



FROM WASTE TO RESOURCE

CO-COMPOSTING PRACTICES IN INDIA AND BANGLADESH





FROM WASTE TO RESOURCE

CO-COMPOSTING PRACTICES IN INDIA AND BANGLADESH

Author: Sumita Singhal

Research support: Anurag Naidu

Editor: Yashita Mishra

Cover and design: Ajit Bajaj

Layout: Kirpal Singh

Production: Rakesh Shrivastava and Gundhar Das

The Centre for Science and Environment is grateful to the Swedish International Development Cooperation Agency (Sida) for their institutional support

Gates Foundation

This report is based on research funded by the Gates Foundation. The findings and conclusions are those of the authors and do not necessarily reflect the positions or policies of the foundation



© 2026 Centre for Science and Environment

Maps in this report are indicative and not to scale

Material from this publication can be used, but with acknowledgement.

Citation: Sumita Singhal, *From waste to resource: Co-composting practices in India and Bangladesh*, Centre for Science and Environment, New Delhi

Published by
Centre for Science and Environment

41, Tughlakabad Institutional Area

New Delhi 110 062

Phones: 91-11-40616000

Fax: 91-11-29955879

E-mail: cse@cseindia.org

Website: www.cseindia.org

Contents

1. INTRODUCTION	7
2. WHY CO-COMPOST FAECAL SLUDGE BIOSOLIDS WITH MUNICIPAL SOLID WASTE?	8
3. PURPOSE OF THE STUDY	8
4. METHODOLOGY	9
5. REGULATORY FRAMEWORKS AND GUIDELINES	10
6. CASE STUDIES OF CO-COMPOSTING OF FAECAL SLUDGE WITH ORGANIC WASTE	11
Case study 1: Co-composting at Devanahalli FSTP, Bengaluru, Karnataka, India	11
Case study 2: Co-composting at Dhenkanal FSTP, Odisha, India	15
Case study 3: Co-composting at Periyanaickenpalayam FSTP, Coimbatore, Tamil Nadu, India	20
Case study 4: Co-composting at Sakhipur FSTP, Bangladesh	26
7. CONCLUSION AND ANALYSIS	30
ANNEXURE	32
REFERENCES	34

LIST OF FIGURES

Figure 1: Biosolids reuse practice in India	7
Figure 2: Windrow composting process flow diagram at Devanahalli FSTP	16
Figure 3: Windrow composting process flow diagram at Dhenkanal FSTP	20
Figure 4: Windrow composting process flow diagram at PNP FSTP	26
Figure 5: Windrow composting process flow diagram at Sakhipur FSTP	31

LIST OF TABLES

Table 1: Characteristics of tested co-compost at Devanahalli	18
Table 2: Characteristics of tested co-compost at Dhenkanal (as provided by FSMC)	23
Table 3: Characteristics of tested co-compost at PNP	28
Table 4: Characteristics of of tested co-compost at Sakhipur FSTP	32
Table 5: Comparative analysis of the co-composting at various sites	36

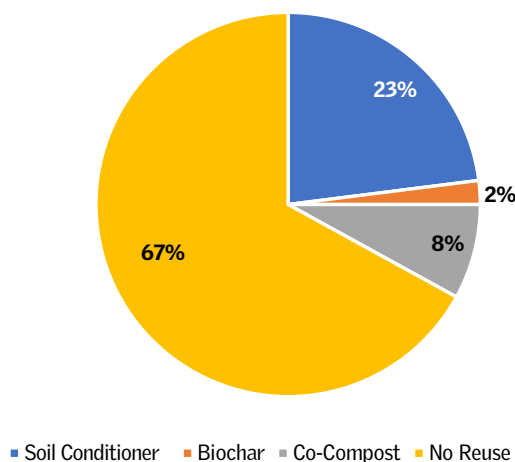
From Waste to Resource: Co-composting practices in India and Bangladesh

1. Introduction

Over the past decade, India has made significant progress in sanitation infrastructure through national missions such as the Swachh Bharat Mission (SBM), the Atal Mission for Rejuvenation and Urban Transformation (AMRUT), the Namami Gange Programme, and the Jal Jeevan Mission (JJM). These initiatives have expanded wastewater treatment capacity, yet a critical challenge remains—managing the growing volume of sludge and biosolids generated by treatment plants.

