



# **MANUAL ON SEWERAGE AND SEWAGE TREATMENT SYSTEMS**

**PART A: ENGINEERING  
THIRD EDITION - REVISED AND UPDATED**

**MINISTRY OF URBAN DEVELOPMENT, NEW DELHI**  
<http://moud.gov.in>

**CENTRAL PUBLIC HEALTH AND  
ENVIRONMENTAL ENGINEERING ORGANIZATION**

**IN COLLABORATION WITH**



**JAPAN INTERNATIONAL COOPERATION AGENCY**

**NOVEMBER 2013**

In keeping with the advancements in this sector, updates as and when found necessary will be hosted in the Ministry website: <http://MoUD.gov.in/> and the reader is advised to refer to these also.

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सत्यमेव जयते

शहरी विकास एवं संसदीय कार्य मंत्री  
भारत

**MINISTER OF URBAN DEVELOPMENT  
AND PARLIAMENTARY AFFAIRS  
INDIA**

## **MESSAGE**

While the population of urban areas has increased from 19.9% to 31.2% between 1971 and 2011, the contribution of urban areas to GDP growth has shown a phenomenal increase from 38% to 60% over the same period. Providing sanitation and hygiene to a growing population of more than 1.21 billion with higher aspiration levels is a major challenge. This increase in population has created a significantly enhanced demand on water supply, health, hygiene and environmental sanitation.

To tackle this, the Government of India has initiated programs and given policy directions to States and Cities through interventions like the launch of the Jawaharlal Nehru National Urban Renewal Mission (JnNURM) and adoption of National Urban Sanitation Policy, 2008. JnNURM seeks to promote cities as engines of economic growth through improvement in the quality of urban life by facilitating the States for creation of quality urban infrastructure, with assured service levels and efficient governance.

The National Urban Sanitation Policy (NUSP), 2008 pertains to management of human excreta and associated public health and environmental impacts, including 100% sanitary and safe disposal of human excreta and liquid wastes from all sanitation facilities like sewers and toilets.

I am confident that the revised and updated manual in three parts - Engineering, Operation & Maintenance and Management will further enable the practicing professionals in design and operation & maintenance of the sewerage and sewage treatment systems economically, efficiently and effectively.

I would like to acknowledge the support extended by the Japan International Cooperation Agency (JICA), Government of Japan and also the efforts of the officials of MoUD in this endeavour. I am hopeful this effort would contribute towards achieving the Ministry's vision of the creation of economically vibrant, inclusive, efficient and sustainable urban habitats.

**(KAMAL NATH)**

डॉ. सुधीर कृष्ण  
Dr. Sudhir Krishna



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## FOREWORD

India is passing through a dynamic phase of development wherein the Government of India is striving hard to provide all the necessary infrastructure facilities to urban population in order to achieve sustainable economic growth. As per the 2011 census, the share of urban population is 31.2% as against 28% of 2001 census of the total population of the country which is expected to be 50% by the mid of the century. Infrastructure facilities being provided for such an unprecedented growth are unable to meet with the requirement due to various compelling circumstances. Water supply and sanitation is one of the basic infrastructure facilities, which has a direct impact on the urban population to meet the desired levels of quantity and quality.

Inadequate and unsafe water supply and sanitation services have a direct effect on the health of the community and an indirect effect on the economy of the country. The report on "The Economic Impact of Inadequate Sanitation in India" released by the Water and Sanitation Program (WSP), World Bank states that inadequate sanitation costs India almost US\$ 54 billion (about Rs. 2.7 lakh crore) or 6.4% of country's GDP in 2006. In view of this huge cost to be paid for inadequate sanitation, it is really necessary on all the concerned agencies dealing with water supply and sanitation sector in the country including the community to find ways for how best this loss to the nation could be minimized.

I appreciate the cooperation extended by the Japan International Cooperation Agency (JICA) and the Government of Japan through their financial and expert support in completing this task of Revision and Updating of the Manual on Sewerage and Sewage Treatment Systems, which was last published by the Ministry during 1993. Untiring efforts of the experts from JICA Study Team and India culminated in bringing out such an exhaustive manual in three parts, is worthy of appreciation.

