

K.J. Nath · Vinod Prakash Sharma
Editors

Water and Sanitation in the New Millennium



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Foreword

The global importance of water, sanitation and hygiene for development, poverty reduction and health is reflected in the United Nations Millennium Declaration, in particular its eight Millennium Development Goals, in the reports of the United Nations Commission on Sustainable Development and at many international fora.

In India, the successive governments launched several flagship programmes like the National Mission for Clean Ganga, Jawaharlal Nehru National Urban Renewal Mission, National Rural Drinking Water Quality Monitoring and Surveillance Programme, and, more recently, the Swachh Bharat Mission and Smart City Mission. However, the planning and implementation of these programmes and methodologies/technologies adapted need critical review and evaluation. The National Academy of Sciences, India (NASI), being a premier organization of scientists, engineers and health professionals, is seriously concerned about the prevailing situation in respect of community water supply and sanitation practices and its very critical impact on community health. We sincerely feel that it is necessary for the leading scientists, technocrats and health professionals and the sector leaders to sit together and deliberate in depth about the maladies and seek remedial and corrective steps. In the above context and as conceptualized and planned by Dr. V.P. Sharma and Prof. K.J. Nath, NASI organized the **1st Policy Support Brainstorming on Safe Water and Sanitation for Rural and Urban India** in collaboration with WHO and Sulabh International Social Service Organisation (SISSO) in July 2009. It was a highly successful event attended by distinguished scientists and technical experts from all over the country. Along with the **Allahabad Declaration**, a set of precise and scientific recommendations were adopted which were forwarded to all the concerned departments. As a follow-up of the brainstorming, participants formulated a number of research and development proposals which were forwarded to the Department of Science and Technology. Further, for an in-depth deliberation and review of the progress in the sanitation, water supply and environmental management sector in the context of the policy and programme of the government, the academy organized the **2nd National Brainstorming in Allahabad**, on 20–22 September 2012, in collaboration with SISSO. The recommendations of this event were particularly contextual in the sense that a comprehensive policy initiative was suggested at the national, state and local levels.

Dr. V.P. Sharma (who left us in October 2015 for the heavenly abode) was very much concerned about the continuing crisis in the water and sanitation sector in

India. Prof. K.J. Nath and Dr. Sharma deliberated on the issue and proposed the 3rd Brainstorming in November 2014 which was approved by the council and organized successfully. Meanwhile, it was felt that the papers presented during the 2nd Brainstorming should be published for larger dissemination among the scientists and professionals in the country. Altogether, 24 papers were presented in 7 thematic sessions. Issues and critical challenges facing the country, on various aspects, were discussed during these sessions. This book is the compilation of those presentations in a systematic manner, so that the valuable information/data generated out of the deliberations will be stored for helping the policymakers and programme implementers in a scientific way.

I am very much grateful to Prof. K.J. Nath, the late Dr. V.P. Sharma and all other contributors for this valuable treasure. The contributions of the distinguished authors are of critical importance and would be extremely useful for the scientists and professionals, working in the sector, to engage in further deliberations and suitable actions.

NASI
Allahabad, India

Akhilesh K. Tyagi

Preface

World Health Assembly 1998, Alma-Ata, adapted four key strategies for attaining health for all. One of these key strategies was promoting healthy lifestyles and reducing risk factors to human health that arise from environmental, economic, social and behavioural causes. If the agenda has remained unfinished by a wide margin, the primary reason could be found in our failure to develop an enabling policy for promoting a hygienic environment conducive to healthful living. Environmental services such as community water supply, sanitation, control of air and water pollution, waste disposal and personal and domestic hygiene along with nutrition and health education are central to the concept of preventive and social medicine, and they are the key pillars of primary health care.

Access to safe water is now a basic human right, as per the resolution of the 29th Session of the UN Committee on Economic, Social and Cultural Rights, November 2002. To protect human health and to prevent sickness and mortality, community water supply needs to be reliable, in sufficient quantity, of adequate quality and readily accessible to all segments of the consumers. The people in the developed countries are mostly having the privilege and opportunity of having adequate quantity of water of acceptable quality, anytime and anywhere in the country. The same is not true for the citizens of most third-world countries like India, particularly the poor. Water scarcity, surface and ground water contamination and lack of access to safe drinking water by the poor are among the main obstacles to full enjoyment of the right to water in our country. The health outcome of the lack of sanitation and safe water is enormous, globally 4 billion cases of diarrhoea, 2.2 million deaths per annum and 62.5 million disability-adjusted life years (DALYS) lost. The World Bank estimates that 99.9% of deaths attributed to poor water supply, sanitation and hygiene occur in the developing countries. An estimated 60–80% of all diseases and over 1/3 of deaths in the developing countries are caused by environment-related factors, and on an average as much as 1/10 of each person's productive time is sacrificed to environment-related diseases.

Following the Alma-Ata and Mardel del Plata conference, the International Drinking Water Supply and Sanitation Decade was launched in India with high hopes and expectations for supplying safe and potable water to most of our population in the 1980s. Unfortunately, the decade has been for all practical purposes a story of misplaced priority, lost opportunity and unfinished agenda. It is time for a

serious introspection to identify the maladies and plan for the future. The scientific and technical leaders of the country as well as the policymakers in the national government owe it to the community to explain our failures during all these years since independence. It is also extremely urgent that a blueprint and a road map for providing safe, clean and affordable water to all segments of our community living in urban, peri-urban and rural areas need to be drawn up, particularly in the context of the new programmes and initiatives being launched by the national government.

