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Transforming Sanitation: Innovations in Faecal Sludge and Septage Management in India"

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Abstract

Access to safe sanitation services is essential for promoting the health and productivity of people in India. Poor sanitation significantly impacts health, and untreated sewage is a major contributor to water pollution. Conventional sanitation systems have serious drawbacks, including overuse of water resources, land and groundwater pollution, and inefficient use of wastewater components. To manage faecal sludge and septage effectively, a comprehensive strategy is needed, meeting minimum standards and being economically viable for all locations. Environmentally friendly sanitation methods offer a solution to this crisis. This paper examines the state of sanitation in Indian cities and proposes a roadmap for improving hygienic conditions and mitigating water, soil, and health-related issues.

Introduction:

Urbanization is a critical aspect of a nation's development, but in the case of India, it has been transforming existing cities in a haphazard and unplanned manner. With rapid economic growth over the past decades, many Asian countries have experienced an increase in their urban population. In India, around 30 percent of the population, accounting for about 340 million people, resides in urban centres.

Both industrialized and developing nations are witnessing the global phenomenon of urbanization. In search of better chances, services, and amenities like healthcare, employment, entertainment, and education, people move from rural areas to towns and cities, Urbanisation is essential for promoting development in social, economic, and cultural spheres of life. According to the 2011 census, India had 7,935 cities and towns with a total urban population of 377.5 million, constituting 31.16 percent of the nation's total population. The majority of the urban population is concentrated in Class-I towns with more than 100,000 inhabitants. According to projections, India's urban population is predicted to grow by 590 million by 2030,constituting around 40 percent of the total population. This period will also witness a significant increase in the working-age population, with 270 million Indians joining the workforce.

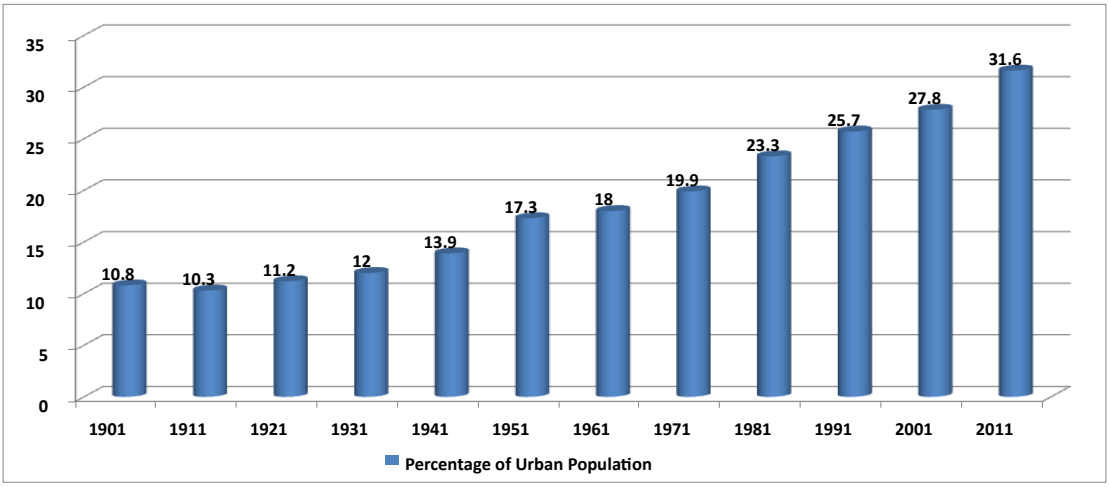
Urban centres are projected to witness robust job growth, increasing at around 3.6 percent annually, resulting in 220 million new jobs by 2030, compared to around 100 million at present.

About 70 percent of all new jobs created in India during the period from 2010 to 2030 are expected to be in cities.

In 2001, India had 35 cities with populations of one million or more, a considerable increase from 12 in 1981 and 23 in 1991. These 35 million-plus cities were home to 107.9 million urban residents. The 2011 census estimated that 377.1 million people lived in urban areas, or 31.6% of the total population of the nation..

