GREY WATER USE: A NEED OF HOUR

Javed Alam and Mohammad Muzzammil

ABSTRACT

India occupies only 3.29 million km^2 geographical area which form 2.4% of the worlds land area, it supports over 15% of world's population with only 4% of the world's water resources. With increased population growth and development, conventional groundwater and surface water sources are becoming increasingly vulnerable to anthropogenic, industrial and natural pollution. there is a need to critically look at alternative approaches to ensure water availability in the Indian continents. To resolve the problem, there is a need to look for alternative water resources. The alternative water resources may include rainwater harvesting, desalination and grey water use etc. The limitation of rainwater harvesting is the uncertain quantity and quality of water. The main issue with desalination is mineral decomposition of potable water and limited inland availability. The use of grey water is, therefore, the last option for the water conservation. Grey water is waste water from baths, showers, sinks and wash basins. It may be considered as a source of water for various uses other than drinking after its proper treatment. Depending on the type of grey water and its level of treatment, it could be reused on-site for landscape water, irrigation; toilet flushing and road sprinkle etc Grey water use is important because it restricts fresh water demand and reduces stress on treatment system. The need, importance and status of the gray water use in the perspective of India have been discussed in the present paper.

INTRODUCTION

Water is the resource that sustains all life on earth and is a key element of development. The amount of water in the world is finite. Humans are dependent on a mere fraction of one percent of the earth's freshwater. The water available in lakes, rivers, and groundwater aquifers is the only fresh water which is readily accessible. Population growth and economic expansion accelerated and intensified the use and abuse of water resources over the past few decades, a greater and greater imbalance between water availability and water demand has resulted. This imbalance has brought a crisis with regard to water in many regions of the world. It is projected that by 2025, about 3.5 billion people will live in water-stressed countries. There are at least 1.1 billion people without access to a safe water supply and about 2.5 billion without adequate sanitation systems and the majority of them live in developing countries. The United Nations Millennium Assembly Declaration set 2015 as the target date for halving the population that is unable to access or to afford safe drinking water. About 33% of the world's population lives in water-stressed countries. The UN recommends that people need a minimum of 50 liters of water a day for drinking washing, cooking and sanitation. The Department of Drinking Water Supply, Government of India recommends 40 liters per capita per day (lpcd) water supply in rural areas to meet the requirements for drinking, cooking, bathing, washing utensils and anal ablution (20).Crisis with regard to water also casts a shadow on sustainable development in Asia and the Pacific region. Deterioration of water quality has been observed in mega-cities in particular, causing both water-borne diseases and the destruction of natural resources downstream. Overexploitation of water resources has brought land degradation due to salinity.

India is the seventh largest country in the world and Asia’s second largest country, with an area of 32, 87, 590 sq.km. The Indian mainland stretches from 8°48 to 37°68N latitude and 68°78 to 97°258E longitude. It has a land frontier of some 15,200 km and a coastline of 7516 km. An overview of India’s total water resources reveals that it is much below the natural capacity and technical feasibility. Barely 25%–30% of the moisture that monsoon clouds carry actually precipitates.

India receives an average of 4000 billion cubic meters of rainfall every year, confined to the monsoon season (June through September). Unfortunately, due to lack of storage and crumbling infrastructure, only 18% can be used (1). Apart from the water available in the various rivers of the country, groundwater forms an important source of water for drinking, irrigation, industrial and other uses. Groundwater is a vital resource, with a large fraction of the population relying on the resource directly or indirectly for livelihoods. Groundwater accounts for about 50–80% of domestic water use and 45–50% of irrigation in the country (2). This heavy reliance on groundwater for both domestic water and irrigation purposes is now approaching its limit as an increasing number of aquifers reach unsustainable levels after decades of exploitation. A crisis situation now exists in a number of states. Groundwater is overdrawn in 75% and 60% of blocks in Punjab and Rajasthan respectively; (3). The situation is, thus, deteriorating at a rapid pace. The gravity of the situation can be appreciated from the fact that the proportion of overexploited blocks nationwide has tripled from 5% to 15% between 1995 and 2004 (3). The World Bank estimate in 2005 warned that if the current trends continue, 60% of all aquifers in India will be in a critical condition within 20 years (4). So the exploitation of groundwater resources should be regulated so as not to exceed the recharging possibilities, as well as to ensure social equity. The detrimental consequences of over-exploitation of groundwater on the environment need urgent attention and co-operation between the central and State Governments. The Constitution lists "water supplies" under the State List while the Central Government is in "overall planning for the development of groundwater resources". Management of groundwater thus suffers from fragmentation of responsibility at both central and state levels. The tragedy of India's water scarcity is that the crisis could have been largely avoided with better water management practices. There has been a distinct lack of attention to water legislation, water conservation, efficiency in water use, water recycling, and infrastructure.