It is in the above context that NASI organized the 1st Policy Support Brainstorming on “Safe Water for Rural and Urban India” in Allahabad, July 2009, in collaboration with WHO and SISSO. It was a highly successful event, attended by the leading scientists, engineers and sector leaders of the country. At the end of the two-day brainstorming, the Allahabad Declaration was adopted, along with a set of concrete recommendations. As a follow-up, a number of R&D proposals were also formulated and submitted to the Department of Science and Technology, GOI.

I would be failing in my duties if I don't mention the total support, advice and guidance that I received from the late Dr. V.P. Sharma, the joint editor of this book, all through the three brainstorming programmes on safe water and sanitation. Dr. Sharma, who was an internationally acclaimed entomologist, vector control expert and malariologist, had been a great source of inspiration and guidance for me during the last four decades. We worked together in the WHO global team for the in-depth evaluation of the Indian malaria control programme in 1985, and ever since then he had been a friend, philosopher and guide for me. It was his concern for environmental issues including sanitation, waste management and provision of safe water that stimulated the idea of the 1st Brainstorming. But for the committed support and leadership of Dr. Sharma, the successful organization of the three policy support brainstorming programmes would not have been possible. His untimely death has been a great loss for the scientific community of the country and a personal shock for me. I am sure that the president, NASI and council members along with the fellows and members would join me in dedicating this book to the memory of Dr. V.P. Sharma.

Dr. Sharma and I deliberated at length regarding the continuing crisis in the drinking water and environmental sanitation sector in the country and decided to organize the 2nd Brainstorming in 2012. The 2nd Policy Support Brainstorming on “Safe Water and Sanitation in the New Millennium” was organized by NASI in collaboration with SISSO in Allahabad, September 2012. As in the 1st Brainstorming, the leading scientists, technocrats and sector leaders participated, and a number of papers dealing with important technical and policy issues were presented. At the end of the brainstorming, a set of recommendations were formulated which was submitted to key government departments and important R&D and HRD

organizations. However, it was felt and Dr. Sharma strongly endorsed the idea that the papers presented in the conference contained important scientific, technical and policy issues which would be extremely valuable for the scientists and professionals of the country, and as such we agreed, and it was proposed to the NASI Council that a book containing these papers should be published. The proposal was approved by the NASI Council, and the internationally reputed publishing house Springer Nature has been entrusted with the publication of the book.

The book contains 20 chapters including the introductory overview of the country situation by the undersigned in Chap. 1. Chapter 2 deals with the present status of rural water supply in the country in the context of the current initiatives by the government. The sanitation scenario along with the flagship programmes including problems, prospects and key constraints is elaborately discussed in Chaps. 3 and 4. The concept of water safety plan, as visualized by WHO, and the guidelines for its applicability for the rural water supply projects in the country are discussed in Chap. 5. Various kinds of technologies applicable for the rural communities and the risk and safety requirement associated with the same, are thoroughly discussed in Chap. 6 including issues related to household point-of-use treatment and its health significance along with consumer safety. The geogenic and anthropogenic contamination of groundwater with arsenic, fluoride, pesticides, heavy metals, etc. and its impact on community health are elaborately discussed in Chaps. 7, 8 and 9. Issues related to arsenic-related technologies and case studies for community-based approach for the same are discussed in Chaps. 10 and 11. Urban wastewater management with particular reference to sewer rehabilitation and maintenance is discussed with elaborate illustrations in Chap. 12. The critical issues of urban solid waste management and the challenges posed by the same for the municipal managers are analysed and discussed in Chap. 13. The bioenvironmental control of vectors and the need for an integrated and eco-based approach are presented in Chaps. 14 and 15. The impact of bacteriological and chemical contamination of drinking water on the health and nutritional status of the community is highlighted in Chaps. 16 and 17. The sustainable management of water resources in India is discussed with particular reference to the feasibility of linking the rivers in Chap. 18. A most interesting case study on the cost-benefit analysis of production of hydropower from the river is critically discussed in Chap. 19. In Chap. 20, the author discusses a novel Gandhian model of development based on non-violent culture.

Kolkata, India

K.J. Nath

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About the Editors



Prof. K.J. Nath, BE (Cal), MEPH (Cal), DSE (Delft), FIE, FNASc, FIPHE, FIWWA, FNESA is widely regarded as one of India's foremost experts on Sanitation and Community Water Supply, Environmental Health and Public Health Engineering. As Professor of Environmental Sanitation and Director of the All India Institute of Hygiene & Public Health (AIHH&PH), Govt. of India (GOI), he did seminal works on rural and urban sanitation and water supply, urban waste management, air and water pollution, water quality surveillance, environmental epidemiology and impact assessment. His expertise has been requisitioned by several National & International Organizations including the Planning Commission, Council of Scientific & Industrial Research (CSIR), Indian Council of Medical Research Institutes (ICMR). Ministries