I am confident that the three parts of the manual will certainly achieve the program objectives of the Government of India as stated in the "National Urban Sanitation Policy" adopted in 2008. I also sincerely hope that this Manual would serve as a guide to policy makers, planners, and all practicing professionals in the field of sewerage and sewage treatment systems so as make the systems economically viable to accrue benefits in the long term on a sustainable basis.

Finally, I would like to acknowledge the untiring efforts of all people who are associated with the task of accomplishing the commendable job of formulation of this exhaustive manual for the benefit and improvement of the sanitation sector.

(Sudhir Krishna)

19.11.2013

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## **PREFACE**

Over the years, there has been continuous migration of people from rural and peri-urban areas to cities and towns. The proportion of population residing in urban areas has increased from 28.0% in 2001 to 31.2% in 2011. The number of towns has increased from 5161 in 2001 to 7935 in 2011. The uncontrolled growth in urban areas has left many Indian cities and towns deficient in infrastructural services such as water supply, sewerage & sanitation, storm water drainage and solid waste management.

Sewerage and sewage treatment is a part of public health and sanitation, and according to the Indian Constitution, falls within the purview of the State List. Since this is non-exclusive, non-rivalled and essential, the responsibility for providing the services lies within the public domain. The activity being local in nature, it is entrusted with the Urban Local Bodies. The Urban Local Body undertakes the task of sewerage and sewage treatment service delivery, with its own staff, equipment and funds. In few cases, part of the said work is contracted out to private enterprises.

Cities and towns which have sewerage and sewage treatment facilities are unable to cope-up with the increased burden of providing such facilities efficiently to the desired level. Issues and constraints that are encountered by the urban local bodies, responsible for providing sewerage and sanitation facilities, are compounded due to various reasons. The main cause of water pollution is the unintended disposal of untreated, partially treated and non-point sources of sewage and more important is its effect on human health & environment.

While the conventional sewerage is an effective system for sewage collection, transportation and treatment, it also remains as highly resource-inefficient in terms of technology. Consequently, high capital and recurrent costs for the O&M of this system at a significant level, prohibits its widespread adoption in all sizes of urban areas in the country.

As per the 2011 Census, only 32.7% of urban households are connected to a piped sewer system whereas 38.2% dispose of their wastes into septic tanks and 8.8% households are having pit latrines (single & double, etc.) and 1.7% of households are having other latrines (connected to open drains, night soil removed by human etc.). About 18.6% of urban households still do not have access to individual toilets – about 6.0% use public /community toilets and 12.6% are forced the indignity of open defecation.

According to the report on the Status of Wastewater Generation and Treatment in Class-I Cities and Class-II towns of India, December 2009 published by Central Pollution Control Board,

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the estimated sewage generation from 498 Class-I cities and 410 Class-II towns (Population estimated for 2008 based on 2001 census) together is 38,524 MLD, out of which only 11,787 MLD (30.5%) is being treated with a capacity gap of 26,737 MLD.

The National Urban Sanitation Policy (NUSP) adopted by the Ministry of Urban Development in 2008 envisions "All Indian Cities and towns become totally sanitised, healthy and liveable and ensure and sustain good public health outcomes to all their citizens, with a special focus on hygienic and affordable sanitation facilities for the urban poor and women". With a view to promote sanitation very rapidly in urban areas of the country and also to recognise the excellent performance in this sector by the cities, the Government of India has instituted an annual award scheme for rating of the cities on certain selected sanitation parameters. The overall goals of NUSP, is to transform the urban sanitation into community driven, totally sanitized, healthy and liveable.


The Millennium Development Goals (MDGs) enjoins upon the signatory nations to extend access to improved sanitation to at least half the urban population by 2015, and 100% access by 2025. This implies extending coverage to households without improved sanitation, and providing proper sanitation facilities in public places to make cities and towns free of open defecation. The Ministry proposed to shift the focus on infrastructure in urban water supply and sanitation (UWSS) to improve the service delivery and formulated in 2008 a set of Standardized Service Level Benchmarks for UWSS as per International Best Practice & brought out the "Handbook on Service Level Benchmarking" on water supply and sanitation.