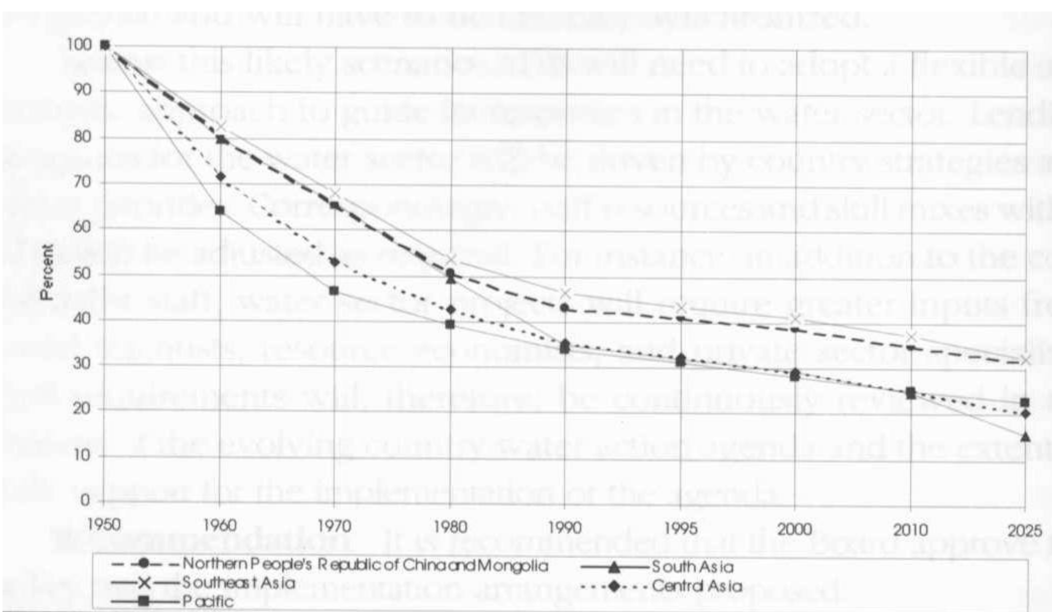
The National Ground water Recharge Master Plan, which provides a nationwide assessment of the groundwater recharge potential, estimates that through dedicated artificial recharge structures in rural areas and rooftop water harvesting structures in urban areas a total of about 36 billion cubic meters can be added to groundwater recharge, at a cost of approximately US$6 billion (6). Artificial groundwater recharge can only be a part of the solution in certain settings, but is not a holistic approach for sustainable development and management that is needed for addressing the problem of overexploited aquifers storage. Thus, efforts to address excessive groundwater exploitation must also concentrate largely on the promotion of appropriate measures to manage water demand.