With this rapid urbanization, there is a pressing need for well-planned and sustainable urban development to accommodate the growing urban population and harness the potential of cities as centres of economic and social progress. Proper urban planning and management are essential to tackle the challenges associated with urbanization and to ensure that cities become hubs of growth, prosperity, and improved quality of life for their residents.
(Chart 1).

Chart1*:* Trends in Urbanization in India



Source: Census, 2011

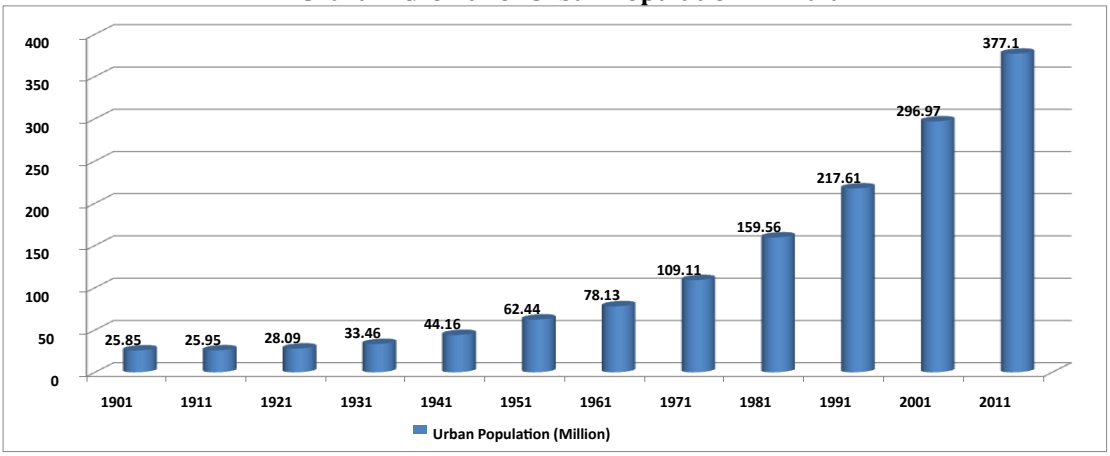
Urbanization plays a pivotal role in the growth and development of a nation. In India, more than 340 million people reside in metropolitan areas, accounting for approximately 30 percent of the country's total population (Chart 2). The trajectory of urbanization is set to accelerate, with India's urban population expected to grow by a staggering 590 million by 2030, constituting almost 40 percent of the nation's total population.

By 2030, India is poised to have the fastest-growing labour force globally, with an estimated 270 million individuals entering the workforce. This surge in the working-age population presents both opportunities and challenges for the country's economic development. Notably, job opportunities in cities are set to witness a remarkable rise, increasing from around 100 million today to 220 million in 2030, growing at an annual rate of 3.6 percent. Consequently, between 2010 and 2030, cities in India are projected to generate an impressive 70 percent of all new jobs in the country (McKinsey & Company, 2010).

This shift towards urbanization brings forth a critical need for well-planned and sustainable urban development strategies to accommodate the burgeoning urban population. Proper urban planning and management are essential to ensure that cities become centres of economic activity, innovation, and improved quality of life for their residents. Adequate infrastructure, access to essential services, and environmentally conscious practices are among the factors that need to be considered to make cities vibrant and conducive to growth.

It is crucial to solve the problems related to housing, transportation, waste management, and environmental sustainability as India experiences this fast urbanisation. Utilising urbanization's potential for inclusive growth, India can advance its socioeconomic development and improve the lives of millions of people. Moreover, leveraging the growing urban workforce and creating favourable conditions for economic opportunities will be instrumental in shaping India's future as a dynamic and thriving nation on the global stage.

Chart 2: Growth of Urban Population in India



Source: Census, 2011

Ministry of Urban Development, Government of India, launched Swachh Bharat Mission in October, 2014 with a view to eliminate open defecation and improving the sanitary conditions in urban areas. The Mission has been implemented in all statutory towns for the period of 2014 to 2019. The estimated cost of implementation of SBM (Urban) based on unit and per capita costs for its various components was Rs. 62,009 crore. The Government of India share as per approved funding pattern amounts to Rs. 14,623 crore. In addition, a minimum additional amount equivalent to 25 percent of Government funding, amounting to Rs. 4,874 crore shall be contributed by the States as State/ULB share.