India has over 1,034 faecal sludge treatment plants (FSTPs)¹ producing approximately 250 tonnes of biosolids daily. However, only 33 per cent of these facilities reuse biosolids, and a mere 8 per cent use them for co-composting.² The rest often remain untreated or are disposed of improperly, posing environmental and health risks. Despite existing guidelines from the Ministry of Environment, Forest and Climate Change (MoEFCC) and the Central Pollution Control Board (CPCB), the absence of a comprehensive national policy on biosolids management and reuse standards for faecal sludge-derived biosolids leads to inconsistent practices across states. Additionally, public concerns about contamination, heavy metals, and high nitrogen levels hinder acceptance of biosolids reuse in agriculture.

Figure 1: Biosolids reuse practice in India



Source: CSE

This is a missed opportunity, as biosolids, when treated to Fertilizer Control Order (FCO) standards, can serve as a valuable agricultural resource, reducing reliance on chemical fertilizers. Co-composting—mixing biosolids with organic waste—can enhance compost quality as it can potentially balance the C:N ratio, improve soil health and promote a circular approach to waste management.

Recognizing these challenges, the Centre for Science and Environment (CSE) conducted a study titled “*Biosolids Quality Evaluation of Faecal Sludge-Based Biosolids and Co-Compost in India 2023.*” The study assessed biosolid quality from FSTPs and co-treatment sewage treatment plants (STPs) across seven Indian states. It highlights key concerns such as pathogen presence and heavy metal presence while exploring opportunities for resource recovery and reuse.³

Building on this research, the current study documents case studies of co-composting of faecal sludge derived biosolids and organic waste practices in India and Bangladesh to analyze existing practices, approaches, economics and suitability for reuse.

2. Why co-compost faecal sludge biosolids with municipal solid waste?

Co-composting faecal sludge (FS) and municipal solid waste (MSW) is advantageous because the two materials complement each other. The human waste is relatively high in nitrogen (N) content and moisture and the MSW is relatively high in organic carbon (OC) content and has good bulking quality. Furthermore, both these waste materials can be converted into a useful product. High temperatures attained in the composting process are effective in inactivating excreted pathogens contained in the FS and will convert both wastes into a hygienically safe soil conditioner-cum-fertilizer.⁴

3. Purpose of the study

This study aims to document case studies of co-composting practices across different ULBs to understand existing practices, approaches, economics and suitability for reuse. Additionally, it seeks to develop practical guidance for management of the faecal sludge derived biosolids through co-composting, which is a huge problem in the existing faecal sludge treatment facilities due to absence of any guidance.

The study is limited to document co-composting case studies to understand the current reuse practices and compare it in terms of various parameters.

4. Methodology

This study adopts a qualitative research design to assess co-composting practices in India and Bangladesh. A case study approach was chosen to document existing practices, challenges and opportunities in biosolid management.

The four case studies were selected through secondary research based on various factors to ensure a comprehensive understanding of co-composting practices across different regions and climatic conditions. Geographical diversity was considered to capture regional variations in waste management approaches. Climatic conditions were evaluated for their influence on composting efficiency, as temperature and humidity impact microbial activity and decomposition rates. The selection also focused on predominant approaches and processes, ensuring that commonly practiced co-composting methods in each region were studied. Additionally, current reuse practices were evaluated to understand how biosolids and co-compost are utilized post-treatment. The quality and efficiency of the process were assessed based on treatment effectiveness and compliance with standards, such as the Fertilizer Control Order (FCO). Lastly, success in the region was considered by examining factors such as adoption rates, scalability and community acceptance of co-composting initiatives.