.Rainwater harvesting and Integrated Water Resource Management (IWRM) are water conservation measures; greywater use is an important undeveloped technology. Greywater use is important because it restricts water demand and reduces stress on treatment system. With increase in population, there will be an increase in stress on sanitation and wastewater disposal system. Gupta et al., (15) predicted that recyclable wastewater will meet 15% of total water requirement in 2050. In water scarce environments, wastewater reuse and reclamation are often considered as a viable option for increased water resources availability. For example, many Mediterranean countries are investing in wastewater reclamation and reuse due to high evaporation and evapotranspiration, low rainfall and increased demand for water for irrigation and tourism (13). Equally, in water scarce developing countries, grey water reuse in schools, hospitals and government institutions is proving to be an essential alternate water resource to fresh ground, surface or rainwater supplies (19). Studies from the Middle-East and India indicate that grey water systems have water saving of 3.4% to 33.4% per annum (12). In 1993-94 Victoria University of Technology in conjunction with Melbourne designed, installed, monitored and assessed greywater reuse system on four home sites (14).

WATER AS A FINITE AND VULNERABLE RESOURCE OF ASIA

In most regions of Asia and the Pacific, water availability has rapidly decreased. While Asia has the world's highest rate of increase of water withdrawal, water availability per capita ranks as least in the world 4,200m^3/capita per year a little more than half the world average of 7,000m^3. In 2025, water availability per capita in the region will be between 15 and 35 percent less than that of 1950 as shown in Figure 1(11). In South Asia, which has the lowest level of water resources per capita, water availability per capita has already decreased by almost 70 percent since 1950. Other sub regions have also experienced drops in water availability per capita, with North Asia having lost 60 percent and Southeast Asia 55 percent since 1950. It is well-known that Iran and Afghanistan suffer chronic water shortages. The Pacific countries also experience water shortages despite good rainfall because of the lack of appropriate investment and technology for water storage. At the same time, more than half of the population in the region lacks access to adequate sanitation systems. Water scarcity impacts food availability, human health, livelihoods and also economic development. It is said that the poor are the most vulnerable to the impact of this water crisis. For a region which is home to about 60 percent of world's population and about 70 percent of the world's poor, the conservation and environmentally-sound use of freshwater resources is the crucial element for socio-economic development and poverty alleviation. Reflecting the importance of sound water management in the promotion of sustainable development in the region, recent international and regional conferences highlight freshwater issues as a priority area for achieving sustainable development. Ministerial Conference on Environment and Development in Asia and the Pacific (MCED) in 2000 identified conservation and integrated management of freshwater resources as one of the eight priority areas for the region. The High-level Regional Meeting for the World Summit on Sustainable Development held in Phnom Penh in November 2001 also paid special attention to freshwater resource management as one of the key issues for sustainable development in the region. The Ministerial Declaration issued at the International Conference on Freshwater held at Bonn in December 2001 also made a call to the Secretary General of the UN to strengthen the coordination and coherence of activities within the UN system on water issues in an inclusive manner. How can the needs of the increasing population of Asia and the Pacific are fully met without sacrificing the sustainability of the region's finite and vulnerable freshwater resource.

In the Asia-Pacific region where about 70 percent of the world's poor live, the needs of the poor should be primarily reflected in water development and management policies. The region's water policy should be linked closely with poverty alleviation policy.



Source: Asian Development Bank, *"Water for All: The Water Policy of the Asian Development Bank"*

Figure 1: Decline in Water Resource Per Capita (1950-2025)

