The Urban Environmental Crisis in India

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New Initiatives in Safe Water and Waste Management

Edited by

Shyamli Singh, Radha Goyal
and Ashish Jain

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ABBREVIATIONS

ABPA	Allergic Broncho Pulmonary Aspergillosis
AFR	Alternative Fuels and Raw Materials
Al_2O_3	Aluminium Oxide
ALMP	Advanced Locality Management Program
AMC	Allahabad Municipal Council
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
APC	Air Pollution Control
APHA	American Public Health Association
As	Arsenic
As_2O_3	Arsenic Oxide
AWWA-WPCF	American Water Works Association- Water Pollution Control Federation
BARC	Bhabha Atomic Research Centre
BBMP	Bruhat Bengaluru Mahanagara Palika
BIMA	Biogas Induced Mixing Arrangement.
BMC	Brihanmumbai Municipal Corporation
BMW	Biomedical Wastes
BOD	Biochemical Oxygen Demand
BPA	Bisphenol A
BREF	Bat (Best Available Techniques) Reference Document
BT	Bio-technology
BTEX	Benzene Toluene Ethylene and Xylene
BTU	British Thermal Unit
C&D	Construction and Demolition
Ca	Calcium
CAB	Culturable Airborne Bacteria
$CaCO_3$	Calcium Carbonate
CAF	Culturable Airborne Fungus
CAGR	Compounded Annual Growth Rate
CaO	Calicum Oxide
CBOs	Community Based Organisations
CCMEWQI	Canadian Council of Ministers of the Environment Water Quality Index
CCS	Carbon Capture and Storage

Cd	Cadmium
$CdCl_2$	Cadmium Chloride
CEA	Central Electricity Authority
CETP	Common Effluent Treatment Plant
CFC	Chloro Fluoro Carbon
CGWB	Central Ground Water Board
CH_4	Methane
CIPET	Central Institute of Plastics Engineering and Technology
Cl	Chlorine
CNG	Compressed Natural Gas
CO	Carbon Monoxide
Co	Cobalt
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
C_p	Specific Heat Content
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
Cr	Chromium
CRRI	Central Road Research Institute
CSIR	Council of Scientific and Industrial Research
CSIR-NEERI	Council of Scientific and Industrial Research- National Environmental Engineering Research Institute
Cu	Copper
DCB	Delhi Cantonment Board
DISHA	Direct Initiative for Social and Health Action
DO	Dissolved Oxygen
DRANCO	Dry Anaerobic Composting
DSC	Differential Scanning Calorimeter
DST	Department of Science & Technology
DTDC	Door-to-Door Waste Collection
EC	Electrical Conductivity
EDMC	East Delhi Municipal Corporation
EM	Effective Micro-Organisms
EPA	Environment Protection Agency
EPC	Engineering Procurement Construction
EPR	Extended Producer Responsibility
EU	European Union
E-waste	Electronic Waste
F	Fluorine

FB	Field Blanks
FC	Fecal Coliform
Fe_2O_3	Ferric Oxide
FICCI	Federation of Indian Chambers of Commerce and Industry
FID	Flame Ionization Detector
FMCG	Fast Moving Consumer Goods
GAP	Ganga Action Plain
GDP	Gross Domestic Product
GHG	Green House Gas
GIBCO	Grand Island Biological Company
GIS	Geographical Information System
GoI	Government of India
GOI-CGWB	Government of India- Central Ground Water Board
GPS	Global Positioning System
GUDC	Gujarat Urban Development Corporation
GW	Gigawatt
H_2S	Hydrogen Sulphide
HAP	Hazardous Air Pollutant
HC	Hydro Carbon
HCl	Hydro Chloride
HDPE	High-Density Polyethylene
Hg	Mercury
HHV	Higher Heating Value
HW	Hazardous Waste
IARI	Indian Agriculture Research Institute
IAWG	International Ash Working Group
ICPE	Indian Centre for Plastics in the Environment
IEA	International Energy Agency
IGT	Institute of Gas Technology
IIT	Indian Institutes of Technology
IMSD	Integrated Mission for Sustainable Development
INR	Indian Rupee
IPCA	Indian Pollution Control Association
IPCC	Intergovernmental Panel on Climate Change
IPMA	International Project Management Association
IRC	Indian Road Congress
ISWM	Integrated Solid Waste Management
ISWMS	Integrated Municipal Solid Waste Management System
ITCC	Indian Type Culture Collection
IW	Industrial Waste

