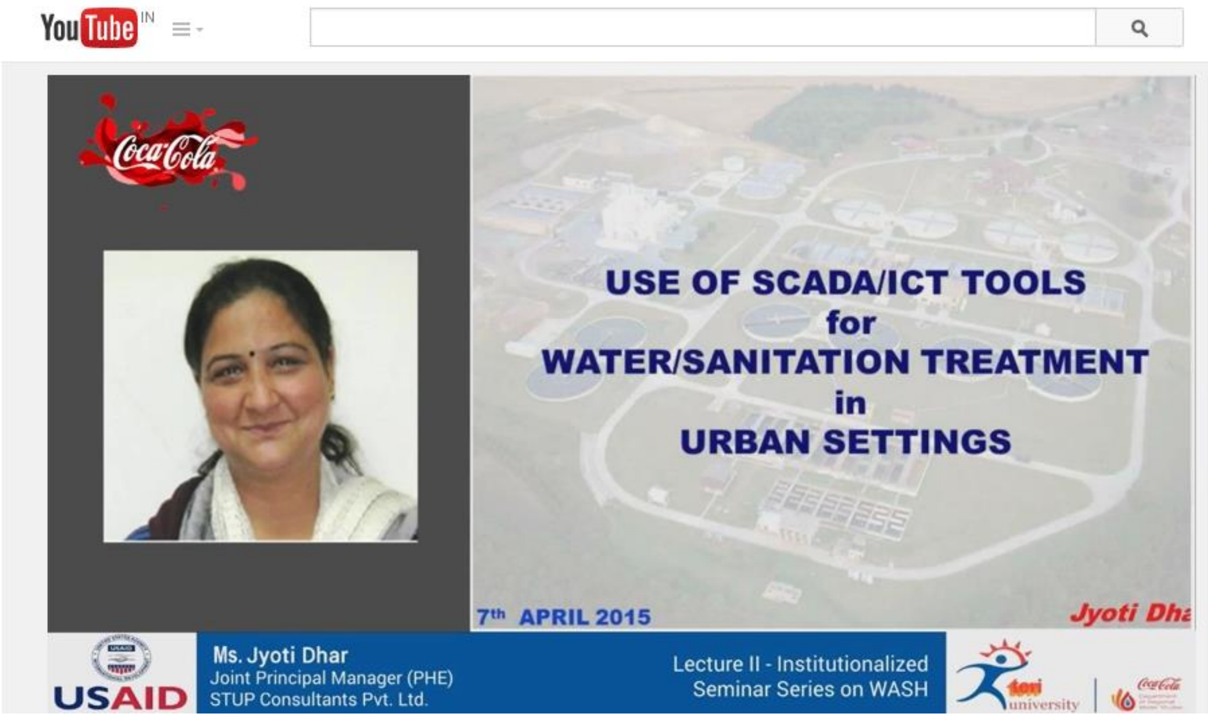
June 2015

Progress report of Coca-Cola Department of Regional Water Studies

Progress report
April 1- June 30, 2015



Highlights

Major activities of the Department during the period were:

- Research projects
- Research publication
- Academic engagement with experts and organizations
- Completion of taught courses for the first batch and initiation of major projects.
- Admission process of new batch of students

1. Research projects

The Department submitted two project reports to respective funding organizations. Feedback was good and they continue to support for the next phase of these projects. A brief description of the reports is given below.

Report I. *Socio-ecological metabolism study for urban water planning- a case study of Delhi*

Submitted to University of Toronto; Funded by Enel Foundation.