of Environment, Health, Urban Development, and Rural Development of the Govt. of India as well as State Govts. & Local and Development agencies, Research Academic Institutes. At the International level, he has served on a number of occasions as a consultant and Member/Chairman of expert panels of the World Bank, Asian Development Bank, WHO, UNICEF, UNEP, UNDP, WSSCC, UN-Habitat, International Scientific Forum on Home Hygiene (IFH), U.K, U.S Trade Development Agency etc. He served as a Member of Steering Committee/Working Group of the Planning Commission from the sixth 5 Year Plan to 10th 5 Year Plan. He was a Member of the Planning Commission High Power Committees on SWM and Public Health (1997–1998), Steering Committees of the 1st and 2nd Phase Ganga Action Plan, Expert Member of NGRBA (2009–2014), National Task Force on Environmental Health, Chairman of the National Co-ordination Council on Water Quality, Rajiv Gandhi Drinking Water Mission. Presently he is the **Chairman, Arsenic Task Force, West Bengal; Chairman, Core Committee on Water Quality, Safety & Security, Govt. of West Bengal and Member, Scientific Advisory Board and SEA Regional Coordinator, International Scientific Forum on Home Hygiene (IFH), UK, Member of the Technology Advisory Group, WHO (Climate Resilient WASH), President of Institution of Public Health Engineers, India (IPHE)**, the premier national professional association of the Public Health Engineers in India. He has published more than 150 research and review papers, books, monographs etc. He has received several awards including Rajiv Gandhi Memorial Sulabh Sanitation Award (1998), Environmental Scientist of the Country award by National Environmental Science Academy (1999), Golden Jubilee award of the Indian Public Health Association (2007), Most Eminent Public Health Engineer of the Country by Institute of Engineers in 2008. **He is a fellow of the National Academy of Sciences, India; Indian of Public Health Association; Institution of Public Health Engineers, India; Institute of Engineers; Indian Water Works Association and he is an Honorary Fellow of the National Environmental Science Academy, India and Member, International Water Academy, Oslo. Prof. Nath has to his credit, more than 150 publications of books, monographs, course manuals, etc. and papers presented in International and National Conferences and published in reputed International and National Journals.**



Dr. Vinod Prakash Sharma, MSc (1960), DPhil (1964), DSc (1979), all from Allahabad University, is postdoctoral research associate of the University of Notre Dame and Purdue University, USA (1964–1968); pool officer of the Forest Research Institute, Dehradun (1969–1970); senior scientist of WHO/ICMR Research Unit on the Genetic Control of Mosquitoes, New Delhi (1970–1975); deputy director of Vector Control Research Centre/Malaria Research Centre (1975–1982); founder director of the National Institute of Malaria Research (1962–1998); and additional director general of the Indian Council of Medical Research (1998). He is FNA, FASc, FNASc, FAMS, FTWAS and fellow of several other learned societies. He has specialized in malaria and vector biology. He has 40 years of research and field experience, published 400 scientific papers and book on *Anopheles* and edited 14 books. Under his leadership, NIMR had earned international reputation of excellence in malaria research and control and

established linkages with leading national and international laboratories. He conceptualized the bioenvironmental malaria control strategy as an alternative to spraying and successfully demonstrated malaria control in various eco-epidemiological settings. Dr. Sharma's work has become legendary. As a result of his indefatigable efforts, today we have technologies to fight malaria which are safe and cost-effective, produce sustainable impact and are free from environmental hazards produced by DDT and other insecticides. His work has been recognized nationally and internationally. He was invited to work on various WHO panels since 1980s. He was chair of the WHO/UNEP/FAO Panel of Experts on Environmental Management (PEEM) for Vector Control (two 5-year terms). WHO invited him to write/review GFATM proposals for SEA Regional countries, i.e. Indonesia, Timor Leste, Myanmar, Bhutan, Bangladesh and India, and for Sierra Leone by the NGO BRAC. He was the principal architect for writing World Bank and other projects for the Indian programme on malaria control. He chaired review committees of the NMEP, Nepal, Bhutan and Thailand, and is actively involved in the evaluation of countries capabilities to proceed towards malaria elimination. He was invited in WHO (Geneva and New Delhi) meetings as temporary adviser. He represented India on the Scientific Committee on the Problems of the Environment (SCOPE), Paris, for nearly 20 years and later was elected as executive member of the SCOPE. In that capacity he coordinated the "Health and Environment" cluster of the SCOPE. He was president of the National Academy of Sciences, India (1999–2000); Indian Society for Parasitology (1993–1997); and National Academy of Vector and Vector Borne Diseases (1979–2008); chief editor of the *Journal of Parasitic Diseases* and *Indian Journal of Malariology*; council member of the International Congress of Entomology, UK (two terms); and member of the WHO Expert Committee on Malaria, Geneva, still continuing. He is a recipient of several national and international awards/honours, e.g. WHO Darling Foundation Prize (1999); ICMR Ambedkar and MOT Iyengar awards; Lifetime Achievement Award; Green Scientist Award; G.P. Chatterjee Memorial Award; Ranbaxy award; FICCI award; Om Prakash Bhasin Award; Vasvik awards; distinguished parasitologist recognition by the World Federation of Parasitologists (2010); Gujar Mal Modi Award (2013); Vigyan Vibhuti award by the Utrakhand State Council for Science and Technology (2013); Meghnad Saha Distinguished Fellow (2005–2010); NASI Distinguished Professor and ICMR Chair in Public Health Research (2010–2015) at the Indian Institute of Technology, New Delhi; and Padma Shri (1992) and Padma Bhushan (2014) awarded by the President of India.

Overview of the Current Scenario of Community Water Supply and Environmental Sanitation in India

1

K.J. Nath

1.1 Introduction

One of the greatest failures of the last 50 years has been the failure to lay the foundation stones of public health in the developing world – environmental sanitation and water supply. It is a failure that today deprives hundreds of millions not only of health but of productivity. It is a failure that undermines the normal mental and physical growth of rising generations. It is a failure that pollutes fresh water resources with faecal matter and organic pollutants on a massive scale. It is a failure that condemns more than a billion people to live with a daily environmental crisis of squalor, smells and diseases. And it is a failure that holds back the development of people and of nations. Despite significant progress made in the economic and industrial development, the demographic and environmental health scenario in the country continues to be a cause of serious concern. Water and air pollution along with malnutrition and lack of sanitation is increasing the disease burden in the society. The existing health infrastructure is unable to cope with the same.