JBIC	Japan Bank of International Cooperation
JICA	Japan International Cooperation Agency
JITF	Jindal Infrastructure Transport and Fabrication
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
KMDA	Kolkata Metropolitan Development Authority
KPI	Key Performance Indicators
LB	Laboratory Blanks
LCA	Life Cycle Assessment
LCDs	Liquid Crystal Displays
LDPE	Low-Density Polyethylene
LFG	Landfill Gas
LMC	Lucknow Municipal Corporation
LPG	Liquid Petroleum Gas
MAR	Managed Aquifer Recharge
mbgl	Meters Below Ground Level
MCD	Municipal Corporations of Delhi
MCGM	Municipal Corporation of Greater Mumbai
MEA	Malt Extract Agar
MFA	Material Flow Analysis
Mg	Magnesium
$MgCO_3$	Magnesium Carbonate
MgO	Magnesium Oxide
MLD	Million Litres Per Day
MMC	Maharashtra Municipal Corporation
MMR	Mumbai Metropolitan Region
Mn	Manganese
MNRE	Ministry of New and Renewable Energy
MoEF	Ministry of Environment and Forests
MoEFCC	Ministry of Environment Forests and Climate Change
MoUD	Ministry of Urban Development
MPCB	Maharashtra Pollution Control Board
MPN	Most Probable Number
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
MT	Metric Ton
MTPD	Metric Ton Per Day
MTPY	Million Ton Per Year
MW	Municipal Waste
MWh	Mega Watt Hour
NA	Nutrient Agar

NAAQS	National Ambient Air Quality Standards
NAAQMP	National Ambient Air Quality Monitoring Programme
NDMC	New Delhi Municipal Council
NEERI	National Environmental Engineering Research
NERI	Navreet Energy Research and Information
NGO	Non-Government Organization
NGT	National Green Tribunal
NH_3	Ammonia
NH-8	National Highway-8
Ni	Nickel
NIMBY	Not In My Backyard
NMMC	Navi Mumbai Municipal Corporation
NMOC	Non-Methane Organic Compounds
NOAA	National Oceanic and Atmospheric Administration
NOx	Oxides of Nitrogen
NO_2	Nitrogen Dioxide
NRCD	National River Conservation Directorate
NSF	National Sanitation Foundation
NSFWQI	National Sanitation Foundation Water Quality Index
NUSP	National Urban Sanitation Policy
NWDMC	National Water Demand Management Centre
O_2	Oxygen
O_3	Ozone
ODS	Ozone Depleting Substances
OECD	Organisation for Economic Co-operation and Development
OFMSW	Organic Fraction of Municipal Solid Waste
OUIDF	Odisha Urban Infrastructure Development Fund
OWQI	Oregon Water Quality Index
PAH	Polycyclic Aromatic Hydrocarbon
Pb	Lead
$PbCl_2$	Lead Chloride
PCB	Polychlorinated Biphenyl
PCDD	Polychlorinated Dibenzo-P-Dioxins
PCDF	Polychlorinated Dibenzo Furans
PCP	Pentachlorophenol
PE	Population Equivalent
PET	Polyethylene Terephthalate
PM	Particulate Matter
PMC	Pune Municipal Corporation
PP	Polypropylene

PPP	Public Private Partnership
PPT	Plasma Pyrolysis Technology
PS	Poly Styrene
PTFE	Poly Tetra Fluoro Ethylene
PVC	Poly Vinyl Chloride
PW	Plastic Waste
PWM	Plastic Waste Management
R&D	Research and Development
RCC	Reinforced Concrete Cement
RDF	Refuse Derived Fuel
RWA	Resident Welfare Association
SA	System Administrator
Sb	Strontium
SBM	Swachh Bharat Mission
SDMC	Systems Director Management Console
SGPI	Sanjay Gandhi Postgraduate Institute of Medical Sciences,
SiO_2	Silicon di- Oxide
SLF	Sanitary Landfill
SO_2	Sulphur Di Oxide
SO_4	Sulphate
SO_X	Oxides of Sulphur
SPM	Suspended Particulate Matter
STPs	Sewage Treatment Plants
SW	Solid Waste
SWM	Solid Waste Management
SWOT	Strength Weakness Opportunities and Threat
TC	Total Coliform
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solid
TEQ	Toxicity Equivalency Quantity
TERI	The Energy Research Institute
TGA	Thermo-Gravimetric Analyser
Th	Thalium
TIFAC	Technology Information, Forecasting and Assessment Council
TIFR	Tata Institute of Fundamental Research
Th	Thorium
ToC	Total Organic Carbon
TOWMCL	Timarpur - Okhla Waste Management Company Limited
TPD	Ton Per Day