This project is a social-ecological metabolism study for urban water planning to investigate nexus between social and environmental objectives of urban planning. It attempts to illustrate city as a tightly coupled social-ecological system, using Delhi's water as a case study. The central feature of the study is (a) to account for water inflows and outflows (including wastewater) and construct a well-defined water mass balance, (b) to illustrate how metabolic flow of water is shaped by economic, policy, social and other variables and how the metabolic structure alters the background water hydrology, (c) to demonstrate spatial diversity and variation of drivers, and (d) to uncover how certain policy choices determine the shape of urban environment with consequences on the social-ecological feedbacks. The study attempts to understand consequences of such policy conundrum when two separate entities become responsible for what is an environmentally unified flow. The study also attempts to illustrate the benefits of using systems approach for urban planning over the conventional sectoral planning approach. Water and Energy are two critical components of urban infrastructure and it is important that planning for these components and associated policies take into account the deep interaction between these two sectors.

Major findings supported with data, literature and analyses in the report are:

1. ***Key challenge***. NCTD both as an urban agglomeration and as an independent state is significantly constrained for access to water resources. It has high dependence for water on hinterland and hence depends on interstate agreements and their application by other states. Long distance conveyance of water exerts its hydrological footprint on distant basins. As water demand increases, so will be the increase in wastewater generation and energy demand. Conflicts may increase in future between states (over interstate river water use), socio-economic strata, ecological vs economic goals, financial prudence vs social goals. There

is uncertainty in dam based resource augmentation, declining groundwater output and reduced water availability for environmental flows.

2. ***Inequitable and unreliable water supply.*** Water supply is not uniform across the city and significant amount of population is using water from private water tankers and underground sources. Given the increasing trend of water quality deterioration of both surface and groundwater, there is lack of access to safe water which increases financial burden on people (either in the form of use of domestic purifiers, purchase of water from private vendors or in the form of medical treatment cost). Lack of trust in the quality of DJB water supply has led to the widespread use of bottled water consumption. Literature suggests that coping strategies adopted by people had costed them INR 3 billion whereas operation expenses of the DJB on the same year were INR 1.6 billion. Researchers estimated that coping cost of households in authorized colonies is INR 10 per kl of water consumed; they pay INR 6 per kl to DJB as tariff and thus bear a cost of INR 16 per kl of water consumed. Coping cost of households is high in under-served colonies. Similarly coping cost borne by commercial, industrial and institutional consumers are INR 42, 47 and 18 per kl respectively.
3. ***Absence of unified planning.*** The DDA is under the administrative control of Central Government and the DJB is under state government. DDA ascertains water demand projections from population projections and water supply norms promulgated by Union government (MoUD) and look for supply-led solutions to meet the demand supply gap, instead of demand-side solution which prompts involvement of all urban utilities in the planning process.
4. ***Abysmal state of groundwater.*** Groundwater of Delhi is bad both in terms of quality and quantity. Still, there is a large-scale private groundwater abstraction. Though it is regulated by CGWB but the enforcement is very limited. Less than one-third of the tube well owners have registered with CGWB and in some areas the groundwater table is declining at the rate of 0.1 to 0.2 meter per year on an average (West, Northwest Delhi and New Delhi districts of Delhi), whereas, central Delhi records decline of 0.4 m per year. Another policy response to this situation is promotion of rainwater harvesting. However, it is estimated that even if this is implemented diligently, the outcome would not be higher than 10% of city's water uses.
5. ***Invisible subsidy to industry.*** No reliable information is available about industrial use of groundwater but it is well known that most industries abstract groundwater privately to meet their requirements. The tariff by DJB for industries is much higher than that of domestic water supply and thus industry finds it profitable to use groundwater than the water from public supply networks.
6. ***Development of parallel water market.*** During 1990s, informal settlements have started sourcing water from private water tank operators. These operators own deep tube wells on city outskirts. Huge profits that these operators derive have led to cartelization and emergence of water mafia. In some unauthorized colony, a new form of water market has emerged. Some local people have developed small water supply networks and pump out water from deep tube wells and supply to some cluster of households for 2 hours a day. Users pay fixed monthly charges to such service providers. These systems are leading to unsustainable use of groundwater.
7. ***Under-recognized importance to water-energy nexus.*** Water and electricity demand in NCTD peaked simultaneously during summer months (April-June) every year. There are increasing instances where water distribution in Delhi is affected adversely due to unavailability of electricity, and power generation companies have to reduce power generation during summers as they have to shut down their boilers due to unavailability of water. Water and energy shortage together affect public welfare and environment adversely due to use of coping strategies such as use of tanker water supply, discharge of untreated sewage and use of diesel generators by commercial and industrial establishments. There is no evidence that city government plans these infrastructures as a unified system. Energy considerations in water sector are limited to its impact on operational cost and there is an undeclared tendency to cope up these expenses through tariff restructuring, subsidies and

