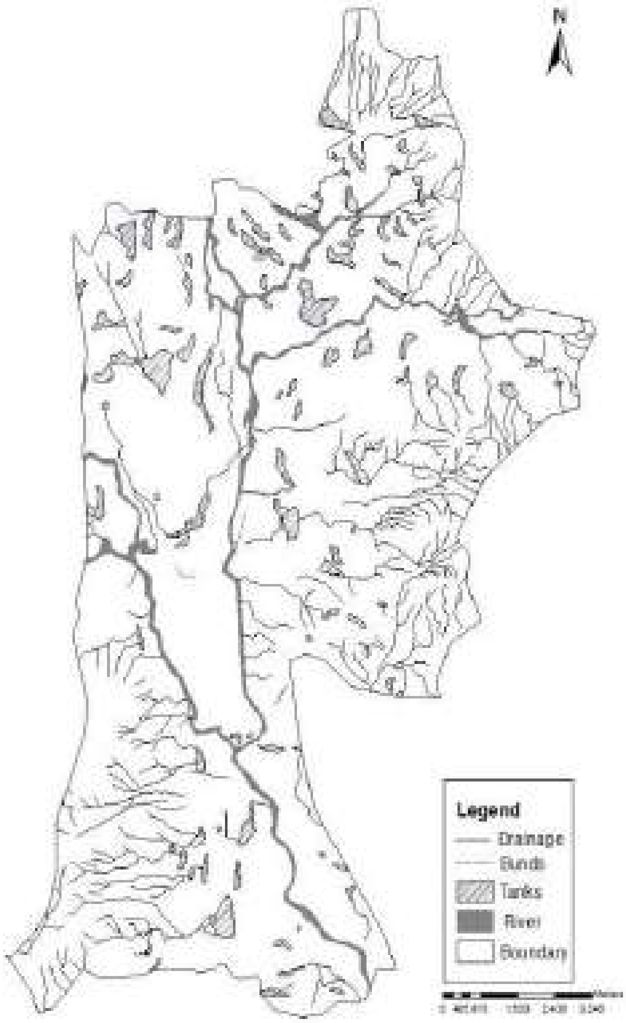

fig. 2(a) : Drainage of the study area

fig. (b) : Hydrogeomorphology of the study area

Pediment zone(PZ) is a transitory zone between the debris slope direction and the next important hill slope element (Nookaraju and Vaidyanadhan,1971). Lying in the zones of 30m to 100m it is noticeable near the villages, Porlupalem, Chemalapalli, Vepagunta, Sowbhagyapuram, Mudapaka and Chintagatla. The joint in the khondalite facilitate recharge to groundwater. Colluvium is identified in the eastern part of the Narava reserved forest dissected by numerous east flowing streams. Due to the heterogeneous mixture from cobble to clay and high density of stream network, this unit is considered as poor hydrogromorphic unit, but it can be strongly considered for check dams aiding in watershed development.

Pediplainshallow (PPS) Smooth and flat buried pediment with shallow (0-5m) overburden of deposits. Ground water potential is poor to moderate, covering mostly the eastern parts of the mandal 20m to 30m of contour. This unit is laid with a thin layer of overburden and lies at shallow depth.

Pediplainmoderate(PPM) are flat and smooth buried pediplain with moderately thick (5-20m) deposits. This unit covers the western and northern parts of the mandal lying between the contours 10m to 20m. Ground water prospects are moderate to good as the unit is near to the rivers Meghadrigedda and Naravagedda.

MEGHADRIGEDDA RESERvOIR AND IRRIGATION SOURCES

The geographic location of the dam site is longitude 83^0 11' 27'' E and 17 45 54 N latitude. The reservoir area is 6.93 sqkm as per bhuvan.nrsc.gov.in/bhuvan_links.php.The catchment area (220.76 sqkm) is under the influence of S.kota, Vishakhapatnam, Ankapalli and Chodavaramrainguage stations. The average rainfall is 1000mm (40”) and the average monsoon rainfall is 37-39”. Meghadrigedda reservoir was formed near the confluence of Meghadrigedda and Narava rivers to supply 8MGD drinking water to the people of Vishakhapatnam city. Even though the entire reservoir falls under the

Pendurthimandal study area, the drinking water facilities are met by 385 bore wells, 15 open wells and 1 piped water supply. The minor irrigation sources are 115, along with 15 sprinklers and 4 drips covering an ayacaut of 1835 hectares (18.35 sqkm) where tanks cover 1.24sqkm, tube wells 6.55 sqkm dug wells 4.55 sqkm, sprinklers 0.12 sqkm and drip irrigation covering 0.03 sqkm as per the year 2018-2019 (*Source: CPO, Vishakhapatnam*)

NDWI ANALYSIS

NORMALIZED DIFFERENCE WATER INDEX is an index to extract water bodies from satellite imagery.NDWI is intended to show the state of water resources and the shortcomings in meeting the needs of the people of the area as optimum utilization of water is the sustenance to the economy.

Extraction of water bodies is an important part of water resource management and has become a very important part of remote sensing science, since water monitoring plays an important role in management of water resources. NDWI uses reflected near-infrared radiation and visible green light to enhance the presence of such features while eliminating the presence of soil and terrestrial vegetation. The NDWI though is a vegetation index but it is sensitive to water content or moisture content of the Vegetation and is a complementary to NDVI. This is a new method todelineate open water features by enhancing the presence of all the waterbodies in a remotely sensed imagery. High NDWI values show a high water content of the vegetation, Gao, B.C., Remote Sensing of the Environment, pp.257 (1996). Choosing the bands for a specific purpose makes NDWI appropriate from monitoring vegetation, drought, crop irrigation or even monitoring the forest cover.

The NDWI product is dimensionless and varies from -1 to 1. Mathematically NDWI is calculated using the formula:

NDWI = GREEN – NIR / GREEN + NIR

Here we derived NDWI for the sentinel image 2020 of the study area. The sentinel image contains 12 bands in which NDWI uses Band 3 (green band) and Band 8 (VNIR band). The formula for the sentinel image is NDWI= B03-B08 / B03+B08, value < 0.3 - non-water, value > 0.3 – water.

The calculated NDWI have indices ranging from -0.632043 to 0.330056 which is classified itself into 5 categories. The positive index range is shown in blue color which represents the surface water bodies i.e., the reservoir and some of the tanks present in the study area. Index values greater than 0 correspond to water bodies and values equal to or less than 0 are non-water bodies such as built up or vegetation. The index values greater than zero here is represented with blue color showing the reservoir and some of the tanks present in the study area. Fig.(3a) and(3b) display flow chart and NDWI of the study area.