It is a paradox that while India has progressed significantly in science and technology and is among the leading economic powers in the world, a substantial portion of the population does not have access to sanitation and safe water.

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India is now in the front ranks of fast growing emerging economies, it is also one of the countries wherein a lot of efforts are still required to eliminate the practice of open defecation.

In urban areas, faecal contamination of community water supply systems is continuing unabated. Pollution of Ganga and other national rivers is a serious threat to their survival. The investment in water supply and sanitation sector was negligible (less than 1%), during the first five 5-year plans. However, during the sixth plan which coincided with the launching of the International Decade of Water Supply and Sanitation, the allocation for water supply and sanitation sector was increased significantly (more than 4%). In recent years, the government has launched several flagship programmes like National Mission for Clean Ganga, Jawaharlal Nehru National Urban Renewal Mission and National Rural Drinking Water Quality Monitoring and Surveillance Programme. A significant development has been the launching of Swachh Bharat and Clean Ganga missions by the government of India in 2014. However, progress of implementation of these programmes and adapted methodologies needs serious review and policy change.

1.2 Looming Water Crisis

Water resource management and providing water security to the millions who are without the same is possibly the most challenging issue mankind would face in this century. The demand for water has increased significantly – by 700% during the last century. Almost 1800 million people globally will face serious water scarcity by 2015, and two thirds of the world population could be under stress. According to UN statistics, 1.2 billion people lack access to improved and safe water supplies, and if we consider microbiological and chemical contamination of water, this figure would be many times higher.

In 1947, the per capita water resources availability in India was measured at 5,150 cubic metres. By the year 2000, it decreased to about 2,200 cubic metres. It has been recently estimated that by 2017, India will “water stressed”, and per capita availability will decline to 1600 cubic metres. Rapid population growth in the country will result in a further decline in the per capita availability of fresh water. Studies undertaken show that the amount of available aggregate annual utilizable water in India, surface and ground together, would be at about 1,100 billion cubic metres. Other problem areas are the fast-growing urban centres, where water requirements are expected to double by 2025. The situation concerning industrial supplies is even more difficult to analyse. Agriculture, the largest consumer of water resources, will probably utilize more than 70% of available water by the year 2025 to support the increasing food demand in the country.

1.3 Lack of Safe Water and Environmental Sanitation: A Critical Threat to Public Health

The World Health Assembly 1978 in Alma Ata adapted four key strategies for attaining health for all. One of these key strategies was “Promoting healthy lifestyles and reducing risk factors to human health that arises from environmental, economic, social and behavioral causes”. If the agenda has remained unfinished by a wide margin, the primary reason could be found in our failure to develop an enabling policy for promoting a hygienic environment conducive to healthful living. The health outcome of the lack of sanitation and safe water is enormous – globally 4 billion cases of diarrhoea, 2.2 million deaths per annum and 62.5 million by disability-adjusted life years (DALYs) lost. The World Bank estimates that 99.9% of deaths attributed to poor water supply, sanitation and hygiene occur in the developing countries. To this, we must add the new menace of the chemical contaminations of groundwater sources, particularly arsenic and fluoride, not to forget about the problems created by salinity and iron and toxic heavy metals and pesticides. The gravity and enormity of the problem is at once evident when we consider that about 30% of our total usable fresh water resources of about 4500 billion m³ is stored underground.

Air pollution is a serious problem in the urban areas which is causing acute respiratory infections, cardiovascular diseases, asthma, etc. This is also abating tuberculosis which continues to be a serious threat to public health because of poverty and malnutrition. Inadequate drainage and improper solid waste management are creating conditions conducive to vector breeding giving rise to vector-borne diseases like malaria, filaria, dengue, encephalitis, etc. Though a scientific and epidemiological assessment is yet to be made, the non-communicable diseases caused by factors related to lifestyle and environment could be serious threat to community health in the coming years.

1.4 Pollution of Fresh Water Sources and Declining Water Quality: A Critical Challenge

In the developing countries, major portion of the waste water (80% according to some estimate) is discharged into the water bodies without any treatment. This is primarily because of lack of resources with ULBs and also absence of appropriate regulation.

Calcutta was the third city in the world to have sewerage system in 1870 after London in 1850 and New York in 1860. Unfortunately, while the European and other developed nations saw a rapid growth of sewerage systems, in India, out of 5000 and odd cities and towns, only 232 are having sewerage systems that are too partially. Treatment of community waste water and industrial effluents discharging into major rivers and other inland water sources is extremely inadequate. In rural areas, open defaecation is as yet the major mode of sanitation, and this contributes significantly to non-profit sources of water pollution along with poor solid waste

management. The water quality monitoring results obtained during 1995–2006 indicate that the organic and bacterial contamination are continued to be critical in water bodies. This is mainly due to discharge of domestic waste water mostly in untreated form from the urban centres of the country. The municipal corporations at large are not able to treat increasing the load of municipal sewage flowing into water bodies without treatment. Secondly the receiving water bodies also do not have adequate water for dilution. Therefore, the oxygen demand and bacterial pollution are increasing day by day. This is mainly responsible for waterborne diseases. *It requires serious introspection by the scientists and technocrats of the country whether the Western model of sewerage and waste water system is based suited to our socio-economic and demographic situations and urban structures. The on-site sanitation model and decentralized waste water system developed by Dr. Bindeshwar Pathak could be considered as an alternate approach.*