Primary data was gathered through field visits, interviews and stakeholder consultations with regional partners (CDD India, IIHS, FSMC and Water Aid Bangladesh), local farmers, treatment plant operators and composting facility managers. Secondary data was obtained from published and shared reports by alliance partners, similar work done in other organizations, on-call consultation with research organizations in the selected regions and policy guidelines on biosolid management and co-composting.

Field observations were analyzed against various key parameters, such as type of co-composting process practiced, area required, size of the beds, material required, ratio, quantity generated, operational challenges, regulatory barriers and market demand for co-compost. Quantitative data, i.e., quality of co-compost where the tests were carried out by the respective stakeholders and such shared results were used to compare against FCO standards to assess compliance and effectiveness.

Finally, each of the selected cases were documented and compared in terms of climate, area requirement, process, material requirement and its proportion, time for maturation, quality compliance, and CapEx, OpEx and reuse options.

5. Regulatory frameworks and guidelines

India currently lacks specific, widely recognized standards for biosolids derived from faecal sludge, leading to uncertainties in quality control and safe agricultural application. While existing policies address aspects of sludge management, none comprehensively define biosolid standards similar to global benchmarks, such as the United States Environmental Protection Agency (EPA) Class A biosolids criteria. The National Faecal Sludge and Septage Management Policy (2017), issued by the Ministry of Housing and Urban Affairs, provides a broad framework for faecal sludge management, building on earlier documents like the Advisory Note on Septage Management in Urban India (2013) and the Primer on Faecal Sludge and Septage Management (2016). However, while it acknowledges reuse possibilities, it lacks detailed operational standards for biosolids derived from faecal sludge. Similarly, the Solid Waste Management Rules, 2016, issued by the Ministry of Environment, Forest and Climate Change, offer a regulatory framework for organic waste management, encouraging the co-processing of organic waste with sewage sludge to produce compost. However, they do not explicitly classify faecal sludge or biosolids, creating regulatory ambiguity regarding their reuse.⁵

Another key guideline, the CPHEEO Manual on Sewerage and Sewage Treatment (2013), provides technical recommendations for septage treatment and reuse. It prescribes that biosolids intended for agricultural application should meet EPA Class A standards through processes such as lime stabilization, solar drying or composting. Despite this recommendation, there is no national enforcement mechanism to ensure compliance with these standards.⁶ Regulatory bodies such as the Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) oversee wastewater treatment and sludge management, offering technical guidance on composting and treatment processes. Yet, there are no mandatory quality standards specifically for biosolids. The Fertilizer Control Order (FCO) under the Essential Commodities Act, 1955, sets quality standards for compost and co-compost products, ensuring that the final product is safe for agricultural use. In the absence of dedicated biosolid regulations, the FCO standards remain the primary benchmark for assessing the quality of co-compost derived from faecal sludge.⁷

Despite these existing policies, the absence of a specific biosolids classification and regulatory enforcement mechanism presents a key challenge. Current frameworks refer to co-composting and organic waste management, but do not comprehensively define acceptable pathogen reduction levels, maximum allowable contaminant levels or standardized treatment processes for ensuring safe reuse.

Given these gaps, it is essential to evaluate different co-composting methods to identify approaches that align with FCO standards and ensure safe agricultural application.

The following sections will explore case studies highlighting treatment processes, quality assessments and regulatory compliance of co-composting practices in India and Bangladesh.

6. Case studies of co-composting of faecal sludge with organic waste

Case study 1: Co-composting at Devanahalli FSTP, Bengaluru, Karnataka, India

Devanahalli is a town located in the Bangalore rural district, situated about 35 kilometers to the north of Bangalore city. It has a population of approximately 33,000 people, with around 6,400 households spread across an area of 16 square kilometers. The town lies within a dry agro-climatic zone, characterized by a semi-arid to arid climate.