Presently fund is available under AMRUT, Swachh Bharat Mission, Namami Gange and 14th Finance Commission for sanitation in urban centres in India. However, septage and faecal sludge management is covered under AMRUT. Sewerage connection is also been ensured under AMRUT and Namami Gange (Table 1).

Table 1: Budgetary Allocation for Sanitation in India (Rs. In Crore)

Scheme	Budget	Duration	Thematic Areas
Swachh Bharat Mission	62009	2014-19	Solid Waste Management, Sanitation, IEC and Capacity Building
AMRUT	50000	2014-19	Sewerage and Septage Management, Water Supply, Storm Water Drainage, Urban Transport, Capacity Building, Reforms and Development of Green Space and Parks
13th Finance Commission	87519	2010-15	Untied Grant for various sectors specially basic infrastructure services such as water supply, waste water, solid waste and storm water based on ULB preference
14th Finance Commission	87143	2015-20	

Source: Ministry of Housing and Urban Affairs, Government of India

Water, sanitation, and health are closely interconnected, especially in developing nations like India. Contaminated drinking water, improper excreta disposal, and poor hygiene practices contribute to the spread of various diseases, including among infants, leading to high infant mortality rates. Sanitation, which used to be solely associated with human waste removal, has evolved to encompass a broader concept, including food hygiene, personal and environmental sanitation, and waste disposal.

Sanitation plays a crucial role in human development and quality of life. It prevents soil and water contamination, ensuring better health. The expanded definition of sanitation now includes personal hygiene, clean water access, waste management, and excrement disposal. Historically, municipal governments have been responsible for providing basic amenities like water supply, sewage, sanitation, and solid waste disposal. State government departments, corporations, and boards handle these services. After the 74th Constitutional Amendment Act, Metropolitan Planning Committees and District Planning Committees were established to facilitate development at the regional level, giving urban local bodies (ULBs) greater responsibilities. Different states have responded differently to the postdecentralization scenario, with some advocating for the elimination of parastatals while others have redefined their functional roles. The 74th Amendment transferred administrative and financial functions to local organizations, empowering them to plan and execute development initiatives

Need for Septage and FSM:

In India, water, sanitation, and health are deeply interconnected, and the lack of proper sanitation infrastructure poses significant challenges to public health and environmental sustainability. Large cities in India have invested in expensive underground pipelines, pumping stations, and wastewater treatment facilities to manage sewage. However, small communities often lack access to centralized sewage systems due to insufficient infrastructure. The prevalence of onsite sanitation systems, such as pit latrines and septic tanks, remains high in urban areas.

The Swachh Bharat Mission, launched in 2014, aimed to address the lack of sanitation facilities in urban homes and eliminate open defecation. However, the focus primarily remained on onsite sanitation systems, with limited attention given to proper construction, maintenance, and safe disposal of faecal sludge and septage. Local installation practices for pit latrines and septic tanks vary significantly, and the lack of regulations and resources at the local level hinders effective management.

As a consequence of inadequate sanitation infrastructure, faecal sludge and septage disposal pose a significant risk to the environment and human health. The collection, treatment, and disposal of sewage sludge or septage are uncommon in Indian cities. The desludging process is often

manual and lacks proper safety measures for sanitation staff. Disposal of sludge is often done haphazardly, contributing to land and water degradation and health issues.

There is a pressing need for a comprehensive and feasible strategy to manage faecal sludge and septage in Indian towns and cities. The challenge lies in finding cost-effective and practical solutions that can be implemented in diverse communities with limited resources. Improved sludge management and ecosanitation practices are required to ensure a clean and healthy living environment.