The Manual on Sewerage and Sewage Treatment (second edition) published in 1993 mainly gave thrust to engineering aspects of the sewerage and sewage treatment systems. The topics additionally covered in the current revised and updated revision are emphasis on O&M and management of sewerage and sewage treatment systems, not dealt with in detail in the earlier edition and are to create awareness amongst the practicing and field engineers on the importance of sustainability of the systems in the long-term. The present Manual on Sewerage and Sewage Treatment Systems has been divided into three parts, as Part – A on 'Engineering', Part – B on 'Operation and Maintenance', and Part – C on 'Management'.

On behalf of the Ministry I would like to highly appreciate and acknowledge the financial and physical support provided by the Japan International Cooperation Agency (JICA), Government of Japan for the preparation of this exhaustive and informative manual.

The Ministry of Urban Development places on record its appreciation of the Expert Committee for the revision and updating of the Manual on Sewerage and Sewage Treatment Systems and the untiring services rendered by Dr. M. Dhinadhayan, Joint Adviser (PHEE) & Member Secretary of the Expert Committee who acted as the fulcrum between the Ministry of Urban Development, GOI and the Japan International Cooperation Agency (JICA) to maintain an extremely balanced relation throughout the period of preparation of the Manual so as to accomplish the task.

I also extend my thanks to all those people who were directly or indirectly instrumental in giving such a praise-worthy shape to the manual

  
(Ashok Singhvi)

**Dr. M. DHINADHAYALAN**  
**Joint Adviser (PHEE)**  
**CPHEEO**



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## **ACKNOWLEDGEMENT**

Ever since the publication of the Manual on Sewerage and Sewage Treatment in 1993 a number of new developments and changes have occurred in the range of technologies for on-site and off-site sanitation systems, including collection, transportation, treatment and reuse of treated sewage & sludge for various uses during the last two decades. While revising the Manual a broad approach was adopted for the need for revision and updating of the manual on the three important aspects, such as i) Engineering, ii) Operation & Maintenance, and iii) Management of sewerage and sewage treatment systems. Additional topics on operation & maintenance and management were added so as to create awareness amongst the practicing and field engineers regarding the importance of these two topics for the long-term sustainability of the systems.

The revision and updating of the existing manual (1993), aims to meet the important requirement of providing advice on the technology options for urban sanitation, for the new infrastructure or upgrading of existing services. It is applicable both for small interventions in specific locations and for larger programs that aim to improve sanitation on a citywide scale. The manual would help the practitioners in the selection of technologies with various options for providing techno-economic solutions keeping in view the health of the community and safeguarding the environment so as to provide a wide range of options to the planners and designers.

The National Urban Sanitation Policy (NUSP) was adopted by the Ministry of Urban Development (MoUD) in 2008. It envisions that "All Indian cities and towns become totally sanitized, healthy and liveable and ensure and sustain good public health and environmental outcomes for all their citizens with a special focus on hygienic and affordable sanitation facilities for the urban poor and women". With a view to promote sanitation very rapidly, in urban areas of the country and also to recognise the excellent performance in this sector by the cities, the Government of India (GOI) instituted an annual award scheme for rating of cities on certain selected sanitation parameters. The overall goal is to transform Urban India into community driven, totally sanitized, healthy and liveable cities and towns.

In view of the importance attached and impetus given to sanitation by the GOI in cities and towns of the country, the MoUD decided to revise and update the existing Manual on Sewerage and Sewage Treatment under the aegis of Japan International Cooperation Agency (JICA), who appointed a JICA Study Team (JST) in July 2010 comprising of experts from Japan.

The JST visited about 40 Sewage Treatment Plants across 8 States during 2010-2011 and gathered first-hand experience on planning, implementation and O & M of sewerage systems and factual knowledge on the social, engineering, financial and management issues relevant to India. The JST retained an Indian Study Team (IST) to assist in the preparation of the manual.