NORTHERN INDIA'S VANISHING WATER

Groundwater comes from the natural percolation of precipitation and other surface waters down through Earth’s soil and rock, accumulating in aquifers cavities and layers of porous rock, gravel, sand, or clay. In some of these subterranean reservoirs, the water may be thousands to millions of years old; in others, water levels decline and rise again naturally each year. Groundwater levels do not respond to changes in weather as rapidly as lakes, streams, and rivers do. So when groundwater is pumped for irrigation or other uses, recharge to the original levels can take months or years. Changes in underground water masses affect gravity enough to provide a signal, such that changes in gravity can be translated into a measurement of an equivalent change in water. "Water below the surface can hide from the naked eye, but not from Gravity Recovery and Climate Experiment (GRACE)," said Rodell. The twin satellites of GRACE can sense tiny changes in Earth’s gravity field and associated mass distribution, including water masses stored above or below Earth’s surface. Using GRACE satellite observations, water changes in critical areas of the world, can be monitored from one month to the next, without leaving our desks said Velicogna. These satellites provide a window to underground water storage changes. The northern Indian states of Rajasthan, Punjab and Haryana have all of the ingredients for groundwater depletion: staggering population growth, rapid economic development and water-hungry farms, which account for about 95 percent of groundwater use in the region. In a recent study, Rodell et al.(5) used GRACE satellites operated by NASA conducted a study on northern India’s ground water depletion. They found that groundwater levels have been declining by an average of one meter every three years (one foot per year). More than 109 cubic km (26 cubic miles) of groundwater disappeared between 2002 and 2008 double the capacity of India's largest surface water reservoir. If measures are not taken to ensure sustainable groundwater usage, consequences for the 114 million residents of the region may include a collapse of agricultural output and severe shortages of potable water.

FALLING WATER TABLES AND THEIR EFFECTS

Fresh water on Earth is locked in ice caps, but of the remaining available freshwater more than 90% is below ground. Compared to surface water bodies, groundwater is relatively protected from contamination by overlying soils and geologic sediments. Thus, groundwater resources are ideal for human consumption. India’s human population is more than 1 billion with an annual growth rate of approximately 1.9% (7). The people of India depend upon groundwater resources for survival. Yet, water tables are falling at an alarming pace across India, threatening the future of India’s water supply with significant human and ecological impacts already evident. For example in Andhra Pradesh, a southern state of India, the groundwater in 26 of 46 *mandals* (similar to counties in the USA) is characterized as ‘overexploited’ (8). India’s Central Groundwater Board cites as reasons for this stress increasing population, deficient monsoons, unregulated wells, and economic pressures such as farmers’ dependency on loans for costly agricultural inputs and fluctuations of product value on international markets (8).

Falling water tables are also compounding the fluorosis epidemic in India. Fluoride is a common component of geologic materials underlying much of India. Fluorosis, a medical condition caused by over-consumption of fluoride, has health effects that range from stiff joints to cancer. As groundwater levels continuously decline, villagers are forced to drill wells past safe surface zones into the portions of aquifers that house toxic waters. India’s Fluorosis and Rural Development Foundation now estimates 60 million people currently suffer some degree of the disease (10).

Human-induced declines in aquifer levels also break surface-groundwater hydrologic connections. In the Maheshwaram watershed of Andhra Pradesh chronic depletion of groundwater has lowered the water table 15 m below the ground surface such that springs and streams formerly fed by groundwater have disappeared (9).

The traditional ‘tank’ system of collecting surface runoff used by Indian farmers for hundreds of centuries is also disappearing. When subsurface soils and aquifers are at maximum water-holding capacity rainwater cannot infiltrate and will thus collect along the surface of a landscape. Ancient canals and spillways that follow natural drainage patterns direct seasonal floodwaters across the landscape into large reservoirs (tanks) semi-circumscribed by earthen dams that Indian farmers use to store overflow collected during the monsoon season for use during the dry season. However, as groundwater is extracted over time subsurface storages are continuously depleted, causing greater proportions of rainfall to infiltrate rather than run off the landscape into rivers and streams or tanks.

The National Water Policy stipulates that the total quantity of the nation's groundwater pumped out must be limited to annual recharge. India's Ministry of Water Resources recently assessed national groundwater resources, but found current data significantly lacking in vast areas of the country (8). While farmers around the country report having to drill deeper every few years to reach ever receding groundwater, little national-scale data is available to accurately assess groundwater reserves and extraction and recharge rates.

USES OF GREYWATER

Greywater can meet a variety of water supply needs and can reduce the impacts of water supply development on sensitive watersheds. Greywater water can be used for landscape irrigation, toilet flushing and industrial processes. In fact, grey water has the greatest potential when replacing freshwater in small-scale landscape irrigation (e.g., public parks, golf courses and small farms) and cooling water for power plants and oil refineries because so much water is used in these processes. Cycling through used water can significantly decrease water use in highly industrialized areas. The level of treatment it receives and where it goes depends on its intended use. An Environmental Protection Agency (EPA) chart, available at http://www.epa.gov/region9/water/recycling/index.html, outlines treatment requirements for various uses of greywater.