The National Urban Sanitation Policy (NUSP) in India has shifted from a traditional centralized sewerage system to a holistic framework. However, clear instructions on septage management are lacking, and the enforcement of regulations remains inconsistent. The 2016 Solid Waste Management Rules allow for the recycling or composting of septage, but its implementation faces challenges.

To address these issues, there is a need for stronger coordination and capacity-building at the local level, enabling urban local bodies (ULBs) to effectively manage faecal sludge and septage. Investment in appropriate technology, infrastructure, and training for desludging services is essential. Moreover, public awareness campaigns and behavioural change programs can encourage the adoption of improved sanitation practices.

In conclusion, the management of faecal sludge and septage in India requires urgent attention to protect public health and the environment. The prevalence of onsite sanitation systems in urban areas and the lack of proper infrastructure and regulations pose significant challenges. Addressing this issue demands a multifaceted approach that involves investment in technology, capacity-building, and public awareness to ensure a clean and hygienic living environment for all.

Faecal Sludge Management:

Faecal sludge, a raw, partially digested, semi-solid slurry, is closely associated with black water, which includes human excreta from toilets. Faecal sludge and septage management (FSSM) is a systematic approach to create an environmentally safe and sustainable infrastructure for non-networked households' sanitation value chain. India's sanitation facilities can be broadly classified into networkbased systems, like piped sewerage, and on-site systems, including pit latrines and septic tanks. Only about one-third of the urban population is served by network-based systems, while the majority relies on on-site facilities. Unfortunately, many cities lack proper faecal sludge treatment facilities and suffer from issues like poorly maintained sewers, clogs, and inadequate preventive maintenance. Over 45 percent of urban Indian households depend on on-site facilities, and the management of faecal sludge and septage poses a significant challenge. Many urban local bodies lack the capacity and resources for proper regulation and maintenance of septic tanks and pit latrines, leading to inadequate desludging services and improper disposal of faecal sludge. This not only threatens the environment but also poses health risks. To address this issue effectively, a comprehensive and financially feasible plan is needed, taking into account the specific circumstances of each area.

The current administration's effort to make India Open Defecation-free (ODF) is commendable, considering that a significant portion of the population lacks access to toilets. According to the 2011 census, over half of India's population did not have access to a toilet, with rural households being more affected than urban households. Open defecation, septic tanks, pit latrines, and pit latrines contribute significantly to groundwater and surface water pollution in many cities.

Managing the sludge from human waste is one of the most challenging aspects of urban sanitation. In most Indian cities, there is a lack of adequate facilities and services for the collection, transportation, treatment, and disposal of faecal sludge. Faecal sludge, which includes sludge from on-site sanitation systems like septic tanks and pit latrines, requires appropriate disposal to mitigate its negative impacts.

Urban sanitation programs need to prioritize Faecal Sludge Management (FSM) and align the objectives of programs like AMRUT and SBM to achieve Open Defecation-free status in a more comprehensive manner. A separate faecal sludge disposal station should be established, and providing a dependable fee-based service for FSM at the urban local body (ULB) level should be a requirement for receiving funds under SBM.

The program should also encourage resource recovery and the development of local service providers through Public-Private Partnership (PPP) models. Proper training of staff in plumbing, septic tank and pit cleaning, and truck operation is essential before deploying them for related tasks.

In conclusion, to achieve ODF status effectively, it is crucial to address the management of faecal sludge and ensure its proper disposal. A concerted effort in the form of a well-planned program with strong incentives for resource recovery and the growth of local service providers can lead to significant improvements in urban sanitation in India. The current administration's initiative to make India Open Defecation-free (ODF) is commendable, given that a significant portion of the population lacks access to proper sanitation facilities. However, the treatment and disposal of sewage in an appropriate manner have not received adequate attention from urban local bodies. To address this issue effectively, several critical aspects need to be considered.

Firstly, there is a need to focus on selecting appropriate toilet designs and disseminating technologies suitable for tropical climates to treat sewage. Adequate infrastructure and capacities

within local municipal organizations must be developed to ensure effective sewage treatment and disposal.