Continued

The MoUD constituted 3 Expert Committees (ECs) (Annex-1) (1st & 2nd in August 2010 and the 3rd in November 2011) by nominating experts from Central Ministries / Departments, academic & research institutions, senior engineers from State Departments & Utilities for reviewing and finalizing the drafts of the JST. Two numbers of each one week long study tours were conducted in November, 2011 and January 2012 by JST for the members of the EC to study the sewerage and sewage treatment systems in Japan. This helped the members of the EC to get the first hand information on the technologies adopted in sewerage and sewage treatment and how the sewerage systems are being operated and maintained. The tours were facilitated by JICA.

The ECs, JST and IST interacted in 16 meetings at New Delhi to give a final shape to all the three parts of the manual. The manuals prepared by the JST, ECs and IST address the following. :

Part – A on ‘Engineering’ addresses the core technologies and updated approaches towards the incremental sanitation from on-site to decentralized or conventional sewerage systems including collection, conveyance, treatment and reuse of the misplaced resource of sewage and sludge and is simplified to the level of the practicing engineer for the day-to-day field guidance in understanding the situation and coming out with a choice of approaches to remedy the situation.

Part – B on ‘Operation and Maintenance’ addresses the issues of standardizing the human and financial resources. These are needed to sustain the sewerage and sanitation systems which are created at huge costs without slipping into an edifice of dis-use for want of codified requirements for O&M so that it would be possible to address the related issues. These financial and related issues are to be addressed at the estimate stage itself, thus enabling to seek a comprehensive approval of fund allocations and human resources. This would also usher in the era of public private partnership to make the projects self-sustaining. This also covers aspects such as guidelines for cleaning of the sewers and septic tanks besides addressing the occupational health hazards and safety measures of the sanitation workers.

Part – C on ‘Management’ is a refreshing approach to modern methods of project delivery and project validation and gives a continual model for the administration to foresee the deficits in allocations and usher in newer mechanisms. It is a tool for justifying the chosen project delivery mechanism and optimizing the investments on need based allocations instead of allocations in budget that remain unutilized and get surrendered in the end of fiscal year with no use to anyone.

These draft manuals were discussed with an All India audience in the 2 National Workshops held at New Delhi on 20th & 21st September 2012 for finalization of Part A: Engineering and on 21st & 22nd January 2013 for finalization of Part B: Operation & Maintenance and Part C: Management, where in delegates from Central Ministries, State Government Departments, Urban Local Bodies, Parastatal Agencies, and representatives from Technology Providers participated and deliberated in detail regarding the contents of each part of the three manuals. These were further reviewed and brought to completion by the Editorial committee constituted by the MoUD with members as in (Annex-2). In all, 6 meetings of the Editorial committee were held at New Delhi.

The Editorial Committee while editing the Manual kept in view the TOR prescribed by the Ministry and also comments, suggestions, views offered by the delegates who participated in National Workshops and views received through e-mail were also accommodated suitably wherever necessary in all the three parts of the manual.

Continued



The Expert Committee places on record its gratitude to:

- The MoUD for the necessary support & encouragement in the preparation of the manual
- The JICA for funding the meetings, study tours, workshops and publishing the manuals.
- The PHE Departments, Water & Sewerage Boards, Urban Local Bodies, and individuals for their valuable suggestions on the draft of the manual.

The Expert Committee is highly indebted to Mr. Akira Takechi, JICA Study Team Leader for his wonderful guidance, whole hearted support and encouragement of the members of the Expert Committee during the entire period in fulfilling the task of preparation of the Manual.

The Expert Committee expresses its gratitude to Dr.S.Sundaramoorthy, Consultant, JST, Team Leader IST & Member Secretary, Editorial Committee as the architect of the manual and his team for giving final shape to all the three parts of the Manual.

I would like to extend my sincere thanks to Dr.S.R.Shukla, Former Adviser (PHEE), CPHEEO, MoUD, Co-Chairman of the Expert Committees, for chairing all the Expert / Editorial Committee meetings and for his continued involvement, guidance and support in preparation and finalization of three parts of the manual.

I express my sincere thanks and gratitude to Ms.E.P.Nivedita, then Director (LSG), for taking the initial efforts through coordination and chairing the deliberations of the EC meetings in laying a broader framework for revision and updation of the Manual.