1.5 Urban Development and Ecological Crisis

Our approach to development and economic growth is not taking care of the ecological concerns. Under the pressure of escalating and indiscriminate urbanization and industrialization, rivers are vanishing into drains, and lakes and wetlands are evaporating from the urban maps. Just to mention, a few examples of many such cases in the country are the following:., Najafgarh drain, Delhi (Sahibi river), Tolly's Nullah (Adi Ganga), Buddha Nala (Ludhiana) and Mithi drain (Mumbai). There will be a time when our children will forget that the Yamuna, Cauvery, Damodar and Churni were rivers. I won't be far from truth if I say that we are committing hydrocide – deliberate murder of our water bodies, at the altar of urban greed.

Real estate and commercial malls are growing to whet the hunger of urban and commercial growth, and beautiful orchards and green gardens of yesterday are fast vanishing into the concrete jungle of high-rise buildings and shopping malls. In Hyderabad, the expanding concrete jungle is eating into the catchment of Himayat Sagar and Osman Sagar lakes – inflows dropping by 25–30%. The future of Kolkata wetlands is facing critical jeopardy. One wonders whether the growth crazy society is possessed by death wish! It needs serious introspection by the scientists, technocrats, planners and the policymakers whether the current model of economic development and growth is ecologically sustainable.

1.6 Restoration of “Nirmal Aviral Dhara” in Ganga

Former Prime Minister of India, Shri Rajiv Gandhi, launched Ganga Action Plan in 1987. Because of many reasons, the activities undertaken during the first phase and second phase of Ganga Action Plan failed to achieve the desired objectives of the programme, and Ganga remains unfit for bathing in its entire stretch from Gangotri to Gangasagar. Almost all other major rivers and their tributaries are also seriously polluted. A major policy thrust in this regard has been the formation of National

Ganga River Basin Authority. The Ganga River Basin Management Plan conceptualized and developed by the IIT Consortium envisages that the restoration of “Nirmal Dhara” in all rivers of the Ganga basin will require, among other actions, the following steps concerning sewage collection, treatment and disposal processes. Complete stoppage of the discharge of sewage, either treated or untreated, from towns into all rivers of the Ganga basin:

- All sewage must be collected and treated up to tertiary level (treatment guidelines for tertiary treatment specified elsewhere; effluent standards: BOD<10 mg/L, SS<5 mg/L, fully nitrated effluent, $P < 0.5$ mg/L, FC<100/100 mL).
- The treated water should be recycled or reused for various purposes, i.e. industrial, irrigation, horticulture, non-contact/non-potable domestic uses, groundwater recharge, etc.

It needs to be emphasized that if the targets and policies of the Ganga Authority are to be implemented effectively by the state government and adequately maintained by the local government authorities, a major capacity building programme has to be undertaken in all urban and rural local government authorities. Maintenance of minimum ecological flows (Aviral Dhara) in our rivers is a critical challenge, as it often clashes with our urban, industrial and energy development policies. Implementation of a number of hydroelectric projects has resulted in significant alteration in hourly, daily and seasonal flows over substantial river length, in the upper Ganga segment (Gomukh to Hardware).

1.7 Water Quality Surveillance in Rural and Urban Areas

Water quality monitoring and surveillance is not adequately taken care of in most of our urban local bodies. In most rural systems, it was nonexistent till recently. The most glaring example of nonexistent water quality surveillance system in the rural areas is the episode of arsenic contamination of groundwater sources in India and Bangladesh. People were using arsenic-contaminated sources for years, without the quality of water of sources, being tested even once. It is only after some of them got sick that the problem was identified. Unfortunately, the utility and importance of this vital function in the overall management of drinking water supply system is often not realized by the concerned authorities and beneficiaries as well. Administrative limitations, lack of government and political support and, on top of this, general public apathy are the primary factors behind the low priority so far accorded to these essential functions. To develop more effective operation and maintenance of urban and rural water supplies, it is required to promote sanitary inspection along with effective consumer level water quality monitoring and surveillance in the rural areas, as a mechanism to identify problems and to take corrective measures at the community level. In absence of adequate operation and maintenance of the distribution systems, lack of leak detection and preventive maintenances, an intermittent system of discontinuous supply results in almost universal

faecal contamination of the distribution system and frequent outbreak of waterborne infections particularly in the unserved areas of the vulnerable groups (urban slums/peri-urban areas). In a recent water quality survey by the National Environmental Engineering Research Institute (NEERI) in all the major cities of towns in the country, it was found that 20–100% of the samples were faecally contaminated. In another survey in Kolkata, it was revealed that faecal contaminations in most of the household reservoirs were even more than in municipal systems. Achieving an acceptable standard of operation and maintenance and introduction of 24x7 supply systems would raise the question of affordability. However, it must be noted that urban India cannot enter the twenty-first century without introduction of continuous uninterrupted water supply to its citizens and protect them from microbial contamination.