Despite the increasing use of water closet flush toilets in India, only 19 percent of human waste is properly treated at treatment facilities. The majority of toilets are linked to septic tanks due to the lack of underground sewer connections to sewage treatment plants. However, many septic tanks do not adhere to the Bureau of Indian Standards' requirements and have issues like overflow, leading to contamination of drinking water with wastewater. The rise in water closet usage poses two new challenges: intensifying water scarcity in an already waterstressed region and contamination of surface water due to untreated sewage. If cost-effective technologies for effluent water purification are not widely adopted, India's water supply will face further deterioration.

Ecological sanitation can be a viable alternative to traditional methods. Inadequate safe and ecological sanitation has already resulted in health problems and severe contamination of water and soil resources in many cities. As India becomes more water-stressed, addressing these issues becomes even more crucial.

Efforts must be made to improve the treatment of faecal sludge in urban areas. The current situation is unsatisfactory, with limited facilities for safely emptying pits or desludging septic tanks. There is a lack of dedicated treatment facilities for faecal sludge, leading to untreated disposal in many cases.

The Swachh Bharat Mission (urban) and the Atal Mission for rejuvenation and urban transformation have made significant progress in the sanitation sector. However, there is a need to focus on inclusivity and equity in providing sanitation services, especially for underserved urban regions. Differentiation between price points and municipal financing subsidies should be considered to ensure equitable access to sanitation for all, including the urban poor.

To achieve effective and sustainable sanitation in India's cities, a comprehensive approach is required, considering appropriate technology, infrastructure development, capacity building, and social equity. Municipalities must actively involve underserved populations in decision-making and service delivery to ensure inclusivity and long-term success in achieving Open Defecation-free status.

The passage highlights the importance of protecting the rights and health of sanitation workers through the implementation of occupational health and safety regulations in cities. It also emphasizes the need for inclusive planning and strategies in the safe management of human waste for successful city-wide sanitation services. The Indian government's Swachh Bharat Mission, launched in 2014, aimed to accelerate universal sanitation implementation and promote investments in sanitation in both urban and rural areas.

With the construction of millions of individual household latrines, public restrooms, and communal toilets, as well as the elimination of open defecation in many cities, the Swachh Bharat Mission's efforts have resulted in substantial progress. State governments were urged to submit faecal sludge management plans under the AMRUT programme, which offered incentives for septage control. This stimulated the development of "safely managed sanitation" systems, particularly in urban areas. The efforts in India have resulted in the completion of numerous Faecal Sludge Treatment Plants (FSTPs), and more are planned for the future.

Furthermore, the passage mentions the creation of a comprehensive inclusive sanitation framework and checklist by the Inclusive Task Force under the NFSSM Alliance to guide city managers and local governments in promoting inclusive sanitation in their communities. This approach ensures that underserved and marginalized communities are given priority in the allocation of resources and decision-making processes, aligning with the Sustainable Development Goal of "Leaving no one behind."

Overall, the passage provides insights into India's efforts towards improved sanitation and the importance of inclusive strategies in addressing sanitation needs effectively. It highlights the progress made so far and the potential for further expansions in the future.

The sanitation system plays a crucial role in managing human waste from its production to final disposal. Among its responsibilities is transporting faecal sludge generated by on-site sanitation technologies to treatment or disposal facilities. Despite the importance of these tasks, they are often neglected. It is essential for a sanitation system to effectively empty and convey faecal sludge.

Improving the process of emptying feces and transporting sludge is vital to enhance safety and efficiency for sanitation workers, households, communities, and the environment. Various service providers are involved in offering these services, ranging from informal individuals and small businesses to official multinational enterprises. The diversity of on-site sanitation systems in terms of sophistication, accessibility, and billing methods contributes to the presence of a wide range of service providers in the vicinity.

There are two methods for emptying on-site sanitation equipment: manual emptying, which involves using a bucket or hand pump, and automated emptying, where a machine takes over using a motorized pump or vacuum vehicle. It's worth noting that the survey respondents providing these services were all male and employed in urban areas.