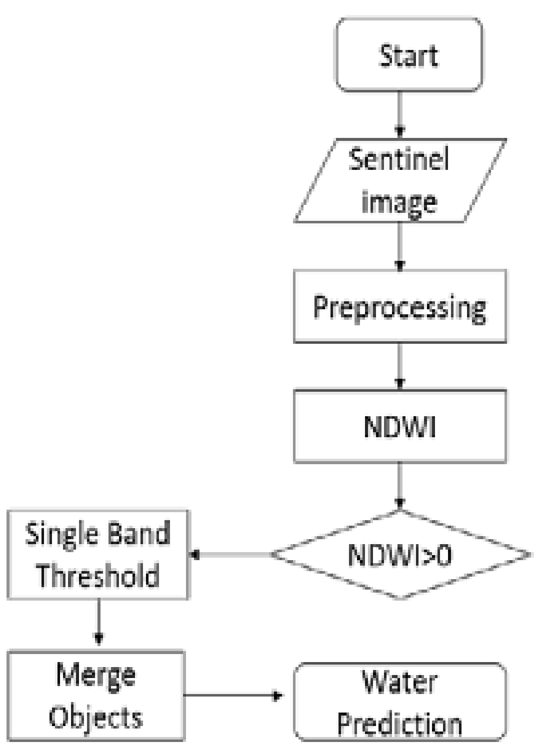

fig. 3(a) : Flow chart for NDWI

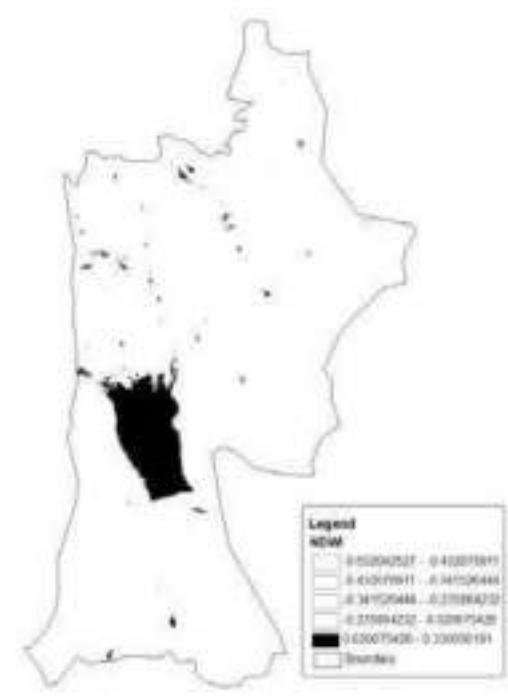

fig. 3(b) : NDWI of the study area

Table 3 : Hydrogeomorphic units

S.No	Slope category	Area (sq km)	Percentage
1	Structural hills	16.44	13.67
2	Residual hills	1.50	1.24
3	Inselberg	0.52	0.43
4	Pediment zone	18.13	15.08
5	Pediment shallow	41.41	34.45
6	Pediment moderate	40.19	33.43
7	Colluvium	2.00	1.66
		120.19	100.00

Source : Calculated by Author

CONCLUSIONS

The hydrogromorphology interpretation is helpful to understand the nature and water potentiality of the different landforms. The composition of material of landforms and their pattern inferred rechargability and geomorphic characteristics help to identify the ground water potential zones.

Agriculture is the main economic activity of the people. Paddy is the main crop and other crops include sugarcane, groundnut, horse gram ragi and sesame. There is no irrigation system; the entire activity is under dug wells, bore well and tanks. The total number of tanks are 114 tanks and tank area is 4.80sqkm (SOI 1965), the smallest tank is in Juttada covering 0.01sqkm and the largest tank is in Pinagadi covering an area of 0.87 sqkm. The number of tanks found after delineation are 108 covering an area of 5.22 sq. km. as per 2020 Sentinel-2 satellite data.

Most of the tanks have silted up and their live capacity has been reduced, and few tanks have also disappeared indicating the surface water resources position is considerably weak and does not evoke much hope of their development, unless measures of rejuvenation of tanks is seriously considered. People receive water supply for only two hours, the bore well at many places have dried up or have turned brackish. Some of the villages Ramapuram and Pinagadi have tank as well as municipal supply facilities, but people of Valimeraka and Pedagadi villages depend on bore wells and wells for drinking water. Rain water harvesting strategy could be developed so that water is stored inside underground channels during the rainy season when water is in plenty and consumed in the dry season when water is scare.

Desilting of tanks will increase the tank capacity and groundwater recharge by drilling bore wells and deepening the existing the wells, more groundwater could be harnessed which would in turn enable to raise two or three crops a year. The multiple cropping patterns would provide more work to the agricultural laborers and ensure greater return to the farmers. The mandal officers must encourage the farmers in desilting the tanks for storage of monsoon water.

Acknowledgements

The authors wish to thank USGS earth explorer for providing the satellite data.

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One Day Webinar

Planning and Design of Piped Irrigation Network

28 August 2020

BRIEf REPORT

In this new COVID-19 situation, skill enhancement and training of professional has emerged as a very important aspect and a challenge. Online activities are our attempt to continue giving training experience to participants.

In view of limited availability of water resources and rising demand for water, which has acquired critical importance for sustainable management of water resources, Central Board of Irrigation and Power (CBIP) organised One Day Webinar on "Planning and Design of Piped Irrigation Network", in association with Indian Geographical Committee of International Water Resources Association.

The Unique feature of this webinar was safety of participants in COVID 19 situation, as no physical contact and travel was involved, and financial saving to concern departments.

In all 30 participants attended the Webinar. They were from Haryana Irrigation & Water Resources Department, Karnataka Water Resources Department, Kerala Water Resources Department, Maharashtra Water Resources Department, National Water Development Agency, Rajasthan Water Resources Department and Visvesvaraya Jala Nigam Ltd.

Following topics were presented and discussed during the Webinar:

- Piped Irrigation Network Planning and Design – *Dr. Manoj Khanna, Principal Scientist, Water Technology Centre, ICAR-Indian Agricultural Research Institute*
- Piped Irrigation Network Planning and Design-UGPL Network – *Mr. Sabarna Roy, Senior Vice President (Business Development), Electrosteel Castings Limited*

four Days' Online Training Programme

Integrated Pipe Irrigation Network and Micro Irrigation

(for the Engineers of Water Resources Department, Government of Rajasthan)

12-15 October 2020

BRIEf REPORT

The global spread of COVID-19 coronavirus has infected millions of people around the world, and is continuing at a faster pace. At the moment, it's a challenge to contain the pathogen. This crisis is experienced directly by some and indirectly by all of us. We have to fight together this pandemic and come back stronger as this is the need of the hour. In this new COVID-19 situation, skill enhancement and training of professional has emerged as a very important aspect and a challenge.