TSDF	Treatment Storage and Disposal Facilities
TSPM	Total Suspended Particulate Matter
TSS	Total Suspended Solid
UP	Uttar Pradesh
UFPM	Ultra Fine Particulate Matter
UK	United Kingdom
ULBs	Urban Local Bodies
UN	United Nations
UNEP	United Nations Environment Programme
UNFCC	United Nations Framework Convention on Climate Change
US	United States
USA	United States of America
USD	United State Dollar
USDOE	United States Department of Energy
USEIA	United State Environmental Impact Assessment
USEPA	United State Environment Protection Agency
USFA	United State Fire Administration
V	Vanadium
VFA	Volatile Fatty Acid
VMCH	Vinyl Acetate - Maleic Acid - Vinyl Chloride
VOCs	Volatile Organic Compounds
W2E	Waste to Energy
WAWQI	Weight Arithmetic Water Quality Index
WHO	World Health Organization
WLO	Waste Lubricating Oil
WPs	Waste Pickers
WQI	Water Quality Index
WRI	Western Research Institute
WTE	Waste To Energy
YAP	Yamuna Action Plan
Zn	Zinc
$ZnCl_2$	Zinc Chloride

FOREWORD

It is my immense pleasure to introduce this valued and timely edition highlighting the concerns of solid waste and wastewater management, with special emphasis on the urban locale in the Indian context. *Albeit,* several publications are available dealing with an assortment of themes in solid waste management, the emphasis of those is largely on the issues and needs of industrialized nations. A very few books have been specifically authored to provide the nature of information that is vital for those in the developing countries.

I extend my heartiest congratulations to all the esteemed authors who have contributed their expertise to present the valuable information about the current crisis of solid waste in urban India, its policy framework and initiatives taken so far for its sustainable management. The book attempts to identify the lacunae in new initiatives embarked upon in terms of technologies, policies and regulations to alleviate the water and waste problem faced in the metropolitan cities of India. The book has an added flavor of practical solutions, discussed for professionals in India as well as other developing countries. The book has been primed for decision-makers, policy makers, researchers, academicians and professionals involved in the management of solid wastes, air pollution, river water and ground water quality.

I hope this book will prove to be a valuable and important source of information to provide remedial solutions to the ever increasing problem of waste and water management in India and other developing countries.

Dr. Rakesh Kumar
Director, CSIR- NEERI

PREFACE

The edited book, "**The Urban Environmental Crisis in India: New Initiatives in Safe Water and Waste Management"** by Cambridge Scholars Publishing is motivated by the urgency of furthering the adoption of safe water and waste management practices in India. The management of solid waste is a national crisis. The number of available landfills is decreasing, the health risks associated with waste incineration are of great concern and the growing public / NIMBY opposition to siting new waste management facilities is a growing problem especially for urban local authorities. There is need for policy intervention in an inclusive production-consumption- recovery pattern of waste management in India. The book tries to present a full picture of the state-of-the-art research and development of actionable knowledge discovery in new initiatives in safe water, waste management and applications. The inception of the book was triggered by applications of real-world challenges and complexities. Although there has already been a lot of documentation in this huge public services breakdown zone, there is no calling a halt to more information dissemination especially for validating business related use. There seems to be a gap between academia and businesses and between academic research and ground realities in the context of popularizing waste management. This book is an attempt to address the ubiquitous challenges and complexities from a real-world perspective. It features new methodological, technical and practical progress in promoting initiatives. It presents recent developments and discoveries in solid waste management practice and its associated risks of air, water and soil pollution to stimulate more research and to rapidly pass on such discoveries to the community. This is an up-to date collection of scientific contributions written by specialists in various areas of policy, waste management and safe water for both practitioners and for the research community.

The intended clients would likely be researchers, research students, policy makers, academia and decision makers. The book should also interest industry in working on sustainable development, solid waste management and related areas. It provides a coherent view of the state of the art and practice to enable developers and managers with technical and organizational approaches.