In conclusion, addressing the proper emptying and transportation of faecal sludge is essential for an

effective and safe sanitation system, and efforts should be made to improve these aspects for the benefit of all stakeholders involved.

The market offers a wide variety of vacuum trucks, each available in different sizes and configurations to serve specific functions. These trucks typically come with storage capacities ranging from 200 to 16,000 litters. Standard vacuum trucks have even larger capacities, capable of transporting up to 55,000 litters of liquid. Mechanical emptying, especially for large tanks, proves to be a fast and effective method for emptying on-site sanitation systems. This approach is significantly safer and better for the health of service providers, as they can avoid direct contact with the waste by using hoses and pumps to handle the task.

However, vacuum trucks do have some limitations due to their technical design. They are generally effective only up to a depth of two to three meters, and their parking proximity to the on-site sanitation technology should be within 25 meters, based on the pump's power. This restriction can pose challenges, particularly in unplanned and informal areas where large trucks may struggle to access narrow streets and poorly maintained roads.

India's efforts in faecal sludge management (FSM) have witnessed remarkable progress, spearheaded by the formulation of a national policy on FSSM in 2017. The government's unwavering commitment to addressing sanitation challenges is evident in the implementation of key initiatives such as the ODF+ and ODF++ protocols, which prioritize FSM in the Swachh Survekshan survey, and the allocation of financial resources for FSM under the AMRUT and NMCG missions. These initiatives have laid the foundation for a collaborative approach, involving various stakeholders, to drive positive change in FSM across the country.

One of the key contributors to the success of India's FSM initiatives is the collaborative involvement of multiple entities. The Ministry of Housing and Urban Affairs (MoHUA), state governments, urban local bodies (ULBs), the Central Public Health and Environmental Engineering Organization (CPHEEO), nongovernmental organizations (NGOs), academic institutions, and charitable organizations like the Bill and Melinda Gates Foundation (BMGF) have played pivotal roles in promoting FSM.

A notable achievement in India's FSM journey has been the establishment of Faecal Sludge Treatment Plants (FSTPs). With over 700 FSTPs constructed, 150 currently operational, and an additional 220 under construction, these facilities serve as critical components of the FSM infrastructure, ensuring safe treatment and disposal of faecal sludge.

Moreover, to ensure the sustainability and effectiveness of FSM, state-specific FSSM rules are being formulated in 19 out of 36 states and union territories. These regulatory frameworks delineate responsibilities between different entities at the state and local levels, fostering synergies between various FSM schemes, and guaranteeing the provision of affordable, suitable, and sustainable FSM services across the nation.

However, despite these commendable efforts, challenges persist in FSM implementation. One such challenge is the technical limitations of vacuum trucks, which are commonly used for transporting and emptying faecal sludge. Vacuum trucks are limited in their ability to reach depths greater than two to three meters, and their accessibility is often hindered by narrow streets and poor road conditions, particularly in unplanned and informal areas. Addressing these limitations is essential to ensuring comprehensive FSM coverage across all regions.

To overcome these challenges and protect the health and safety of FSM service providers, a multibarrier approach is employed. This approach encompasses several precautionary measures, such as the use of protective gear, proper ventilation, and safety ropes in confined spaces, ensuring a safe and hygienic working environment.

Furthermore, FSM service providers have benefited from the adoption of mechanical emptying methods, such as hand-held pumps. These methods enhance efficiency while minimizing direct contact with faecal sludge, thereby improving the health and safety of the workforce.

India's successful FSM journey is not only characterized by technological advancements but also by behaviour modification efforts. The Ministry of Housing and Urban Affairs, in collaboration with various states, has implemented coordinated activities to encourage behaviour change and foster the adoption of hygienic practices.

In addition to technological and behavioural interventions, financial investment has played a pivotal role in advancing FSM. The AMRUT and NMCG missions, along with state-specific allocations, have ensured that adequate funds are channelled into the development of FSM infrastructure and services.