I am also privileged to express my sincere thanks on behalf of the Expert Committee to Ms.Veena Kumari Meena, then Director (LSG) and Ms.Nandita Mishra, Director (PHE) for their support in finalization of the Manual.

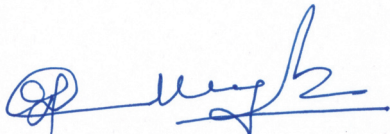
The contribution made by Mr.V.K.Chaurasia, Joint Adviser (PHEE), Mr.J.B.Ravinder, Deputy Adviser (PHE), Mr. A.K. Saha, Assistant Adviser (PHE), and Dr.Ramakant, Assistant Adviser (PHE), CPHEEO for enriching the contents of the Manual is very much appreciated. The painstaking efforts taken by Dr.Ramakant, Assistant Adviser (PHE) and Member-Coordinator, during the entire process of preparation of the Manual is stupendous and laudable.

A special mention and deep appreciation is due for the meticulous and diligent efforts of Dr.S.Saktheeswaran, Editorial Consultant (JICA) & Copy-Editor to JICA for bringing out the manual in a concise form, through several stages of editing and incorporating all the feedbacks.

The help and contribution by Mr. Takashi Sakakibara, JICA expert, CPHEEO and Mr.C.Krishna Gopal, Consultant, NUSP Cell is highly appreciated.

The Committee also acknowledges the contribution and support of the representatives of SMEC India Pty Ltd for the first phase of the study and CH2M HILL for the second phase of the study for their excellent logistics support and facilitation throughout the period.

I would like to acknowledge all those connected individuals, organizations, institutions, Bilateral and Multilateral agencies for their efforts directly and indirectly, through their valuable contribution, suggestions and inputs.



(M. Dhinadhayan)

**Annex-1**  
**JICA Study Team (JST)**

No	Name	Designation / Department
1	Akira Takechi	Team Leader
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4	Dr Alok Kumar	Planning & Design (Sewer)
5	Guillermo Madariaga	Planning & Design (Mechanical & Electrical)
6	Masatoshi Yamada	General Editor / Sewerage Management
7	Yoshitaka Ito	O&M (Facility, Sewer)
8	Teruo Suga	O&M (Mechanical)
9	Mikio Suzuki	O&M (Electrical)
10	Akira Morita	Onsite Planning & Design/O&M
11	Gururaj Rao	Coordinator / O&M
12	Dr Kiyoshi Moriyama	Sewerage O&M Planning
13	Masaaki Mukaide	Civil Facility Designing
14	Takenori Shoryuji	Facility O&M Planning
15	Takehiro Nakano	Water Quality / Safety

**Indian Study Team (IST)-Counterpart to JST**

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1	Dr S Sundaramoorthy	Team Leader from February-2012 & Sewage Treatment
2	Shri M K Amirthalingam	Sewage Collection systems
3	Shri R Vasudevan	Electrical and Instrumentation Systems
4	Shri D Harsha	Management Practices in Sewerage
5	Shri I Kalyanasundaram	Sewerage Structures
6	Shri P Subramani	Sludge Management and Bio-methanation
7	Dr S Saktheeswaran	Sewage Reuse and Copy-Editor

**Annex – 1 (continued)**  
**Indian Expert Committee-Part-A**

No	Name	Designation / Department
1	Adviser(PHEE) (Vacant)	CPHEEO/, MoUD, Chairman
2	Dr. S.R. Shukla	Former Adviser (PHEE), CPHEEO, MoUD, Co-Chairman
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4	Shri B.B.Uppal	Former Deputy Adviser (PHE), CPHEEO, MoUD
5	Shri V.K.Chaurasia	Joint Adviser (PHEE), CPHEEO, MoUD
6	Dr. R.K.Singh	Deputy General Manager (Projects), HUDCO, MoHUPA
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11	Shri M.Dhanabalan	Retd Chief Engineer,TWAD Board, Chennai
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14	Shri C. Lallunghnema	Joint Secretary (Tech.), PHED, Mizoram
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19	Dr. Ramakant	Assistant Adviser (PHE), CPHEEO, MoUD, Coordinator
20	Dr. M.Dhinadhayalan	Joint Adviser (PHEE), CPHEEO, MoUD, Member Secretary