grants-in-aid only. They do not recognize that energy shortage can play a pivotal role for water sourcing in future and might cripple operation of entire water infrastructure, and might compromise the goal of 24x7 water supplies. Energy planners view water sector as minor consumer of energy since much of the energy share is on account of domestic and industrial demand. Energy demand forecasting thus consider only such demand as major determinants for future energy needs of the city. Unmet gap in existing urban water infrastructure and future needs can peg the electricity demand for water sector up to 12% of the total. Further, design period, material and technology choice by water utilities do not consider the energy locked in these infrastructure. The current mechanism of incorporating energy considerations in water sector as merely an operational cost favors centralized systems of water treatment as they enjoy economy of scale. This study points out that energy and environment impacts when analyzed from a system analysis, the decentralized form of urban water infrastructure and wastewater recycling has advantage over current practice of centralized urban water treatment systems.

8. ***Mainstreaming of local water entrepreneurs.*** Weak financial strength of urban utilities for expansion of piped water services to uncovered communities and unattractiveness of investments in peri-urban areas (including slums) have prompted urban utilities to start contracting to local water players as alternate delivery mechanism. Evaluation of this model using life cycle cost analysis (LCCA) will be useful to plan future governance structure of this sector and planning for appropriate public-private-partnership (PPP) model.

Report II. *Towards a better water-energy-carbon nexus in cities*

Submitted to Asia Pacific Network; It is a multi-institution partnership project involving AIT, Thailand and Hiroshima University, Japan.

Water-energy-carbon nexus directly influence three key contemporary policy issues crucial for cities: climate change mitigation, water security and energy security. Water and energy are generally managed as separate entities, local decision makers usually act on them separately but an integrated knowledge as well as considerations to up-stream implications is immensely useful. Improving this nexus in cities will greatly aid sustainability efforts of city governments.

Major findings so far are:

1. ***A number of drivers influence water, energy and carbon nexus in cities.*** The geophysical, climatic, social & economic environment in cities affects water-energy development of cities. Energy-carbon footprint per person with respect to per unit of water utilized thus differs within cities and countries. The drivers that influence the water-energy nexus, is vital for water sector planners to be understood, in order to formulate policies for optimizing energy-carbon footprints. Urban settlements constitute more than half of the global population and 2.8 billion more will be added by 2050. Energy use in water sector will continue growing to meet increasing water demand. Climate change will influence the water availability, water quality, salt water intrusion, water and energy demand, and may impact built infrastructures which has further implication on energy. The technological change, innovation and other factors affect the adoption of new water treatment technologies. This might have positive or negative implications on energy. However, newer technologies which are less energy intensive could be emphasized. For example most households in New Delhi are purchasing reverse osmosis based water purification units in recent years, eventually

increasing energy footprint of water. In California extensive use of sea water desalination is growing due to depleting surface water resources. Water consumption pattern, physical loss of water in networks, ageing infrastructures and its maintenance further have more energy implications. 45–88 million m^3 of water is lost every day due to leakages in water supplies worldwide. Half of it is in developing countries. This is sufficient to serve 200–400 million people (Olsson, 2012).