1.8 Sanitation: The Unfinished Agenda

The International Decade on Water Supply and Sanitation was launched in 1980, and much was expected in terms of health benefit from the projects undertaken during the decade. Unfortunately, most of the national governments in the developing world provided an extremely disproportionate priority to sanitation in comparison to water supply. The propensity to give priority to water supply over sanitation has cost us hugely in terms of health gains. It is improved hygiene and sanitation – keeping faecal matter away from hands and food and from water itself when it is stored in the home – that transforms health. And the neglect of hygiene and sanitation goes a long way towards explaining why water supply programmes have often not brought the expected health benefits. The supply-driven, subsidized government programme did not succeed during the decade, primarily because lack of enabling environment (hygiene behaviour change + demand for sanitation), lack of capacity development at the community level/ULBs/PRI, lack of IEC support and awareness among the consumers and sanitation were not a perceived need of the community. *The decade was a spectacular failure.*

Total Sanitation Campaign (TSC), launched in India during the 1990s, and community-led total sanitation (CLTS), launched in many developing countries, created the much needed enabling environment, triggered behaviour change in the community and generated demand for sanitation. But the improvement was not sustainable without adequate government support for a sustainable technology. Often toilets with flimsy construction materials and unsustainable technology were washed away and many Nirmal Grams, open defaecation-free (ODF) villages reversed to OD villages. In the context of developing countries, in majority of the rural households, economic decision might not be in favour of investment on sanitation, and as such market alone cannot be the key to promotion of sanitation, and an element of subsidy, as such, cannot be avoided altogether.

1.9 Swachh Bharat Abhiyan: Road to Success

The prime minister has launched the Swachh Bharat Abhiyan with lot of passion and a sense of urgency. His passionate appeal has created positive impact on various sectors of the community. However, it must be realized that the programme as such is not fundamentally different from the Nirmal Bharat Abhiyan launched by the previous government, and the success of the same would largely depend on mobilization of resources and total participation of the people. A positive impact of the prime minister's appeal has been the response from the corporate sector in mobilizing the CSR funds for sanitation promotion. We must learn from our past mistakes in policy planning and management. CLTS/sanitation marketing and government-subsidized programme need not be mutually exclusive; rather future sanitation programme should draw upon the strength of CLTS/sanitation marketing and integrate them into a scaled-up nationwide programme supported by the government and promoted by the sector partners with provision of minimal subsidies required by the poor for having access to sustainable sanitation.

1.10 Epilogue: Promoting Water Safety and Sanitation Pays

Providing safe water and sanitation to the community is a basic precondition for improving health and alleviating poverty. A World Bank study says India is losing 4%–6% of GDP in damages related to public health, unsafe water, lack of sanitation and environmental pollution. In this logic, a much higher allocation on water supply, sanitation and public health sector (close to 4% of GDP) would be amply justified. Gains for the developing world, from investment on water and sanitation, could reach 15 US\$ per capita per year.



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Group of the Planning Commission from the sixth 5 Year Plan to 10th 5 Year Plan. He was a Member of the Planning Commission High Power Committees on SWM and Public Health (1997–1998), Steering Committees of the 1st and 2nd Phase Ganga Action Plan, Expert Member of NGRBA (2009–2014), National Task Force on Environmental Health, Chairman of the National Co-ordination Council on Water Quality, Rajiv Gandhi Drinking Water Mission. Presently he is the **Chairman, Arsenic Task Force, West Bengal; Chairman, Core Committee on Water Quality, Safety & Security, Govt. of West Bengal and Member, Scientific Advisory Board and SEA Regional Coordinator, International Scientific Forum on Home Hygiene (IFH), UK, Member of the Technology Advisory Group, WHO (Climate Resilient WASH), President of Institution of Public Health Engineers, India (IPHE)**, the premier national professional association of the Public Health Engineers in India. He has published more than 150 research and review papers, books, monographs etc. He has received several awards including Rajiv Gandhi Memorial Sulabh Sanitation Award (1998), Environmental Scientist of the Country award by National Environmental Science Academy (1999), Golden Jubilee award of the Indian Public Health Association (2007), Most Eminent Public Health Engineer of the Country by Institute of Engineers in 2008. **He is a fellow of the National Academy of Sciences, India; Indian of Public Health Association; Institution of Public Health Engineers, India; Institute of Engineers; Indian Water Works Association and he is an Honorary Fellow of the National Environmental Science Academy, India and Member, International Water Academy, Oslo. Prof. Nath has to his credit, more than 150 publications of books, monographs, course manuals, etc. and papers presented in International and National Conferences and published in reputed International and National Journals.**

Dinesh Chand

2.1 Introduction

Safe drinking water is the basic necessity for life. Supplying of drinking water in rural areas has always been one of the prime goals of the government. The government policies and programmes in rural water supply have also undergone a series of changes ever since Independence. In the initial years, emphasis was laid upon providing physical infrastructures like sanitary wells, handpumps, etc. Thereafter, one can see a transition from implementation of simple drinking water supply systems to a techno-sociological approach seeking active participation of the people. Serious steps to ensure sustainability of the systems were initiated in 1999 to institutionalise community participation in planning, implementation and operation and maintenance of rural drinking water supply schemes through *Sector Reform Project*. Principally, *Sector Reform* ushers a paradigm shift from “government-oriented supply-led approach” to “people-led demand-centric approach”.