Central Board of Irrigation and Power (CBIP), has always been striving to provide the best of its services in the capacity building/HR development programs in the field of development of Water Resources, Power & Renewable Energy. Accordingly, CBIP has conceptualized workshops and training programs, on the identified topics keeping in view the problems being faced by the various departments/organisations in accelerated development of these sectors.

Online activities are our attempts in this direction. Proposed online mode of deliberations will be beneficial to participating officers, who can perform their office work during training period as they are not to leave office/station of duty, besides financial savings to the organisations, towards boarding & lodging and travel cost of participants.

In this direction, CBIP organized Four Days' Online Training Course on "Integrated Pipe Irrigation Network and Micro Irrigation, exclusively for the engineers of Water Resources Department, Government of Rajasthan, during 12-15 October 2020.

Following topics were presented and discussed during the Online Training Course:

- Integration of Canal/Tank/ Watershed Systems with Drip - *Dr. T. B. S. Rajput, Adjunct Professor (Ag Engg), IARI, New Delhi*
- Modelling and Automation in Micro Irrigation - *Mr. Dilip Yewalekar, Sr. Vice President – Projects, Jain Irrigation Systems Ltd , Jalgaon*
- Use of Software and DSS in Micro Irrigation - *Dr. T. B. S. Rajput, Adjunct Professor (Ag Engg), IARI, New Delhi*
- Emerging Challenges in Pipe Distribution Network for Irrigation Purpose - *Mr. Sabarna Roy, Sr. Vice President [Business Development], Electrosteel Ltd., Kolkata*
- Micro Irrigation System Concept, Design and Components - *Dr. Manoj Khanna, Principal Scientist, Water Technology Centre, IARI, New Delhi*
- Irrigation Scheduling under Micro Irrigation - *Dr. K.V. Ramana Rao, Scientist-G, Science & Engineering Research Board, DST, New Delhi*
- Piped Irrigation Network Planning and Design - *Dr. Manoj Khanna, Principal Scientist, Water Technology Centre, IARI, New Delhi*
- Operation and Maintenance of the Irrigation Systems - *Mr. Dilip Yewalekar, Sr. Vice President – Projects, Jain Irrigation Systems Ltd , Jalgaon*

Webinar on

Integrated Water Resources Management

27 - 28 October 2020

BRIEf REPORT

The concept of IWRM emerged around the 1980s in response to increasing pressures on water resources from competition amongst various users for a limited resource, the recognition of ecosystem requirements, pollution and the risk of declining water availability due to climate change. The three basic ”pillars” of IWRM 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. IWRM addresses both the management of water as a resource, and the framework for provision of water services to all categories of users, and it addresses both water quantity and quality. India has not yet reached the level of Water Resources Development as has already been achieved by many developed countries; therefore, there is a need for India to undertake developmental measures along with management measures.

Central Board of Irrigation and Power, in association with Indian Geographical Committee of IWRA, organised a Webinar on “Integrated Water Resources Management” on 27 and 28 October 2020 with an to apprise with the process, which promotes the coordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystem.

More than 25 delegates participated in the Webinar.

Following topics were presented and discussed during the Webinar:

- Integrated Water Resources Management-An Overview -Mr. R.K. Khanna, Former Chief Engineer, Environmental Management Organisation, Central Water Commission and Dr Girija K Bharat, Founder Director, Mu Gamma Consultants Pvt. Ltd.
- Water Use Efficiency in India: Governance and Management Challenges - *Mr. Vivek P. Kapadia, Secretary to Government of Gujarat and Director, Sardar Sarovar Narmada Nigam Ltd.*
- Water Use Efficiency in India: Governance and Management Challenges - *Prof. Man Singh, Project Director, Water Technology Centre, ICAR-IARI, New Delhi*
- Water Quality Aspects - *Dr Girija K Bharat, Founder Director, Mu Gamma Consultants Pvt. Ltd.*
- Impact of Climate Change on Water Resources - *Dr. Pulak Guhathakurta, Scientist F and Head, Climate Research Division, India Meteorological Department*

Three Days' Online Training Programme

Integrated Pipe Irrigation Network and Micro Irrigation

(for the Engineers of Narmada Valley Development Authority)

7-9 December 2020

BRIEf REPORT

The global spread of COVID-19 coronavirus has infected millions of people around the world, and is continuing at a faster pace. At the moment, it's a challenge to contain the pathogen. This crisis is experienced directly by some and indirectly by all of us. We have to fight together this pandemic and come back stronger as this is the need of the hour. In this new COVID-19 situation, skill enhancement and training of professional has emerged as a very important aspect and a challenge.

Central Board of Irrigation and Power (CBIP), has always been striving to provide the best of its services in the capacity building/HR development programs in the field of development of Water Resources, Power & Renewable Energy. Accordingly, CBIP has conceptualized workshops and training programs, on the identified topics keeping in view the problems being faced by the various departments/organisations in accelerated development of these sectors.

Online activities are our attempts in this direction. Proposed online mode of deliberations will be beneficial to participating officers, who can perform their office work during training period as they are not to leave office/station of duty, besides financial savings to the organisations, towards boarding & lodging and travel cost of participants.

In this direction, CBIP organized Three Days' Online Training Course on "Integrated Pipe Irrigation Network and Micro Irrigation, exclusively for the engineers of Narmada Valley Development Authority, during 7-9 December 2020.

Following topics were presented and discussed during the Online Training Course:

- Integration of Canal/Tank/ Watershed Systems with Drip - **Dr. T. B. S. Rajput**, *Adjunct Professor (Ag Engg), IARI, New Delhi*
- Micro Irrigation System Concept, Design and Components - ***Dr. Manoj Khanna***, *Principal Scientist, Water Technology Centre, IARI, New Delhi*
- Use of Software and DSS in Micro Irrigation - **Dr. T. B. S. Rajput**, *Adjunct Professor (Ag Engg), IARI, New Delhi*
- Irrigation Scheduling under Micro Irrigation – **Dr. Yogesh Anand Rajwade**, *Scientist, Central Institute of Agricultural Engineering Bhopal*
- Piped Irrigation Network Planning and Design - **Dr. Manoj Khanna**, *Principal Scientist, Water Technology Centre, IARI, New Delhi*
- Indian Irrigation Sector – A Case Study and Emerging Challenges in Pipe Irrigation Network for Irrigation Purpose - **Mr. Sabarna Roy**, *Senior Vice President [Business Development], Electrosteel Ltd., Kolkata*

Programme was highly appreciated by the participants.

IWRA News

DISCOvER THE DISTINGUISHED RECIPIENTS Of IWRA'S 2020 AWARDS!