2. ***Implications on energy and carbon footprints must be considered in planning, design and operation of urban water infrastructures.*** Various factors determine the design and construction of water infrastructures such as: water sources, quality, future water demand, water/waste water standards, environmental regulations, natural hazards, feasible technologies, budget etc. Any new water infrastructure design & construction should be assessed and regulated by responsible institutions. Operational energy of water infrastructure depends on infrastructures' design while it is ideal to consider embodied energy of construction materials in those systems. Different scenarios should be studied and planned for instance, selection of lined canal versus natural conduit for drinking water transport or open drainage versus closed pipes for waste water collection for construction/rehabilitation of water systems. There is need to assess or model every element of urban water system to foresee its possible energy-carbon implications.
3. ***Intra-city comparison.*** In Bangkok and Tokyo, surface water is major water source while in Delhi excessive extraction of ground water is in practice till date eventually with higher energy footprints on water abstraction. Moreover ground water depth in most of the East, West & South parts of Delhi have increased in recent years costing more pumping energy. The energy intensity in drinking water treatment is slightly higher in Tokyo than Bangkok and Delhi due to its higher water quality standards, but this is not the accurate comparison as value chain of energy footprints will be higher in city like Delhi if energy intensive end use water purification is involved. Majority of energy use in drinking water system is higher for Tokyo during treatment i.e. 45% while in Bangkok, treatment only consumes 20%. However, excessive pumping in Bangkok involves higher percentage of energy use in water transport and distribution i.e. 80%, while in Tokyo is just 55%. The non-revenue water loss in New Delhi is 50% while in Bangkok is 24% and Tokyo is 8%. Tokyo has comparatively better water systems management practices than in other Asian cities. Also, capacity utilization of water and waste water treatment plants has implication on energy-carbon footprints. The water and waste water treatment systems operate at optimum capacity in Tokyo compared to Delhi and Bangkok (while the coverage in Delhi and Bangkok are still increasing), these results in comparatively lesser energy footprints.
4. ***Opportunities for reducing energy and carbon footprints in urban water systems.*** Apart from efficient design and optimum operation in urban water system management, other options to reduce net energy-carbon footprints must be explored. Majority of energy in many cities still comes from fossil fuels. Some water and wastewater treatment plants in Tokyo are implementing use of solar energy to supply some energy. Similarly waste water treatment byproducts are utilized as resource recovery by reusing its chemical energy. For instance in Tobu Sludge Plant of Tokyo, Carbide products manufactured from sludge are being used as fuel in coal-fired power plants. Small percentage of treated waste water is also utilized in Delhi for gardening. The application of decentralized green energy systems in water/waste water system and resource recovery from treated waste water shall be scaled up.
5. Most cities' water/waste water, energy and carbon management policies and practices exist independently outside the framework of water-energy-carbon nexus. Some actions from few cities' government exist to reduce net energy-carbon footprint related to urban water sector notably, design of energy-carbon efficient infrastructure, promoting use of alternative energies and recovery energy from treatment byproducts. Integrating water, energy and carbon policies with direct participation from different government departments will enhance their overall goals and help achieve common objective to meet GHG reduction targets, ensure energy and water security.

6. Cities' water-energy-carbon nexus is a key area to look into both from direct and indirect perspectives as an essential part of reducing overall GHG emission of the city.
7. Energy and carbon footprint of urban water cycle depends on multiple characteristics of urban water cycle including nature of water sources, distances, nature/extent of infrastructure, choice of technologies, water losses and management practices. Better understanding of water-energy-carbon nexus drivers would assist policy makers since energy security, climate change mitigation and water security are three key contemporary policy issues and must be integrated and optimized locally.
8. City governments and water utilities should plan the urban water infrastructure development in coherent manner addressing the optimization of overall energy.
9. Resource recovery and reuse of resources from waste water treatment helps to reduce the overall energy-carbon footprints.
10. Evaluation of overall urban water management should be done at regular intervals based on performance assessment. Every city has opportunities to apply different options for reducing energy-carbon footprints and each cities' objectives of water and waste water management depends on its local context, like use of ground water/sea water as source of drinking, reuse of waste water for gardening or other purposes. Thus design of the system varies within cities. Scenario analysis like an example of Delhi for centralized vs decentralized waste water system should be studied in the planning process.
11. Proper assessment on each elements of urban water cycle on energy-carbon implications is needed. Efficient operation of water infrastructures such as capacity utilization should be planned such that energy-carbon implications could be optimized even under different future scenarios.