SOME IMPORTANT STUDIES ON GREY WATER

National Environmental Engineering Research Institute (NEERI) Nagpur and UNICEF Bhopal, Madhya Pradesh have developed, implemented and evaluated greywater reuse systems for small buildings (schools) in rural areas. During 2005 and 2006, NEERI and UNICEF collaborated to investigate the possibility of recycling greywater (bathroom water) in residential tribal schools in rural Western Madhya Pradesh. UNICEF and NEERI along with Government and Non-government partners have constructed six greywater treatment plants in Dhar and Jhabua districts. The operation and maintenance of these greywater treatment plants are looked after by students and Parent Teachers Association (PTA). Department of Tribal Welfare, Government of Madhya Pradesh has committed funds for regular maintenance of these plants. It is proposed to build similar greywater treatment plants in 60 Ashram schools in Dhar and Jhabua districts using funds available with Government of Madhya Pradesh. The greywater treatment and reuse particularly in boarding (Ashram) schools is an attempt to provide water for toilet cleaning. These systems are currently operating in 9 Ashram schools in Dhar and Jhabua district of Madhya Pradesh.

In order to conserve water by recycling and reuse of grey water as an alternative source for toilet flushing and gardening / irrigation etc, a NEERI residential quarter was selected to study the detailed quantification, characterization and reuse of wastewater generated from bath, wash basin and laundry (excluding kitchen wastewater). Grey water treatment plant was designed and constructed for a flow of 480 lit/day. Based on the daily observations, daily potable water demands for a household and grey water generation from bath, laundry and wash basins were observed to be 165 LPCD and 80 LPCD respectively. And for reuse for toilet flushing and irrigation of an area of 22 sq m the water demands calculated to be 24.50 LPCD and 46 LPCD respectively. The study revealed that about 40% to 60% potable water can be saved by reuse of grey water. It is estimated that about Rs. 6 lakh / year water charges can be saved if recycled grey water is used for gardening, irrigation and for toilet flushing in the households of NEERI Colony. Recycling and conservation of water in urban areas is therefore an essential contribution to the future environmental sustainability.

Latha et al.(16) carried out water usage surveys in capital cities of India. They found that an average wastewater of 586 litres is generated per day per household. Greywater represents about 68% of the total waste water. When kitchen wastewater is also excluded, the percentage of greywater becomes about 61%. If the greywater can be managed in an environmentally responsible manner in accordance with ecologically sustainable development principles and protection of public health and the health of the household, it become a water resource of the significant value. Table 2 gives the approximate amount of wastewater generated in domestic premises.

A study conducted on Greywater treatment and reuse in seven apartments in Haifa, Israel. It was found that 60-70% of water demand is transformed into greywater. The greywater after treatment was reused for the toilet flushing for the seven apartments. The study concluded that the greywater reuse can reduce fresh water demand by 10-25%, if it is used only for toilet flushing. (17).

Nolde (18) investigated and examined many types of small-scale greywater technologies in Germany. AquaCycle modular system is the most successful and widely used system there. In this system, like most systems, the greywater originates from bath tubs, showers, hand-washing basins, and occasionally from washing machines. It was found that 95% of the supplied systems are installed in single and double-family households with a treatment capacity of about 600 L/d. Furthermore, 200 m^3 of water could be saved yearly if the system were used to its full capacity.

Waste water type	Total waste water		Total Grey water	
	(%)	L/day	(%)	L/day
Toilet	32	186	-	-
Hand basin	5	28	7	28
Bath/Shower	33	193	48	193
Kitchen	7	44	11	44
Laundry	23	135	34	135
Total	100	586	100	400

Table 2: Approximate amount of waste water generated in domestic premises (WWW.Sydeneywater.com)

ADVANTAGES OF GREYWATER RECYCLING

The average bath produces 120L of water; a shower 80L and the washing machine 100L per load. This water has to be redirected from the various sources via 50mm pipe to a central point. The water then runs through a gravity filter and is automatically pumped to the garden first via irrigation pipe and then multiple garden hoses and Gardena sprinklers.