1. Crystal Drop Award
2. Water Drop Award
3. Ven Te Chow Memorial Lecture Award
4. New Honorary Members
5. New Fellow Members

IWRA is pleased to announce the distinguished recipients of the Association's 2020 awards.

You are invited to come and meet these amazing water leaders at the XVII World Water Congress taking place in Daegu, South Korea, from September 21st to 25th 2020, where there will be a dedicated IWRA Awards Ceremony.

The IWRA Executive Board congratulates all of the winners and thanks everyone for making so many nominations to be considered by the Awards Committee for this year's honours. This was no easy task for the Committee. It is inspiring to be able to recognise the achievements and contributions that all of these people have made so far towards the sustainable management and use of the world's water resources.

vEN TE CHOW MEMORIAL AWARD & LECTURE

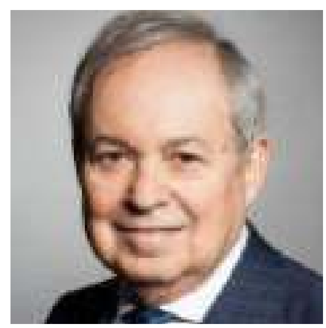
The **ven Te Chow Memorial Lecture** provides for an outstanding lecture at IWRA's World Water Congresses in honour of the first president of the IWRA. Awardees are well known in the water community, and have a demonstrated ability to give outstanding lectures.

Soontak Lee
Yeungnam University, World Water Council & President of IHES

Prof. Dr. Soontak Lee is presently a Distinguished Professor / Professor Emeritus of Hydrology and Water Resources Engineering of Yeungnam University, Korea. He is also a Honorary Governor of the World Water Council (WWC) and President of the International Hydrologic Environmental Society (IHES). Prof. Lee has been engaged as a Co-Chair of the International Scientific Committee (ISC) of the 7th World Water Forum in Daegu-Gyeongbuk Korea in 2015, as well as a Chairperson and President of the UNESCO-IHP Intergovernmental Council from 2010 to 2012. He has obtained four Doctoral degrees, Ph.D., D.Sc., Hon. D. Eng. Sc. & Hon. Dr. Tech. Sc.

CRYSTAL DROP AWARD

The Crystal Drop Award is provided to organizations or individuals in recognition of their laudable contributions to the improvement of the world's water situation. These contributions may be through path breaking research on water issues, practice in water management or governance, knowledge transfer or dissemination, and/ or outstanding contributions.



Doğan Altinbilek
Middle East Technical University

Prof. Doğan Altinbelik is an Emeritus Professor of Water Resources Engineering at Civil Engineering Department of Middle East Technical University, Ankara, Turkey. After receiving his B.S. degree in Civil Engineering from Middle East Technical University (METU) in 1965, Prof. Altinbilek received his M.S. and Ph.D. degrees in Civil Engineering from Georgia Institute of Technology, Atlanta, USA. Since 1970, he has been involved in an academic profession holding posts at Middle East Technical University of Turkey and King Abdulaziz University of Saudi Arabia. From 1996 to 2001, he was the Director General of State Hydraulic Works (DSI), which is the major government agency in Turkey responsible for water resources development including hydropower, irrigation and water supply to large cities. From 2005 to 2009, Prof. Altinbilek was appointed as President of Energy Group at IC Holding, in Turkey and also as Chairman of Board of AES-IC Ictas Energy Production Company.

Prof. Doğan Altinbilek is an Honorary Member and the Past President (2013-2015) and Past Vice President (2007-2019) of the International Water Resources Association (IWRA). In addition, he served as a Governor (2006-2018) and Vice President (2012-2018) of World Water Council (WWC) where he continues to serve as an Honorary Governor. Prof. Altinbilek is also an Honorary Member and the Past President (2004-2008) of International Hydropower Association (IHA).

WATER DROP AWARD

The Water Drop Award recognises a student or early career professional, typically under the age of 35, who has made an innovative contribution to the water sector. These contributions may include, but are not limited to ground breaking recent research on water issues, entrepreneurship in the water sector, and raising the profile of younger people in the water sector.

Laura Movilla Pateiro
University of Vigo

Dr. Laura Movilla Pateiro is a lecturer in Public International Law at the University of Vigo, Spain. Her main field of research is international water law, with a particular focus on the law of transboundary aquifers.

NEW HONORARY MEMBERS

Honorary Membership is the highest honour IWRA can bestow and is awarded to those who have made significant contributions to the field of water resources and/or attained acknowledged eminence in some field of water resources. IWRA Honorary Membership provides free membership for life to an individual.

Patrick Lavarde
French Ministry of Environment

Claudia Sadoff
International Water Management Institute (IWMI)

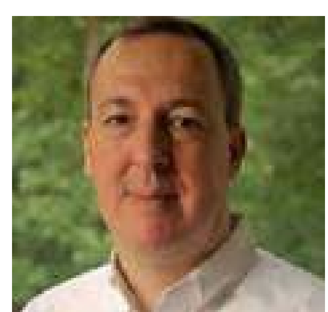
Jennifer J. Sara
World Bank Group

NEW fELLOW MEMBERS

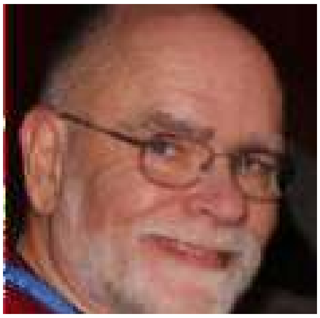
IWRA Fellow Membership is granted to an existing IWRA member who has been with IWRA for at least ten years and has either made major contributions to the Association, has held a position of high responsibility, has attained a high level of academic qualification in the field of water resources management, or has made significant contributions though their work. IWRA Fellows are eligible for discounted membership for life.

Emmanuel M. Akpabio
University of Uyo

Henning Bjornlund
University of South Australia & IWRA Executive Board



Carl Bruch
Environmental Law Institute



Michael Campana
Oregon State University

Zhao Hao
Ministry of Water Resources
People's Republic of China

Shaofeng Jia
Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences

Yuanyuan Li
Ministry of Water Resources, People's Republic of China & IWRA Executive Board

Christopher A. Scott
University of Arizona

Raya Marina Stephan
International Water Law Consultant & IWRA Executive Board

Poh-Ling Tan
Griffith University

Philippus (flip) Wester
International Centre for Integrated Mountain Development (ICIMOD)

IWRA 2020 GENERAL ASSEMBLY

24 September

Online Meeting

All IWRA members were invited to attend the 2020 General Assembly. The General Assembly was hold online via Zoom on September 24th at 2pm Central European time.