2. Research publications

Research paper publication in an International peer-reviewed journal takes time; the publication by faculty members with primary affiliation to Coca-Cola Department has started. First publication came in the Journal of Applied Water Science.

Jasrotia S, Kansal A, Mehra A (2015). Performance of aquatic Plant species for phytoremediation of arsenic-contaminated water. Jr Applied Water Science. Springers. DOI 10.1007/s13201-015-0300-4.

In addition to the above, faculty members of the Department are successful in publishing in prestigious Journals but with their affiliation to their previous department. Three more papers have been submitted by faculty members which are under review.

Appl Water Sci
DOI 10.1007/s13201-015-0300-4

ORIGINAL ARTICLE

Performance of aquatic plant species for phytoremediation of arsenic-contaminated water

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Received: 23 February 2015 / Accepted: 3 June 2015

Abstract This study investigates the effectiveness of aquatic macrophyte and microphyte for phytoremediation of water bodies contaminated with high arsenic concentration. Water hyacinth (*Eichhornia crassipes)* and two algae (*Chlorodesmis* sp. and *Cladophora* sp.) found near arsenic-enriched water bodies were used to determine their tolerance toward arsenic and their effectiveness to uptake arsenic thereby reducing organic pollution in arsenic-enriched wastewater of different concentrations. Parameters like pH, chemical oxygen demand (COD), and arsenic concentration were monitored. The pH of wastewater during the course of phytoremediation remained constant in the range of 7.3–8.4, whereas COD reduced by 50–65 % in a period of 15 days. *Cladophora* sp. was found to survive up to an arsenic concentration of 6 mg/L, whereas water hyacinth and *Chlorodesmis* sp. could survive up to arsenic concentrations of 2 and 4 mg/L, respectively. It was also found that during a retention period of 10 days under ambient temperature conditions, *Cladophora* sp. could bring down arsenic concentration from 6 to <0.1 mg/L, *Chlorodesmis* sp. was able to reduce arsenic by 40–50 %; whereas, water hyacinth could reduce arsenic by only 20 %. *Cladophora* sp. is thus suitable for co-treatment of sewage and arsenic-enriched brine in an algal pond having a retention time of 10 days. The identified plant species provides a simple and cost-effective method for application in rural areas affected with arsenic problem. The treated water can be used for irrigation.

Keywords Phytoremediation · Water treatment for arsenic removal · Water hyacinth · Algae

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Introduction

The occurrence of arsenic has been marked in groundwater supplies in several regions in more than 70 countries and over 150 million people are estimated to be exposed to arsenic, predominantly belonging to rural areas (Shankar et al. 2014). The treatment technology for arsenic removal includes electro dialysis, ion exchange, ultrafiltration, etc., which produces arsenic-enriched water rejects. The outcome of these technologies is potable water along with arsenic-rich wastewater. This waste is generally stockpiled and thrown or disposed in nearby surroundings that could lead to leaching of arsenic back into the soil and water system making groundwater more susceptible to arsenic concentrations. Management of arsenic-rich waste from these systems is a major environmental concern (Magalhaes 2002). New sustainable techniques need to be identified to address removal of arsenic residues in the water environment.

Phytoremediation of toxins from aquatic environment is gaining popularity as a low-cost environment-friendly

Published online: 17 June 2015

3. Academic networking

The Department started seminar series under the USAID supported project which have been recorded and put on You Tube. Annexure I give the details of lectures (with web links).

The Department will soon be a part of the consortium under “Harit Aravalli” project initiated by Navjyoti Foundation and will provide scientific guidance. The project aims to revive water bodies in Aravalli region.