Water which in turn includes rural drinking water supply is a state subject and has been included in the Constitution of India among the subjects entrusted to Panchayati Raj Institutions (PRIs) by the states. To accelerate the coverage of problem villages with drinking water, the government of India introduced Accelerated Rural Water Supply Programme (ARWSP) in 1972–1973 to support states/UTs through financial and technical assistance to implement water supply schemes. Later on in 1986, the “National Drinking Water Mission (NDWM)” was launched to accelerate the pace of coverage and resolve rural drinking water problem. Subsequently, it was rechristened as “Rajiv Gandhi National Drinking Water Mission (RGNDWM)” in 1991. This programme aimed at covering of all rural habitations with population of 100 and above, specially the uncovered habitations and having water quality-affected sources, and to set up water quality monitoring and

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surveillance system following “catchment area approach”. The Tenth Five-Year Plan and subsequent plans emphasised participatory approach wherein PRI would act as nodal institution for convergence of drinking water supply programmes at grass-roots level to ensure sustainability of systems. The strategies to achieve the objectives of RGNDWM were as summarised below:

- (a) To accelerate coverage of the remaining not covered (NC), partially covered (PC) and slipped back habitations from fully covered (FC) to PC or NC categories, with safe drinking water systems
- (b) To provide safe drinking water to all water quality problem habitations and to set up water quality monitoring and surveillance system
- (c) To implement water supply systems with sustainable sources ensuring continued safe drinking water supply in all covered habitations

As of 1 April 2005, 96.13% of rural habitations were fully covered (FC), 3.55% were partially covered (PC) and 0.32% was not covered (NC) with drinking water facilities, through millions of handpumps and over one lakh piped water schemes. However, there were slippages of FC habitations into NC or PC due to lowering of groundwater table or failure of sources, systems outliving their lives, increase in population, etc. In order to address the major issues like sustainability, water availability and poor water quality, etc., ARWSP Guidelines have been revised w.e.f. 1 April 2009 and renamed it as “National Rural Drinking Water Programme (NRDWP)” focussing on the following areas:

- To move forward from coverage of habitation towards coverage of households with drinking water
- To move away from overdependence on single drinking water source to multiple drinking water sources, through conjunctive use of surface water, groundwater and rainwater harvesting to ensure sustainability and prevent occurrence of slip-back habitations
- To encourage water conservation practices and revival of traditional water bodies
- To converge various water conservation programmes at the village level so as to ensure household level drinking water security adopting water budgeting and preparing village water security plans
- To consciously move away from high-cost treatment technologies to tackle arsenic and fluoride contaminations and to develop alternative safe sources for arsenic-affected habitations and adopt dilution practices in these aquifers through rainwater harvesting techniques to tackle fluoride contamination
- To establish water testing laboratories, at the district and subdivision levels, and to develop the capability for preliminary water testing at gram panchayat level
- To encourage handing over of rural drinking water schemes management (RWSM) to PRIs and earmarking of assets, and 10% of NRDWP-allocated funds as incentive to the states for transfer of management to PRCs was introduced

Further, one of the six components of “Bharat Nirman”, which envisages to building strong rural infrastructure in 4 years (2005–2006 to 2008–2009), was to provide drinking water supply through coverage of over all not covered, slipped back and water quality problem habitations under the drinking water programme.

2.2 Challenges in the Rural Drinking Water Sector

2.2.1 Coverage and Moving Up on the Ladder

As per Census 2011, 75.71% of Indian households have access to drinking water within the reach of 500 m. However, according to recent estimates of the “Ministry of Drinking Water and Sanitation”, 72.27% of the rural population have access to drinking water. Out of 1.71 million rural habitations in the country as of 1 April 2016, 1.31 million habitations were FC, 0.33 million PC and 71,077 remained NC which includes water quality-affected and slip-back habitations. In fact, from the 1990s, there has been a considerable reporting of increase in coverage of rural water supply during the successive 5-year plans right from the 1990s.

However, the increase in annual investment in the WATSAN sector does not translate in proportion with increase in access to drinking water (Figs. 2.1 and 2.2). Thus, there is an urgent need to address the twin problem of sustainability of water sources and their quality. MoDWS has estimated a huge gap in financial resources for tackling problems of sustainability and quality of water sources.

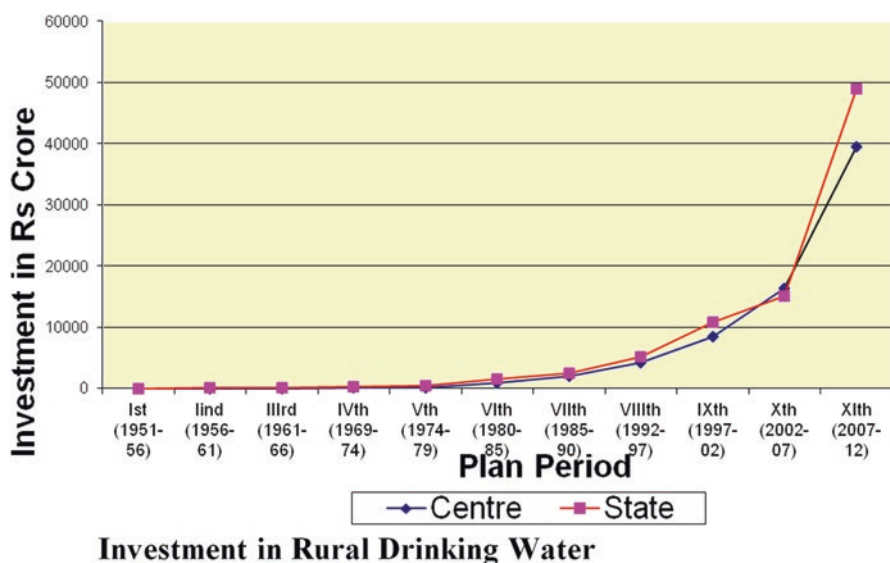
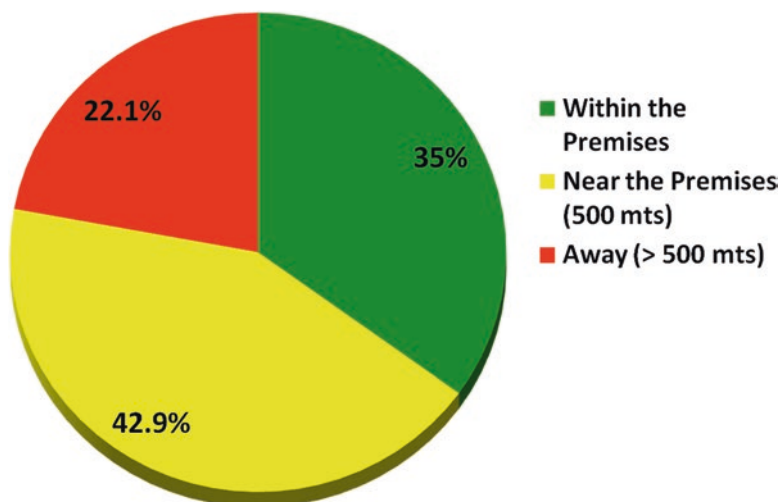