Reduction in fresh water demand

Grey water can replace fresh water in many instances, saving money and increasing the effective water supply in regions where irrigation is needed. Residential water use is almost evenly split between indoor and outdoor. All grey water except kitchen water could be recycled outdoors, achieving the same result with significantly less water diverted from nature.

Less strain on septic tank or treatment plant

Greywater use greatly extends the useful life and capacity of septic systems. For municipal treatment systems, decreased wastewater flow means higher treatment effectiveness and lower costs.

Less energy and chemical use

Less energy and chemicals are used due to the reduced amount of both freshwater and wastewater that needs pumping and treatment. For those providing their own water or electricity, the advantage of a reduced burden on the infrastructure is felt directly. Also, treating your wastewater in the soil under your own fruit trees definitely encourages you to dump fewer toxic chemicals down the drain.

Groundwater recharge

Greywater application in excess of plant needs recharges groundwater. Many municipalities not only offer incentives for voluntary water recycling, but also use reclaimed water to recharge groundwater aquifers and supplement water supply reservoirs. This is known as indirect potable reuse and is practiced in several locations throughout the United States by injecting recycled water into an aquifer or a water supply reservoir.

Plant growth

Greywater enables a landscape to flourish where water may not otherwise be available to support much plant growth.

GOVERNMENT DIRECTIVES TO USE GREY WATER IN INDIA

After rain water harvesting, in the metropolitan cities of India particularly in Mumbai it is mandatory for all new buildings to recycle grey water and use it for non- potable purposes. The Brihanmumbai municipal corporation (BMC) has passed the by-laws and included it in the development control (DC) rule to make it compulsory for all new residential and commercial building to have rainwater harvesting system and also grey water reuse system, failing which BMC will not issue occupation certificate to such building.

As BMC will stop giving occupation certificates to the buildings, the builders will follow the rule strictly. It will reduce the stress of the regular water supply. It will be applicable to all building projects where the plot size is 20,000 sq feet and above. Recycling of water is also a condition under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) to get funds for projects.

This initiative has been taken by Municipal Corporation of Nanded Waghala City Municipal Corporation (NWCMC) as a part of commitment made in the Memorandum of Agreement signed with Govt. of India and Govt. of Maharashtra while seeking financial assistance under Jawaharlal Nehru Urban Renewal Mission (JNNURM). Specific by laws are expected for promote and regulate grey water recycling and reuse in residential and commercial premises in the Corporation limits. The recycling of black water is presently proposed to be kept out of purview of this byelaw.

CONCLUSION

For India's future generations to be ensured of a reliable water supply, sustainable management practices must be implemented to preserve the nation's dwindling groundwater resources. For more then one billion people of India, though hidden from the naked eye, groundwater depletion is a real and serious issue deserving of political and humanitarian attention. The present study reviews and suggests the concept of using greywater in various possible fields and thus, making fresh water demand with in control. The use of grey water in India is in the stage of infancy. Though, various developed countries are already utilizing this new water potential after some preliminary treatments depending upon the type of use. In India the greywater system may be very effective in the school /college campuses especially those with residential facilities.