4. Second semester result and dissertation placement

The first batch of student has completed the course work and the result is given in Table 1. Final status of student placement is given in Table 2. Interest from 32 organizations was received to engage our student (Annexure II).

Table 1 Final grades of M.Tech / M.Sc (Water Science and Governance) – Class of 2014

S.No.	Name	SGPA	CGPA
	M.Tech (WSG)		
1	Priyank Jain	8.88	8.72
2	Deepali Goyal	8.28	8.18
3	Ruchika Satish	8.17	8.02
4	Rajesh Ramamoorthy	7.63	7.80
5	Praveen Kumar S	7.28	7.35
6	Manas Awasthi	6.91	7.14
7	Mohd Zeeshan	7.00	6.89
8	Qazi Syed Wamiq Ali	6.44	6.79
9	Akash Purohit	6.17	6.76
10	Anurag Prakash	6.06	6.45
11	Vishal Singh	5.77	6.18
	M.Sc (WSG)		
1	Niyati Seth	8.78	8.53
2	Shoobhangi Tyagi	8.19	8.35
3	Pallavi Kharbanda	7.59	7.85
4	Prapti Verma	7.93	7.80
5	Bedashree Choudhury	7.69	7.56
6	Sakshi Chawla	7.00	7.26
7	Himanshi Gupta	6.85	6.58
8	Aparna Gupta	5.92	6.27

Table 2 Status of Student dissertation placement.

S.No.	Name	Company Name
M.Tech (WSG)		
1	Akash Purohit	Clearford
2	Anurag Prakash	TERI University
3	Deepali Goyal	TERI University
4	Manas Awasthi	WABAG
5	Mohd Zeeshan	TERI
6	Praveen Kumar S	Dhan Foundation
7	Priyank Jain	TERI University
8	Qazi Syed Wamiq Ali	Coca-Cola
9	Rajesh Ramamoorthy	TERI University
10	Ruchika Satish	Coca-Cola
11	Vishal Singh	TERI
M.Sc (WSG)		
1	Aparna Gupta	TERI
2	Himanshi Gupta	TERI
3	Niyati Seth	TERI
4	Pallavi Kharbanda	Coca-Cola
5	Prapti Verma	TERI
6	Sakshi Chawla	Coca-Cola
7	Shoobhangi Tyagi	Coca-Cola
8	Bedashree Choudhury	TISS, Guwahati

Faculty members of the Department had a detailed discussion (Departmental meeting held on April 20, 2015) on the preparedness of the student to do dissertation in various organizations. All faculty members were unanimously of the view that in their assessment the student lack maturity and systematic approach required for problem diagnosis and hence it will not be appropriate to expose them to outside organization. Failure to perform will lower the confidence of the student and will bring disrepute to the Department. It was decided that this year the students will preferably be placed in TERI, TERI University and Coca-Cola. From the next batch, the student will have to do the first 6 months of dissertation only under the guidance of a faculty in a university.

5. New admissions

The total number of applicants this year were 46 (Indian) and 6 (International). Of the 46 applicants, 9 students were screened out in the initial stage as they were not found suitable for the programme. 37 students were allowed to appear for the entrance examination. During the interview, 6 students were absent and another 6 students were not found suitable. Final list of 25 selected candidates has been displayed. The exact status of admissions will be provided in the next report.

Publicity of the department to attract good number of students from reputed institute is recognized as a major focus area during this academic year.