Dr. Tishyarakshit Chatterjee,
Director, IIPA, Former Secretary, M/o Environment & Forests, GoI

ACKNOWLEDGEMENT

This prestigious project of editing a book entitled **"The Urban Environmental Crisis in India: New Initiatives in Safe Water and Waste Management"** was successful due to assistance received and time devoted by many prestigious personalities. Words are inadequate to convey the appreciation for all the help provided by them. First, our sincere gratitude goes to the chapters' authors who contributed their time and expertise to this book. Without their support, this book would not have become a reality; which may prove to be a great asset to the community.

With token of responsibility, the editors are indebted to India Development Service (IDS) and University of Wisconsin Whitewater (UoWW), Chicago, USA for their valuable support.

Special thanks to Shri T. Chatterjee, Director, Indian Institute of Public Administration (IIPA) and to Dr. Rakesh Kumar, Director, CSIR-National Environmental Engineering Research Institute (CSIR- NEERI) for their incomparable guidance and support which inspired the pace of the project.

We are extremely grateful to the Administration Department, Finance & Accounts Department, Photocopy Department, and the Consumer Centre of IIPA and Indian Pollution Control Association (IPCA) for uniting the necessary facilities, and investing their time and efforts as and when required in the process of editing the book. We would like to extend our deep thanks to Dr. Lolita Pradhan, Research Officer at IPCA for her dedicated support and assistance in completing this project. We would also thank Mr. Ajay Garg, Secretary, IPCA for his constant motivation and support.

Editors' humble duty of acknowledging everyone would fail if we miss to thank the Cambridge Scholars Publishing Newcastle upon Tyne, United Kingdom without their support and assistance the book would not have seen the light of the day.

Last but not the least the Editors express their sincere and heartfelt thanks to the Almighty for providing them good health and peace of mind which facilitated in producing the edition. The editors sincerely pray and wish to the Divine for many more such endeavors.

Shyamli Singh, Radha Goyal and Ashish Jain

INTRODUCTION

At the dawn of the new millennium, 300 million Indians lived in the country's nearly 3700 towns and cities, in sharp contrast to only 60 million in 1947 when the country became independent. Estimates show that by 2045 nearly 800 million Indians will be living in the country's cities—more than the total population of the whole of present-day Europe. The mega cities are under severe stress, ranging from shambling infrastructure to depleting groundwater and unhygienic sanitary conditions.

This volatile state of affairs has not been satisfactorily appreciated at both national and international level. The book titled "**The Urban Environmental Crisis in India: New Initiatives in Safe Water and Waste Management"** examines the programs and policies espoused so far to remediate the situation, identifies the shortcomings, and looks into the new initiatives that have been undertaken to make the cities self-sustainable units of governance and reliable service providers.

The book cruises through different realms, starting from the need to revisit the existing policy framework. The sustainability prism of solid waste management is fractured and fragmented. Most of the times it has been realized that the policies related to the management of urban solid waste are understated, lack coherence and are not holistic. The policies appear to be more like ill –fitted pieces of the jigsaw puzzle. The book provides glimpses of the informal sector involved in solid waste management laying stress on the rag picker community. It compares reductionist analysis and further incorporates the system thinking development model in the informal sector. The system design approach seems to project that the natural and human designed systems are independent, but actually the two forms interact with each other enabling the franchise model within the biological physical and chemical boundaries.

The status of plastic waste generation and the disposal of the same has been further elaborated upon in the book. The generation of e-waste and the management of the same is emphasized. The chapter also explores the reasons of export of e-waste from developed countries to developing countries such as India and China, as well as the continent of Africa. The need for regularization of the informal sector in managing e-waste, discussion on the flow of e-waste through different niches, substantiating the legal framework and EPR is toured through. The trend of MSW

generation in the present context and the future trend of solid waste generation is explored, positioning emphasis on the concept of ISWM and detailing a comparative analysis of the stand-alone versus regional approach for the SWM facility. The book also tends to capture the various technological options for waste treatment *viz.* incineration composting, bio-methanation, gasification, pyrolysis, incineration, bio-ethanol production, and hydrogen energy to deal with ever mounting unsegregated waste in the megacities such as Mumbai. The special sectors of Paper & Pulp and Plastic recycling industries in India are accentuated upon in the book reflecting the ground reality of the recycling industry in India. The option for using MSW as a source of thermal energy generation is also explored in the book.