**Annex – 1 (continued)**  
**Indian Expert Committee-Part-B**

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3	Shri. R. Sethuraman	Former Joint Adviser (PHEE),CPHEEO, MoUD
4	Shri M Sankaranaryanan	Retd. Joint Adviser (PHEE), CPHEEO, MoUD
5	Shri. J.B.Ravinder	Deputy Adviser (PHE), CPHEEO, MoUD
6	Shri M.Sathyanarayanan	Director(Projects), Metropolitan WS&SB, Hyderabad
7	Shri. J.S.Bahra	Executive Engineer, Punjab WS& SB, Chandigarh
8	Shri. S.V.Ahuja,	Project Director, GJTI, GWSSB, Gandhinagar
9	Shri. G.Elangovan,	Retd. Engineering Director, CMWSSB, Chennai
10	Prof. A.Mazumdar,	Former Professor, AIIH&PH, Kolkata
11	Dr. Kazmi Absar Ahmed	Associate Professor, Dept of Civil Engineering, I.I.T, Roorkee
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13	Shri.B. I. Dalal	Additional C E, Surat Municipal Corporation, Surat
14	Shri S.M. Jejurikar	C E, (M&E), Greater Mumbai Municipal corporation
15	Shri Sumit Dutta	C E, (S&D), Kolkata Metro Development Authority
16	Shri Dilip Kumar Padhi,	Retd. Member Secretary, Odisha W S & S Board
17	Shri S.P. Rudramurthy	Additional C E, (CP&WWM), BWSSB, Bengaluru
18	Dr. Ramakant	Assistant Adviser (PHE), CPHEEO, MoUD, Coordinator
19	Dr. M.Dhinadhayalan	Joint Adviser (PHEE), CPHEEO, MoUD, Member Secretary

**Annex – 1 (continued)**  
**Indian Expert Committee-Part-C**

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4	Dr. Urmila Brighu	Associate Prof, Dept of Civil Engineering, MNIT, Jaipur
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6	Shri S. Srinivasan	Sr. Vice President, Commercial, IL&FS Water, Chennai
7	Prof. Kulbhushan Balooni	Associate Prof. Economic Area, IIM, Kozhikode, Kerala
8	Dr. R.K.Singh	Deputy General Manager(Projects),HUDCO, MoHUPA
9	Dr.Ramakant	Assistant Adviser(PHE),CPHEEO, MoUD, Co-ordinator
10	Dr. M.Dhinadhayalan	Joint Adviser (PHEE),CPHEEO, MoUD, Member- Secretary

The list of Editorial Committee members is in the next page

**Annex -2**  
**Editorial Committee-Part-A**

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1	Dr. S.R. Shukla	Former Adviser (PHEE), CPHEEO, MoUD, Chairman
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3	Shri V.K.Chaurasia	Joint Adviser (PHEE), CPHHEO, MoUD
4	Shri. J.B.Ravinder	Deputy Adviser (PHE), CPHEEO, MoUD
5	Dr. S. Sundaramoorthy	Retd. Engg. Dir. CMWSSB, Editorial consultant
6	Dr. M.Dhinadhayalan	Joint Adviser (PHEE), CPHEEO, MoUD

**Editorial Committee-Part-B and Part-C**

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2	Shri M Sankaranaryanan	Retd. Joint Adviser (PHEE), CPHEEO, MoUD
3	Dr. Urmila Brighu	Associate Professor, Civil Engineering, MNIT, Jaipur
4	Dr. Kazmi Absar Ahmed	Associate Professor, Civil Engineering, I.I.T, Roorkee,
5	Dr. S. Sundaramoorthy	Retired Engg. Dir. CMWSSB, Chennai, Editorial consultant
6	Prof. A.Mazumdar,	Former Professor, AIIH&PH, Kolkata
7	Shri R.N.Gupta,	Former Engineer-in-Chief, PHED, Chhattisgarh
8	Dr. Ramakant	Assistant Adviser (PHE), CPHEEO, MoUD, Coordinator
9	Dr. M.Dhinadhayalan	Joint Adviser (PHEE), CPHEEO, MoUD