The agenda for this meeting was as follows:

Agenda Item	**Speaker**
Welcome remarks by the Secretary General	*G. Fradin*
Statement from the President	*G. Eckstein*
Activity report by the Executive Director	*C. Clench*
Financial update by the Treasurer	*R. Martin-Nagle*
Membership update by Chair of the Membership Committee	*T. Soo*
How to get more involved – a call to action by the President	*G. Eckstein*
Closing remarks by the Secretary General	*G. Fradin*

The IWRA General Assembly offered the opportunity again in 2020 to learn more about the Association and to hear from some of the senior board members and staff.

Not only members found out what is going on at IWRA, but also learnt about the new and exciting initiatives being planned, including online conferences and changes in the membership structure.

The recording of the General Assembly will be shortly posted it on our website, so that everyone can listen to the presentations at a later time if they were unable to join the meeting live. Any questions submitted either during the General Assembly or received via email afterwards will be answered online.

During this General Assembly, we shared some documents that can be reviewed again and included the following documents:

- IWRA's Strategic Priorities Document
- IWRA's Articles of Incorporation and By-laws
- IWRA's recent Activity Reports
- The calls to host the XIX World Water Congress and IWRA Regional Water Congresses
- IWRA's 2019 Financial Report

And, members were also invited to visit IWRA's three main websites:

- IWRA
- XVII World Water Congress
- IWRA On-line Conference

If you have any questions about the General Assembly, your membership or anything else, please contact us at office@iwra.org.

IWRA CELEBRATED ITS 49TH ANNIvERSARY!

On November 29th, 2020, the Association celebrated its 49th anniversary, been established in 1971 in the United States!

And, as it reached its 50th anniversary in 2021, IWRA was pleased to commemorate this important event again with its members, partners and supporters.

Water academics, experts, practitioners, professionals and students were a fundamental piece in the past year's IWRA activities and initiatives. In particular, during an unprecedented COVID-19 outbreak that has affected the lives of millions in 2020, and the work of countless organisations, globally.

Today, members, partners and supporters building on these activities and initiatives, continue to play an instrumental role in both the Association's present and future. Their efforts and commitment helped, and reinforce currently, the long IWRA heritage of publications, events and projects, while creating new opportunities and collaboration towards the sustainable use and management of the world water resources.

In the last 12 months, the crucial role of this vital resource to address the water, sanitation and health challenges posed by, for instance, the coronavirus pandemic, became evident. IWRA acknowledged this, and consequently produced a number of outputs with eight issues of its journal Water International, including a recent COVID-19 Commentary Series (Volume 45, Issue 5), and seven IWRA Policy Briefs, also with a dedicated number on "Covid-19 Challenges the Water Sector". In addition, it was decided to postpone the XVII World Water Congress to next year, from September 12th to September 16th 2021, to take place in Korea in the same city, Daegu, and the same venue, EXCO. This change in dates was done to ensure firstly, travel arrangements and a healthy and secure environment for participants, and secondly, to provide them with a unique place to network and exchange on Water Security and Resilience, as well as the lessons learned from the COVID-19 pandemic. Moreover, and under the world's new normal, IWRA has organised its first ever Online Conference on "Addressing Groundwater Resilience under Climate Change" from October 28th to October 30th 2020. This very successful event counted with more than 2650 registered participants from over 130 countries, nearly 100 speakers and moderators, 13 sessions with High-Level Panels, and a diverse list of sponsors and supporters representing Africa, Asia, Europe and the Americas. As well, we have participated and networked in many international water events and meetings, namely OECD's Water Governance Initiative, the World Water Council's Board of Governors and Forum, Human Right 2 Water, SIWI's Source to Sea Platform and Korea International Water Week 2020. We have organised eight IWRA webinars, including one on "Water & COVID-19", and launched two new member-led task forces on Groundwater, and Young and Early Career Professionals. More activities and initiatives can be found at www.iwra.org.

Both IWRA Executive Office and the Executive Board, looked forward to continuing to work closely with its membership and the international water community in 2021. In particular, in preparation for the Association's 50th anniversary the following year!

All members, partners and supporters were, therefore, invited to contact the Association to become more engaged and collaborate in order to further address the impacts of the COVID-19 outbreak and other challenges that lie ahead for the sustainable use and management of the world's water resources in years to come.

International Water Resources Association (IWRA)

Introduction

International Water Resources Association (IWRA) is a non-profit, non-governmental, educational organisation established in 1971. It provides a global, knowledge based, forum for bridging disciplines and geographies by connecting professionals, students, individuals, corporations and institutions who are concerned with the sustainable use of the world's water resources.

The goal of IWRA is to improve and expand the understanding of water issues through education, research and information exchange among countries and across disciplines.

IWRA seeks to continually improve water resource decision-making by improving our collective understanding of the physical, ecological, chemical, institutional, social, and economic aspects of water.

Objectives

- Lead and influence water policy and governance
- Develop and publicize methodological tools for assessment, improvement and conjunctive use of water
- Advance water resources planning, management, development, technology, research and education at international, regional, and national levels
- Provide a multi-disciplinary forum to address and discuss water issues
- Generate, synthesize, and disseminate knowledge and information in the area of water and related resources and the environment
- Encourage, promote and participate in international, regional, national and local programs and activities related to water resources for common benefit of humankind and biosphere

IWRA Geographic Committees

IWRA actively promotes the exchange of knowledge and experiences across countries and regions. The critical importance of local-base knowledge and experiences is strongly emphasised in our information exchange activities. The belief that sustainability requires interdisciplinary action and international cooperation is a driving force behind the Association.

IWRA has developed national or geographical committees in China, **India**, Japan and Ocenia to further implement its mission and focus its activities. These committees allow for extensive regional networking among IWRA members.

IWRA World Water Congress

Since 1973, IWRA has held a World Water Congress every three years in various locations around the world.

The objective of the World Water Congress is to provide a meeting place to share experiences, promote discussion, and to present new knowledge, research results and new developments in the field of water sciences around the world. For almost four decades the World Water Congresses have been excellent events for the identification of major global themes concerning the water agenda; and for the bringing together of a large cross-section of stakeholders for the development and implementation of decisions in the field of water.