Overall, India's progress in FSM serves as a beacon of hope for other nations facing similar sanitation challenges. The collaborative efforts of the government, stakeholders, and organizations have demonstrated that sustainable and inclusive FSM solutions are within reach, even with minimal budgeted investments. This progress aligns with the Sustainable Development Goal of "Leaving no one behind" and is a testament to India's commitment to providing sanitation for all..

Conclusion:

Sanitation is an essential aspect of human development, contributing to overall health, hygiene, and quality of life. In India, ensuring access to proper

sanitation facilities remains a significant challenge, particularly in urban areas. A lack of adequate sanitation not only leads to water-borne infections but also poses environmental and public health risks. The majority of the urban population in India relies on traditional individual septic tanks, and the sanitation conditions in many towns and cities are far from satisfactory. As a result, there is an urgent need to improve infrastructure and deliver essential urban services in slum areas, including water supply, access to toilets, drainage, and solid waste disposal. Moreover, providing affordable and adequate sanitary facilities to low-income urban residents is crucial for creating a healthier and more inclusive society.

The Critical Link Between Sanitation and the Environment:

The link between sanitation and the environment is inextricable. Inadequate sanitation facilities contribute to the prevalence of water-borne infections, leading to poor health conditions. The absence of proper sewage lines in many cities results in a low percentage of the urban population served by such infrastructure. Consequently, a significant portion of urban dwellers relies on individual septic tanks, increasing the need for proper infrastructure and service delivery in slum areas.

The Plight of Sanitation in Indian Cities:

Sanitation conditions in most Indian towns and cities remain dire. Lack of a comprehensive sewer network and ineffective sewage treatment plants exacerbate the issue. Open defecation becomes a reality for many slum inhabitants due to the lack of proper sanitation facilities. Managing faucal sludge is critical to prevent the spread of disease-causing organisms, including bacteria, viruses, protozoa, and helminths. Faecal sludge management involves emptying and transporting sludge from on-site sanitation systems to designated locations for treatment or disposal, such as pit latrines or septic tanks.

Challenges Faced by Sludge Operators:

Sludge operators play a vital role in the faecal sludge management process by emptying pit latrines and septic tanks when necessary. However, cleaning septic tanks is not typically carried out by local inhabitants, and sludge operators often encounter challenges when attempting to declog tanks. The costs associated with declogging can vary significantly from city to city. The responsibility of regulating sludge operators lies with both urban local bodies (ULBs) and private organizations. Sludge operators associated with ULBs offer services within their borders, while commercial operators extend their services outside their regions.

The Role of the Private Sector in Faecal Sludge Management:

Stimulating and scaling the participation of private sector firms in the FSSM (Faecal Sludge and Septage Management) value chain is essential to meet the growing demand for faecal sludge treatment. Involving the private sector has several advantages, including reduced workload for ULB staff, access to technical expertise, higher service standards, streamlined implementation processes, and innovative ideas. The FSSM value chain provides various opportunities for the private sector to contribute to faecal sludge management.
Private Sector Engagement in the FSSM Value Chain:
Urban local bodies (ULBs) can contract out activities in the FSSM value chain to private players. These activities include emptying faecal sludge from residential properties and delivering it to Faecal Sludge Treatment Plants (FSTPs). Private sector players can also take responsibility for the development and operations of FSTPs. Some ULBs even permit private players to combine treatment-related activities with conveyance-related operations.

Developing a Cohesive Ecosystem for Private Sector Participation:
To foster sustained private sector participation, a cohesive ecosystem is necessary. Various components need to be considered to encourage the private sector's involvement:
Showcasing Market Opportunities: Potential players from allied industries, such as solid waste management and liquid waste management, need to be made aware of the market opportunities in faecal sludge management.
Balanced Risk Sharing Mechanisms: Agreements between the state/city level bidding authority and concessionaires should include balanced risk-sharing mechanisms. Ensuring timely payments by the bidding authority is also critical.
Capacity Building and Training: Ensuring that private sector workers are educated about health, hygiene, and safety protocols is essential to improve the quality of services.
Encouraging Innovation: Incentivizing innovation and creative solutions can drive improvements in faecal sludge management practices.

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