Another sector of the book deals with air pollution and related aspects in developing world. The chapters dedicated to air pollution deal with GHG implications of various waste management facilities in India. To achieve low carbon waste management, the ideal choice of technologies needs to be supported by upstream and downstream management strategies. Air pollution generating from solid waste management practices leading to public health crisis in urban India is also emphasized in the book. The book further maneuvers through ambient air quality assessment around the Okhla and Gazipur landfill site. The open-solid waste dumping sites in Delhi are a major source of bio aerosols and trace gases. Residents and garbage handling workers at the landfills are at high health risks. The recovery of landfill gasses also helps in strengthening India's efforts to hit the CO_2 emissions target set at the World forums on climate change. The impact of greenhouse gases and its source of emission with special emphasis on landfill proposing a very valuable and sustainable solution to capture excess carbon to reduce landfill carbon footprint is echoed in the book.

The book further widens its scope and covers the river water quality and the ground water and landfill leachate assessment evaluating physio-chemical and biological parameters.

AUTHORS' AFFILIATION

Dr. Shyamli Singh, Assistant Professor	Indian Institute of Public Administration, New Delhi
Dr. Sameer Prasad, Professor	University of Wisconsin–Whitewater (UWW), California, U.S.A.
Dr. Tara Mccloskey, Professor	George Washington University, Washington DC
Dr. Shantha Parthan, Professor	University of Canterbury, New Zealand
Dr. Jasmine Tata, Professor	Loyola University, Chicago
Dr. S.K Nigam, Additional Director	Central Pollution Control Board, New Delhi
Dr. A.B Akolkar, Member Secretary	Central Pollution Control Board, New Delhi
Er. Anuj Sinha, Chairman	Network of Organisations for Science and Technology Communication, Delhi and Member Secretary, Institute of Peace Research and Action, Delhi.
Dr. Seema Awasthi, Director	ICUC Consultants Pvt. Ltd, New Delhi
Dr. Satyawati Sharma, Professor	Centre for Rural Development and Technology, IIT Delhi, New Delhi
Dr. Kalpana Arora, Project Fellow,	Centre for Rural Development and Technology, IIT Delhi, New Delhi
Ms. Ritika Pathak, Research Scholar	Centre for Rural Development and Technology, IIT Delhi, New Delhi
Mr. Ashish Jain, Director	Indian Pollution Control Association, New Delhi
Ms Roshnimary Sebastian, Research Scholar	Department of Civil Engineering, IIT Delhi, New Delhi
Mr. Dinesh Kumar , Research Scholar	Department of Civil Engineering, IIT Delhi, New Delhi
Dr. Babu Alappat, Professor	Department of Civil Engineering, IIT Delhi, New Delhi
Dr. Ritu Paliwal, Senior Environmental Consultant	AECOM, Gurgoan, Haryana

Ms. Niharika Pandey, Research Scholar	Department of Civil Engineering, IIT Delhi, New Delhi
Dr. Arvind K. Nema, Professor	Department of Civil Engineering, IIT Delhi, New Delhi
Dr. Seema Mishra, Director	SIES Indian Institute of Environment Management, Nerul, Navi Mumbai, Maharashtra
Dr. Devayani Savant, Adjunct Professor	SIES Indian Institute of Environment Management, Nerul, Navi Mumbai, Maharashtra
Dr. C. Srinivas, Adjunct Professor	SIES Indian Institute of Environment Management, Nerul, Navi Mumbai, Maharashtra
Dr. Saumya Singh, Adjunct Professor	SIES Indian Institute of Environment Management, Nerul, Navi Mumbai, Maharashtra
Dr. Ruchira Ghosh, Research Scholar	Department of Energy and Environment, TERI University, New Delhi
Dr. Arun Kansal, Professor	Coca-Cola Department of Regional Water Studies, TERI University, New Delhi
Dr. Radha Goyal, Deputy Director	Indian Pollution Control Association, New Delhi
Dr. Papiya Mandal, Scientist	CSIR-National Environmental Engineering Research Institute, New Delhi
Dr. S. Agarwal, Scientist	CSIR-National Environmental Engineering Research Institute, New Delhi
Dr. Rahul Upadhyay, Water Resources and Environment Specialist	Freelance Consultant
Dr. M.K. Chaturvedi, Scientist	CSIR-National Environmental Engineering Research Institute, New Delhi
Mr. Pradeep Kumar Khandelwal, Chief Engineer	East Delhi Municipal Corporation, New Delhi
Dr. Venkatesh Dutta, Assistant Professor	Department of Environmental Science, Babasaheb Bhimrao Ambedkar University, Lucknow, Uttar Pradesh