Following is the list of IWRA World Water Congresses held so far:

XvIth World Water Congress in Cancun, Mexico
Dates: 29 May - 03 June, 2017
Theme: "Bridging Science and Policy"

Xvth World Water Congress in Edinburgh, Scotland, UK
Dates: 25-29 May, 2015
Theme: "Global Water, a resource for development : Opportunities, Challenges and Constraints"

XIvth World Water Congress in Porto de Galinhas, Brazil
Dates: 25-29 September, 2011
Theme: "Adaptive Water Management: Looking to the future"

XIIIth World Water Congress in Montpellier, france
Dates: 1-4 September, 2008
Theme: “Global Changes and Water Resources”

XIIth World Water Congress in New Delhi, India
Dates: 22-25 November, 2005
Theme: “Water for Sustainable Development, Towards Innovative Solutions“

XIth World Water Congress in Madrid, Spain
Dates: 5 – 9 October, 2003
Theme: “Water Resources Management in the 21st Century”

Xth World Water Congress in Melbourne, Australia
Dates: 12 – 16 Mars, 2000
Theme: “Sharing and Caring for Water”

IXth World Water Congress in Montreal, Canada
Dates: 1 – 6 September, 1997
Theme: “Water Resources Outlook for the 21 st Century: Conflicts and Opportunities”

vIIIth World Water Congress in El Cairo, Egypt
Dates: 13 – 18 May, 1994
Theme: “Satisfying Future National and Global Water Demands”

vIIth World Water Congress in Rabat, Morocco
Date: 13 – 18 May, 1991
Theme: “Water for Sustainable Development in the 21st Century”

vIth World Water Congress in Ottawa, Canada
Date: 29 May – 3 June, 1988
Theme: “Water for World Development”

vth World Water Congress in Brussels, Belgium
Date: 9 – 15 June, 1985
Theme: “Water Resources for Rural Areas and their Communities”

Ivth World Water Congress in Buenos Aires, Argentina
Date: 5 – 9 September, 1982
Theme: “Water for Human Consumption: Man and his Environment”

IIIrd World Water Congress in Mexico City, Mexico
Date: 23 April, 1979
Theme: “Water for Human Survival”

IInd World Water Congress in New Delhi, India
Date: 12 – 16 December, 1975
Theme: “Water for Human Needs”

Ist World Water Congress in Chicago, U.S.A.
Date: 24 – 28 September, 1973
Theme: “Importance and Problems of Water in the Human Environment in Modern Times”

AWARDS

Since its creation, IWRA recognises the contributions towards water management and the excellence of water researchers, professionals and organisations. IWRA presents 5 main awards.

Crystal Drop Award

For individuals or organisations in recognition of their laudable contribution to the improvement of the world’s water situation. The Crystal Drop Award is awarded once every three years and presented at the IWRA World Water Congress organized by IWRA.

Previous Recipients

2017: Hilda Cecilia Tortajada Quiroz and Salman M. A. Salman

2015: Vijay P. Singh

2011: International Water Management Institute (IWMI)

2008: Mahmoud Abu-Zeid

2005: Malin Falkenmark

2003: Benedito Braga

2000: Yutaka Takahasi

1997: Rotary International

1994: Asit K. Biswas

1991: Yahia Abdel Mageed

1988: UNEP and its Executive Director Dr. Mostafa Kamal (joint award)

1985: UNICEF

vEN TE CHOW MEMORIAL AWARD AND LECTURE

IWRA has established a Chow Memorial Lecture program to honor its first president as well as provide for an outstanding lecture, to be delivered at its triennial World Water Congresses.

IWRA has offered the Ven Te Chow Memorial Award and Lecture since 1988 in the name of the great hydrologist who was also the Association's founder and first president.

Previous Recipients

2017: V. P. Singh

2015: Rabi Mohtar

2011: Peter H. Gleick

2008: John Pigram

2005: Benedito Braga

2003: Asit K. Biswas

2000: Janusz Kindler

1997: Glenn E. Stout

1996: Ben Chie Yen

1994: Andras Szollosi-Nagy

1991: Malin Falkenmark

1988: Vujica M. Yevjevich

WATER DROP AWARD

The Water Drop Award recognises since 2020 a student or early career professional, typically under the age of 35, who has made an innovative contribution to the water sector. These contributions may include, but are not limited to ground breaking recent research on water issues, entrepreneurship in the water sector, and raising the profile of younger people in the water sector.

WATER INTERNATIONAL BEST PAPER AWARD

The Best Paper Award and honourable mention are awarded by year to author(s) based on the originality, innovation, technical quality, and contribution to water resources management of an article appearing in Water International.

OTHER SPECIAL AWARDS

Institutions that are responsible for water resources management are the frontline for delivering this precious resource for the people and for ensuring the protection of the environment. Faced with constantly changing needs and pressures, the provision of good water management means the integration of sound knowledge and good science with appropriate policies and efficient implementation. This award seeks to recognise regional, national or local institutions that have exhibited sustained excellence in water resources management. The award seeks to share and promote the associated experiences and knowledge with other organisations, scientists and water professionals around the world to improve sustainable and equitable water management.

The mandate of the present Executive Board of IWRA is from January 2019 to December 2021

Gabriel Eckstein (USA)
PRESIDENT

Gabriel Eckstein is Professor of Law at Texas A&M University and Director of the law school's Program in Natural Resources Systems. He focuses his research and teaching on water, natural resources, and environmental law and policy issues at the local, national, and international levels. He regularly advises UN agencies, national and sub-national governments, non-governmental organizations, and other groups on international and US water and environmental issues. He also directs the consultancy International H2O Solutions, as well as the non-profit International Water Law Project. From 2010-2015, Professor Eckstein served as Treasurer of IWRA; in 2017, he chaired the XVI World Water Congress International Scientific Committee. Professor Eckstein also serves as Associate Editor for Brill Research Perspectives: International Water Law, and on the Editorial Board of the Journal of Water Law. He holds a Juris Doctor and an LL.M. in International Environmental Law, an M.S. in International Affairs, and a B.A. in Geology.

Patrick Lavarde (france)
PAST PRESIDENT

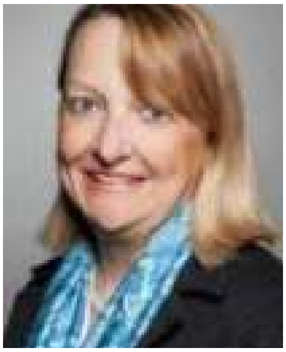
Patrick Lavarde is currently a member of the Environment and Sustainable Development Advisory Board of the French Ministry of Environment. He is also the Co-Chair of the ISC of the 9th World Water Forum to be held in Dakar in 2021 and was Governor of the World Water Council from 2012 to 2018. Patrick was President of IWRA from 2016 to 2019 after being a Director during the term 2012-2015. In 2007, he created the French National Office for Water and Aquatic Environments (ONEMA). Being its General Director until October 2012, he engaged in water research coordination, national monitoring of water bodies, regulation and enforcement, and technical support to stakeholders. From 1998 to 2007, he was General Director of the National Research Institute on Environmental Sciences and Technologies, the leading French institution on freshwater issues. During this mandate, he chaired the Partnership on European Environmental Research and was deeply involved in the European Network of Water Research (Euraqua). Previously he worked for public organisations involved in forestry, agriculture and water, at national and local levels.