REFERENCES

1. Planning Commission, Government of India. India: Assessment 2002 – Water supply and sanitation. A WHOUNICEF sponsored study. New Delhi: Government of India, 2002. Available at: http://planningcommission. nic.in/reports/genrep/wtrsani.pdf.
2. Kumar R, Singh RD, Sharma KD. Water resources of India. Current Science. 2005; 89:794–811.
3. Central Ground Water Board. Ground water resources assessment. New Delhi: Government of India, Ministry of Water Resources, 2006. Available at: http://cgwb.gov.in/groundwater/GW_assessment.htm. Accessed: 10 October 2011.
4. Briscoe J, Malik RPS. India's water economy: Bracing for a turbulent future. Washington DC: World Bank. 2008. Available at: http://water.worldbank.org/water/publications/india.
5. Rodell M, Velicogna I, Famiglietti JS. Satellite-based estimates of groundwater depletion in India. Nature. 2009; 460: 999–1002.
6. Central Ground Water Board. Master Plan for Artificial Recharge to Ground Water in India. New Delhi: Government of India, Ministry of Water Resources, 2005. Available at: http://cgwb.gov.in/documents/
7. Census of India. (2001) National Summary of Data. http://www.censusindia.gov.in/
8. Central Ground Water Board (CGWB). (2006) Dynamic Ground Water Resources of India, Ministry of Water Resources, Government of India, Faridabad.

9. Marechal, J.C., Dewandel, B., Ahmed, S., Galeazzi, L., and Zaidi, F.K. (2006) Combined estimation of specific yield and natural recharge in a semi-arid groundwater basin with irrigated agriculture. Journal of Hydrology, 329: 281-293.
10. Pearce, F. (2006) When Rivers Run Dry: Water: The Defining Crisis of the Twenty-First Cen*tury*. Beacon Press: Boston.
11. ADB 2001, "Water for All: The Water Policy of the Asian Development Bank"
12. Al-Jayyousie O.R., (2003) Greywater reuse: towards sustainable water management. Desalination 156(1), 181-192.
13. Angelakis A.N. and Bontoux L., (2001) Wastewater reuse and reclamation in European countries. Water Policy **3**, 47-59.
14. Christov a-Boal D., Lechte P., Shipton R., (1995) Installation and Evaluation of Domestic Greywater Reuse Systems Executive Summery, Victoria University of Technology, Victoria, Australia.
15. Gupta S.K. and Deshpande R.D., (2004) Water for India in 2050: first order Assessment of available options, Current Science, vol. 86, No 9, pp 1216-1224.
16. Latha, N. , N Deepa, B K Anand, K V Raju and H L Shashidhara (2005) Wastewater Reuse in Megacities - Emerging Trends in Bangalore city. IWMI-TATA Partners Meet, Anand, Gujarat, India
17. E. Friedler,R.Kovalio and N.I.galil., (2005).On site greywater Treatment and Reuse in Multi-storey Buildings. Water Science and Technology, Vol. 51 No.10 pp 187-194.
18. Nolde E. (2005).Greywater Recycling Systems in Germany—Results, Experiences and Guidelines. Water Science and Technology, Vol. 51, No.10. pp 203-210.
19. Godfrey, Sam; Labhasetwar, Pawan; and Satish Wate.(2009) "Greywater reuse in residential schools inMadhya Pradesh, India—A case study of cost-benefit analysis." Resources, Conservation, and Recycling 53) 287 – 293
20. Department of Drinking Water Supply (DDWS), (2001) 10 Five Year Plan Document on India Drinking Water supply and sanitation(Rural &Urban)

BRIEF PROFILE OF THE AUTHORS

Dr. Javed Alam graduated in Civil Engineering from AMU, Aligrah in 1985. He got M.Tech. and Ph.D. , in Hydraulic Engineering from AMU Aligarh respectively in 1987 and 2005. From 1986 to 1998 he worked as lecturer and from 1998 to 2004 as lecturer (selection grade) and 2004 to 2006 as Reader and from 01-01-2006 to till date as Associate Professor in AMU Aligarh.

Dr. Mohammad Muzzammil graduated in Civil Engineering from AMU, Aligrah in 1982. He got M.Tech. , in Hydraulic Engineering from IIT kanpur in 1982. He obtained a Ph.D. in Hydraulic Engineering at IIT Kanpur in 1992. From 1985 to 2000 he worked as lecturer and from 2000 to 2008 as Reader and from 2008 to till date as professor in AMU Aligarh.