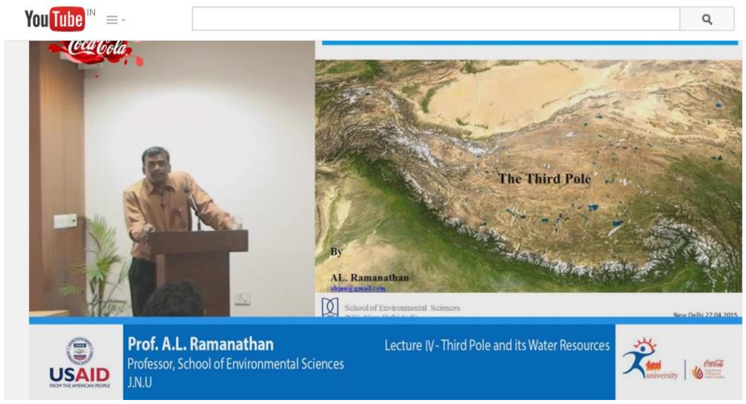
Annexure I

Institutionalized Seminar Series

The seminar series is designed to address key issues in the WASH sector, so that wide range of students and working professionals get exposure to the latest techniques, innovations, and required interventions.

Topic Third Pole and Water Resources

This lecture was delivered by Prof. A.L Ramanathan, School of Environmental Sciences, JNU on 27th April, 2015



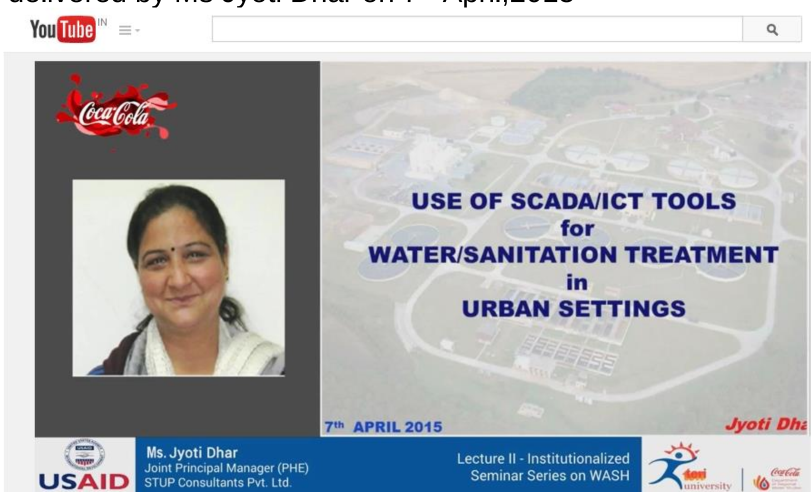
https://youtu.be/dMUCajHBYQ8

Prof. Ramanathan, delivered a talk on *third pole and its water resources.* He discussed that as water demand grows, potential for conflict will increase. Careful management of water resources including managing our glaciers will be a priority in the coming future. He emphasized that glacial melt make a significant contribution to our Himalayan Rivers in the summer season, studies being conducted on glacial mass balance changes in the Himalayas and Karakoram glaciers show a negative mass balance since the last decade of twentieth century. Chemical characteristics of melt waters of some selected Himalayan glaciers are also being conducted in Himachal Pradesh and Jammu and Kashmir by the School of Environmental Sciences, JNU. Since all the Himalayan rivers travel through long stretches and are the major source of water for numerous cities and towns in the plains, protecting freshwater sources for better quality of life and ecosystems is imperative today. He encouraged students to

https://youtu.be/wFojWaJS-XU

Topic -Swachh Bharat Mission and Entrepreneurship Opportunities for Youth
This lecture was delivered by Mr. Ashish Jain, Founder Director, Indian Pollution Control Association on 21st April, 2015
Mr. Ashish Jain delivered a talk on *entrepreneurship opportunities for youth in the sanitation sector.* He discussed his experience of handling and segregating waste in urban systems and how using low cost technologies and innovations in the sector can help society at large. He emphasized that simple improvisation in the disposal of aerosol bottles done by his team is in use now. Use of new technologies will reduce the pressure on landfills in the cities which will eventually bring positive health impact on society. He invited the youth to participate in such initiatives and make a difference to the sanitation sector in the country.