Blanca Jiménez-Cisneros (Mexico)
vICE-PRESIDENT

Blanca Jiménez-Cisneros is an Environmental Engineering with PhD degree in Water from the Institut National des Sciences Appliquées, France. She has over 30 years of experience at the academia, public sector and as a consultant for the private sector and international organisation. Her main fields of expertise are water reuse for agriculture and human consumption and water resources management with focus on developing countries. She has been researcher at UNAM in Mexico, the University of Pretoria in South Africa and the Federal University of Curitiba, Brazil. Dr Jiménez has authored more than 460 publications and has around 6000 quotations. She was co-coordinator for the freshwater resources chapter for the AR4 of IPCC and has been engaged as reviewer in the same field for the AR5. In 2012 she joined UNESCO as Director of the Division of Water Sciences and Secretary of the International Hydrological Programme (IHP). She has received several Mexican and international awards, among which the IWA Global Water Award 2010 and the Royal Polar Star presented by the King of Sweden for her contributions on water and nutrients reclamation and the involvement of the youth on water research, respectively. She has been recently appointed as the new Director General of the National Water Commission of Mexico (Conagua).

Karin Krchnak (Slovakia)

vICE-PRESIDENT



As an environmental lawyer, Karin Krchnak has worked to improve policies and procedures related to environmental management and resource conservation worldwide for over 25 years. She has spent the last 15 years in leadership positions around improving water resource management. This has included managing initiatives focused on advancing corporate water stewardship, water security, and building better governance through increased transparency, rule of law and institutional strengthening. She currently leads the 2030 Water Resources Group, hosted by the World Bank Group. Ms. Krchnak received her B.A. in Political Science from Duke University and her J.D. from the University of Maryland School of Law. She has published extensively in international environmental policy and sustainable development, particularly on freshwater issues. She has served on numerous steering committees, including the Board of Governors of the World Water Council, its Executive Management Team and as Chair of the Governance Commission.

Yuanyuan Li (China)

vICE-PRESIDENT

Yuanyuan Li is Vice-President and Professor of the General Institute of Water Resources and Hydropower Planning and Design at the Ministry of Water Resources of China, which is the most important technical supporting agency to the national water resources development and strategy planning, water policy research, formulation and management. His fields of expertise include water resources management mechanisms, human activities-water resources interaction, water resources system analysis and planning, water ecology and environment protection etc. He has led many nationwide water resources surveys, strategy studies, comprehensive water resources planning, major water projects technological demonstration, water policies formulation and management activities as well as international programmes and cooperation. He has widely published books and papers about water related topics. His research results have been awarded numerous state science and technology awards. He is serving as a Director on the Executive Board of IWRA for the 2012-2015 period and is the Chair of the IWRA Chinese Committee.

Guy fradin (france)

SECRETARY GENERAL

Guy Fradin is currently President of the Forestry, Water and Rural Areas Department in the Ministry of Agriculture. He first worked as a forester within the National Office for Forestry (1976/1980), then in the Forestry Department of the UN Food and Agriculture Organization (FAO, 1980/1982) and in the International Department of the Ministry of Agriculture (1982/1989). Subsequently, he was in charge of economic issues for the Ministry (1989/1992) and then was appointed as the Deputy Director for Rural Areas and Forestry (1992/2000). He served as Deputy Director of the Ministry of Agriculture Office (1997), Regional Director of Agriculture and Forestry in Ile-de-France (2000/2003), Director of Nature and Landscapes in the Ministry of Ecology (2003) and Director of the Office of the Ministry of Environment (2003/2004) before being appointed Director General of the Seine Normandy Water Agency (2004/2011).

Renée Martin-Nagle (USA)

TREASURER

Renée Martin-Nagle, PhD is President and CEO of A Ripple Effect pllc, Special Counsel at Eckert Seamans, and a Visiting Scholar at the Environmental Law Institute. She received her PhD in 2019 from the University of Strathclyde, and her doctoral thesis, “Governance of Offshore Freshwater Resources”, was published by Brill Nijhoff in January 2020. For more than twenty years prior to joining the water community, she was the chief legal counsel for Airbus Americas, retiring in 2011 as General Counsel, Chief Compliance Officer, Head of Environmental Affairs, Corporate Secretary and a member of the Board of Directors. Renee earned an LL.M from George Washington University Law School (with highest honors), a Juris Doctor from the University of Pittsburgh School of Law, a Bachelor of Arts from St. Francis University and an Associate of Arts from Mount Aloysius College. Her LL.M. thesis, “Fossil Aquifers: A Common Heritage of Mankind”, won the 2011 Jamie Grodsky Prize for Environmental Law Scholarship.

COMMITTEE CHAIRS

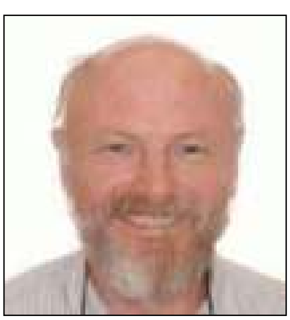
Rabi Mohtar (Lebanon)

AWARDS COMMITTEE

Rabi Mohtar is a Professor of Environmental Resources Engineering at Texas A&M University, where he founded the University's Water-Energy-Food Nexus Initiative (WEFNI), and Dean of the Faculty of Agricultural and Life Sciences at the American University of Beirut (2018), where he has introduced several initiatives, including the Water-Energy-Food-Health Nexus Renewable Resources Initiative (WEFRAH), a University wide initiative focused on regional collaboration to achieve primary resources security. In both institutions, Mohtar continues his efforts to develop analytical frameworks for the quantitative assessment of resource allocation tradeoffs and with the goal of providing effective tools to empower stakeholder dialogue, particularly between policy makers, scientists, and civil society. In 2015, he gave the Ven Te Chow memorial Lecture during IWRA's XV World Water Congress and convened a High-Level Panel during the XVI World Water Congress. He has published over 200 peer-reviewed articles, refereed conference proceedings, books and chapters addressing global resource security, linking science and policy, characterizing soil-water medium using thermodynamic modeling, non-traditional water applications for sustainable integrated water management.

Henning Bjornlund (Australia)

SCIENTIfIC, TECHNICAL & PUBLICATIONS COMMITTEE



Henning Bjornlund has been at the University of South Australia for more than 20 years. Since January 2015, he has been a Research Professor of Water Management and Policy. For the last three years he served as a Director of IWRA. In that capacity, he presented a number of papers and served on two steering committees for research projects. He has extensive experience in managing large research projects and published some 175 refereed papers. Prior to joining academia Henning was involved in the management of educational institutions, businesses, tropical farming operations and a development aid organisation. He served in various capacities such as board member, chairman and executive director. Henning offers a unique blend of experiences crossing academia, industry and the NGO sector.