Fig. 2.1 Investment in rural drinking water



Availability of Drinking Water

Fig. 2.2 Availability of drinking water

2.2.2 Sustainability

The average annual rainfall in the country is extremely abundant by global standards. However, much of this rain falls in relatively brief downpour during the monsoon, and there is great disparity across different regions. Groundwater is a critical water resource in India, as it accounts for 85% of drinking water sources and over 65% of irrigation water. However, current trend reveals that 60% of groundwater sources will be in a critical state of degradation within the next 20 years. With the combination of these climatic conditions with a range of man-made pressures like over-withdrawals of water and massive infrastructure building, this dependence is leading to a rapid and very worrying deterioration of groundwater resources underlined by current events.

In the last three decades, groundwater levels buckled under over-exploitation. The water levels started to decline making bore wells dry. As a result, those habitations which were earlier “covered” by the government started “slipping back” and, at times, started providing contaminated water. While accessing drinking water continues to be a problem; assuring its quality has become another big challenge.

Water quality problems are caused by municipal and industrial pollution as well as over-exploitation. With the rapid pace of industrialisation and greater emphasis on agricultural growth combined with financial and technological constraints, ineffective enforcement of pollution laws has contributed towards pollution of fresh water sources. These include sewage and industrial discharges and run-offs from agricultural fields and urban areas. Water quality has also got affected significantly by floods, droughts and due to lack of awareness and education among users. The need for users’ involvement in maintaining water quality and looking at other aspects like safe water storage, hygiene, environment sanitation and proper disposal of waste and waste waters are critical elements of maintaining water quality.

2.2.2.1 Source Sustainability: Quantity and Quality

In places where surface water is available but unsafe for drinking or farming—more than 70% of India's surface water resources are polluted by municipal waste or toxic industrial chemicals—groundwater has generally been considered as a safe alternative. As far as the overall picture is concerned, presently, 178 districts (30%) have “unsafe” levels of groundwater development. Many of these districts also have serious water contaminations, but those districts which are considered “safe” in terms of availability of groundwater quantity need to be focussed. Among these “safe” districts, as many as 169 districts have one or more water quality problems (arsenic/fluoride or salinity). Thus, it was found that a total of 347 districts (about 59% of all districts in India) taking 169 districts having water contaminants together with another 178 districts with “unsafe” levels of groundwater development have problems of either inadequate availability or quality of groundwater. This clearly reveals that the coverage of most habitations in India has achieved from physical angle, but from water quality angle, it might be misleading.

Groundwater can get contaminated by a variety of sources including point and nonpoint sources of pollution and geogenic occurrences. As such pollution sources pose a relatively serious threat to a country's groundwater resources and need to be identified and tackled urgently. Point sources are often legally permitted to discharge a certain amount of substance and can be regulated by permitting procedures. However, there are also illicit pollutant discharges under this category from non-permitted sources which may cause serious water quality problems.

In contrast, nonpoint sources of pollution are not only hardly identifiable or locatable but also much complex to regulate as compared to point sources of pollution. Nonpoint source contaminants, naturally occurring substances, like arsenic, fluoride, iron, nitrates, salinity, other heavy metals, tannins, hardness and odour, often have unidentifiable source. However, when the polluters are unidentified, or the problem results from the behaviours and activities of residents, administration of control becomes more cumbersome.

2.2.2.2 System Sustainability: Quality of the System and Their Operation and Maintenance (O&M)

Over 5.69 million handpumps benefiting 620.6 million people and over 7.05 lakh piped water schemes benefiting 480.3 million people have been installed in the country so far under the Rural Drinking Water Programme. The total estimated cost for O&M of these as per the present provision (10–15% of the assessed capital cost/year) would be around Rs 2000 crore per year at present rate of funding. However, majority of the schemes remain non-functional, and many others become permanently defunct due to lack of skilled staff for proper maintenance and repairs and inadequate financial support. It is, therefore, necessary to give highest priority to O&M. Most of the states face resource constraints leading to poor maintenance. Funds under the state and NRDWP are provisioned to meet O&M costs which may not be adequate in most of the states.

In view of the huge cost of O&M, suitable institutional set-up and funding arrangements through community participation need to be evolved for upkeep of