Topic:Use of SCADA/ICT Tools for Water/Sanitation Sector in Urban Settings
This lecture was delivered by Ms Jyoti Dhar on 7th April,2015



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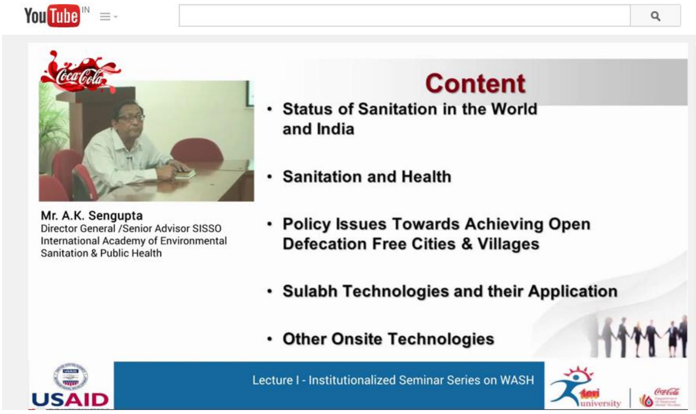
She is an expert consultant on SCADA and has worked extensively on SCADA applications in the water sector. She delivered a talk on the *importance of instrumentation in controlling water distribution systems and waste water collection systems in urban settings.* She discussed her experience with innovative SCADA tools in urban systems and how upgrading water treatment plants including booster pump stations to SCADA ensured better monitoring and control of water losses. She emphasized that use of SCADA in the Bhagirathi Water Treatment Plant and Sonia Vihar Water Treatment Plant has ensured reduction in water losses. SCADA tools can be used to link water pollution related epidemics and design interventions, which will help improve health in urban settings.

Topic Challenges in the Sanitation Sector-The Way Forward

This lecture was delivered by Mr. A.K. Sengupta on 23rd March, 2015



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Mr. A.K. Sengupta, Director General, International Academy of Environmental Sanitation and Public Health interacted with students of TERI University and delivered a talk on *challenges of total sanitation in the urban sector in India*. He discussed his experience with innovative low cost sanitation technologies in urban India where safe disposal of solid wastes and waste water for urban communities in informal settlements is a major challenge. He emphasized that achieving targets of Swachh Bharat Mission in the next few years will need cost effective, innovative technologies to solve sanitation issues. It is imperative to achieve this if we are to save our rivers, protect fresh water sources and provide healthy habitat.

Annexure II

List of Organisation

1. Action for Food Production (AFPRO), New Delhi
2. Council on Energy, Environment and Water (CEEW), New Delhi
3. Clear ford, New Delhi
4. Centre for Science and Environment (CSE), New Delhi
5. CSIRO, New Delhi
6. Dhan Foundation, Tamil Nadu
7. Danish Hydraulic Institute (DHI), New Delhi
8. HCL Foundation, Noida
9. Indian Agricultural Research Institute Maharashtra, Pune
10. Water Technology Center, New Delhi
11. Indian national Trust for Art and Cultural Heritage (INTACH), New Delhi
12. Ion Exchange, New Delhi
13. Jain Irrigation, New Delhi
14. Jal Bhagirathi Foundation, Jaipur
15. Jindal steel, New Delhi
16. Maharashtra Water Resources Regulatory Authority (MWRRA), Mumbai
17. National Clean Ganga Mission, New Delhi
18. The National Environmental Engineering Research Institute (NEERI), Nagpur
19. National Institutes of Health (NIH), Roorkee
20. National Institute of Oceanography, Goa
21. SaciWATERs, Hyderabad
22. SM Sehgal, Gurgaon
23. STUP Consultants, New Delhi
24. Sustainable Reference, New Delhi
25. Tata Institute of Social Sciences, Mumbai
26. UEM India, Noida
27. United Microelectronics Corporation (UMC), Ahmedabad
28. WABAG, Chennai
29. Water for People, New Delhi
30. Wateraid, New Delhi
31. World Bank, New Delhi
32. World Wide Fund for Nature (WWF), New Delhi