Tom Soo (Australia)

MEMBERSHIP COMMITTEE

Tom Soo is a senior executive and consultant in the water sector. He has been Executive Director of IWRA and the World Water Council and also has a background in consulting to international institutions, public authorities, academia, as well as private industry. Tom's current focus areas include institutional arrangements, strengthening the link between knowledge generation and policy making; hydro-environment engineering and research; water quality; building networks between private industry, research and government stakeholders; as well as strategy and technical consulting in the sector of water and natural resources. Over the years, Tom has participated in numerous international committees and task forces. He holds a research masters degree in geography; and also has a degree in computer systems engineering (electrical). He currently heads up the International Association of Hydro-Environmental Engineering and Research; is a founding member of the Water Policy Group; a member of the Steering Committee of the Global Water Partnership; as well as chairs the International Advisory Committee of the UNSW Global Water Institute, and the Membership Committee of the IWRA.

CALL FOR PAPERS

This journal aims to provide a snapshot of the latest research and advances in the field of Water Resources. The journal addresses what is new, significant and practicable. Journal of IWRA (India) is published twice a year (January-June and July-December) by IndianJournals.Com, New Delhi. The Journal has both print and online versions. Being peer-reviewed, the journal publishes original research reports, review papers and communications screened by national and international researchers who are experts in their respective fields.

The original manuscripts that enhance the level of research and contribute new developments to the water resources sector are encouraged. The work belonging to the fields of Water Resources are invited. The journal is expected to help researchers, technologist and policy makers in the key sector of Water Resources to enhance their understanding of it.The manuscripts must be unpublished and should not have been submitted for publication elsewhere. There are no **Publication Charges.**

1. GUIDELINES f OR THE PREPARATION Of MANUSCRIPTS fOR PUBLISHING IN "IWRA (INDIA) JOURNAL"

The authors should submit their manuscript in MS-Word (2003/2007) in single column, double line spacing as per the following guidelines. The manuscript should be organized to have Title page, Abstract, Introduction, Material & Methods, Results & Discussion, Conclusion, and Acknowledgement. The manuscript should not exceed 16 pages in double line spacing.

- Take margin as 1." (Left, Right, Top & Bottom) on A4 paper.
- The Title of the paper should be in bold and in Title case .
- The next item of the paper should be the author's name followed by the co-authors.
- Name of the corresponding author should be highlighted by putting an asterisk, with whom all the future correspondence shall be made.
- This should be followed by an affiliation and complete official addresses.
- Providing e-mail id is must.
- Please keep the title, author's name and affiliation center aligned.
- Use the following font sizes:

  Title: 14 point bold (Title Case), Author's name(s): 12-point bold, Author's Affiliations: 10-point normal, Headings: 11-point bold & caps, Sub-headings: 11-point normal & caps, Body Text: 10-point normal.
- The manuscript must be in English.
- Manuscripts are accepted on the basis that they may be edited for style and language.
- Use Times new roman as the font.
- Words used in a special context should appear between single quotation marks the first time they appear.
- Lines must be double-spaced (plus one additional line between paragraphs).
- Tables and figures must be included in the same file as the text in the end of the manuscript. Figures must be inserted into the document in JPEG or Tagged Image File Format (TIFF) format.
- Abbreviations should be spelt out in full for the first time they appear and their abbreviated form included in brackets immediately after.
- Communicating author will receive a soft copy of his/ her published paper at free of cost.

Submission of Manuscript

The manuscript must be submitted in doc and pdf to the Editor-in-Chief as an email attachment to uday@cbip.org. The author(s) should send a signed declaration form mentioning that, the matter embodied in the manuscript is original and copyrighted material used during the preparation of the manuscript has been duly acknowledged. The declaration should also carry consent of all the authors for its submission to Journal of IWRA (India). It is the responsibility of corresponding author to secure requisite permission from his or her employer that all papers submitted are understood to have received clearance(s) for publication. The authors shall also assign the copyright of the manuscript to the publisher IndianJournals.Com (India).

PEER REvIEW POLICY

Review System : Every article is processed by a masked peer review of double blind or by three referees and edited accordingly before publication. The criteria used for the acceptance of article are: **contemporary relevance, updated literature, logical analysis, relevance to the global problem, sound methodology, contribution to knowledge and fairly good English**. Selection of articles will be purely based on the experts' views and opinion. Authors will be communicated within Two months from the date of receipt of the manuscript. The editorial office will endeavor to assist where necessary with English language editing but authors are hereby requested to seek local editing assistance as far as possible before submission. Papers with immediate relevance would be considered for early publication. The possible expectations will be in the case of occasional invited papers and editorials, or where a partial or entire issue is devoted to a special theme under the guidance of a Guest Editor.

The Editor-in-Chief may be reached at: uday@cbip.org

INDIAN GEOGRAPHICAL COMMITTEE OF IWRA (IGC-IWRA)

Water is one of the most precious gifts of the nature to mankind. Benign and life supporting in normal times, menacing during floods, and desperately sought in times of drought, the waters of the rivers, aquifers, springs, lakes, etc., have been part of our daily life. However, with the growing requirements of water for diverse purposes, water is becoming a critical and scarce natural resource and cannot be regarded as available in abundance as might had been believed earlier. It is widely recognized that many countries are entering into era of severe water shortage. The increase in demand is not only due to population growth but also due to improved life style of the people.

The International Water Resources Association (IWRA), established in 1972, with its secretariat in France, has been recognized and respected as a leading advocate in advancing the understanding and management of water resources worldwide.

The Central Board of Irrigation and Power (CBIP) is representing IWRA, in India, as its Geographical Committee, since 1991. The Indian Geographical Committee of IWRA (IGC-IWRA) has been involved in dissemination of information in the field of water resources through publications and training courses/seminars/conferences, both at National and International levels. The Indian Geographical Committee provides information regarding latest developments in the subject to its members.

IGC-IWRA offers following categories of the membership:

- Individual Membership for 01 Calendar year : Rs. 500.00
- Individual Membership for 10 Calendar years : Rs. 4,500.00
- Individual Membership for Life : Rs. 9,000.00
- Institutional Membership for 01 Calendar year : Rs. 2,000.00
- Institutional Membership for 05 Calendar years : Rs. 8,000.00
- Institutional Membership for 10 Calendar years : Rs. 15,000.00

The members of IGC-IWRA will get the following benefits:

- A copy of the IWRA (India) Journal published on half yearly basis.
- Special rates at all IGC-IWRA events
- Announcements on upcoming events featured in IWRA publications and on the IWRA Website
- Have the opportunity to engage in professional networking and information exchange activities

One of the benefits to the Institutional Members is enrollment of their 05 representatives as Individual Members of the IGC-IWRA, besides promotion of activities through IWRA (India) Journal.

For membership and other details, please contact:

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Member Secretary

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