Mr. Karunesh K. Shukla, Research Assistant	DST Centre for Policy Research, Babasaheb Bhimrao Ambedkar University, Lucknow, Uttar Pradesh
Mr. Alok Rai, Research Assistant	DST Centre for Policy Research, Babasaheb Bhimrao Ambedkar University, Lucknow, Uttar Pradesh
Ms. K. Archana, Research Scholar	Department of Environmental Science, Babasaheb Bhimrao Ambedkar University, Lucknow, Uttar Pradesh

CHAPTER ONE

URBAN WASTE MANAGEMENT IN INDIA: A REVISIT OF POLICIES

SHYAMLI SINGH

Introduction

The sustainable management of urban waste has become a major global concern. The sustainability index featured in the management of solid waste calls for innovative thinking, holistic practice and a revisit of policy and recommendations. The character of urban waste has been totally revamped in the past few decades giving it shades of inorganic waste. The burgeoning population leading to urbanization and changes in lifestyles have also contributed greatly to unsustainable disposal habits and individual consumption.

No policy document in India deals with the whole production-consumption-recovery pattern of waste. The sustainability prism of solid waste management is fractured and fragmented. Most of the time it has been realized that the policies related to the management of urban solid waste are understated, they lack coherence and are not holistic. The policies are more like ill–fitted pieces of a jigsaw puzzle. The lack of a sound policy and the gaps between policies lead to a call for a revisit of the existing policies. This revisit would facilitate the plugging of the loopholes and would pave the way for a new urban waste management policy which would be more equitable, sustainable and inclusive. This would in turn cater to the demands of the time and would help in facilitating a stage for the development of sustainable smart cities. *Albeit* the foundation for this has already been laid by the prognostic Solid Wastes Management Rules, 2016, which is drafted to replace the Municipal Solid Wastes (Management & Handling) Rules, 2000, there are a few glitches associated with it. The new Gazette of Solid Waste Rules overlooks the provision of incentives and the imposition of stricter penalties in case of non–adherence. The rules, by and large, are the re-packaging of centralized

treatment technologies. The newly drafted Solid Waste Rules send a clear message of pushing technology to the farthest edge. Unfortunately, this embrace of the technology has totally failed to address the issues of reuse, recycling and citizen-centred responses that lead to decentralized waste management.

This chapter aims to highlight the phases which are indispensable for the transition from a centralized to a decentralized waste management mechanism, to achieve a more viable, mainstream and inclusive strategy. This transition can be engineered through strategically planned revisits of existing plans and policies. The results and recommendations of the reconsideration would then act as an underpinning for optimized waste management practices. The chapter also focuses on alternative development models, which would help with the decline of waste generation. This also calls for a paradigm shift by the annexation of socially and politically motivated management plans. The entire gamut of activities ranging from the generation of waste to its collection, segregation, processing and treatment, and finally its disposal must be viewed through the lens of a cradle-to-cradle approach, yielding a new tangent to the various dimensions. The technology options for decentralized treatment should be starred as the unique selling point, and they will act to enable a better-programmed sustainability. A very important dimension that is the prerequisite for any sustainable waste management practice is a reduction in the generation of waste; this can be achieved by targeting consumer behavior and lifestyle management. The sources of waste generation and the approach to catering for the waste generated need a detailed plan of action. This chapter captures this area too and helps in suggesting ways and methods to educate the masses for responsible consumer behavior.

Waste Generation Trends in India

India, a developing country, is heading towards becoming a mass urban sprawl. The extension ranges from rural communities to urban agglomerations and urban centers. According to the United Nations' 1995 estimates, over 400 million people will be clustered in cities over the next three decades. Concerns about both quantity and quality are being linked to encircling the social facet to be in tandem with scientific and political tangents. Despite the snail's pace of its growth and economy, India still stands as the third largest of economies in terms of Purchasing Power Parity (PPP) (World Bank, 2012). It is observed that the non-organic nature of waste is slowly but surely making its way into urban life patterns