The FSTP in Devanahalli has a treatment capacity of 6 kiloliters per day (KLD). The FSTP has been funded by the Bill and Melinda Gates Foundation. CDD India is the implementing agency for the project, with additional support from BORDA (Bremen Overseas Research and Development Association) and the Town Municipal Council (TMC) of Devanahalli.

The co-composting of biosolids project was initiated in 2016, primarily driven by the need to manage and utilize waste effectively. In 2018, the pilot demonstration was conducted for agronomic performance of using faecal sludge in agriculture, and in 2019, a capacity-building activities were carried out on safe reuse practices for faecal sludge application. The key stakeholders in the project's inception included local authorities, with the plant's operations being managed by the Devanahalli

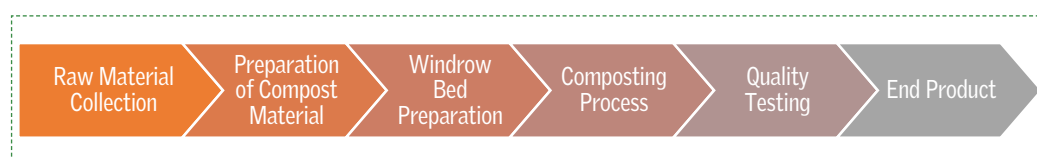
KEY HIGHLIGHTS OF THE PROJECTS

- Type of process: Windrow composting
- Feedstock/raw material used: Faecal sludge and organic solid waste
- Ratio of biosolids to organic waste: 1:2
- Area required for co-composting: 0.25 acre
- Number of windrow beds: 10
- Size of the beds: 8 x 4 x 6ft
- Turning frequency: Every 15 days
- Maturity period/process time: 75–80 days
- Quantity of co-compost produced: 2.5- 3.0 T/Month

Town Municipality, farmer's organization, NGOs and institutes. The project's funding was sourced from TMC funds, with no additional government grants or subsidies involved in the financial support. This initiative aimed to demonstrate Devanahalli as a model sanitation town through integrated waste management by managing both municipal wet waste and faecal sludge.

Flow diagram

Figure 2: Windrow composting process flow diagram at Devanahalli FSTP



Source: CSE

Windrow composting procedure

Raw material collection

Organic wet waste is collected from households, hotels and markets of the town, and the treated faecal sludge from the FSTP is used in the co-composting process. The raw materials are mixed in the ratio of 1:2, i.e., one part biosolids to two parts organic waste.

Pile formation phase

Before preparing the bed, the solid waste is properly segregated to ensure that no plastics or other hard substances are present. The wet waste and treated biosolids are then separately processed through a shredder machine.

Layering for bed formation is carried out by using the organic waste and treated biosolids in an alternate order.

The dimension of the windrow bed is 8 feet x 4 feet x 6 feet. The pile is arranged in a sandwich manner, with the 6 feet height divided into three to four equal layers. Each layer consists of organic waste overlaid with bio-solids. There are ten beds in total, and the quantity of co-compost generated is about 2.5–3 tonnes per month.⁸

Decomposition phase

It takes around 30–35 days for the compost to decompose. Each pile is turned upside down every 15 days during the entire decomposition phase, with close monitoring of moisture and temperature. To maintain the moisture content and

temperature, water is sprinkled on the beds. During decomposition, the peak temperature should reach up to 65–70°C, at which pathogens are deactivated.

Maturation phase and final product

It takes around 75–80 days for the co-compost to mature. Once the co-compost is matured, it is turned and mixed well. Then, it is sent for grinding and sieving. Finally, the sieved compost is stored in a storage room in the facility.



Process of sludge drying and its conversion into co-compost

Image credit: CSE

Quality assurance

Details of the sample

Name: TMC Devanahalli, Bangalore, Karnataka

Number of samples: 1

Date of sample: 08/02/2024

Date of analysis: 15/02/2024

Date of report: 15/02/2024

Table 1: Characteristics of tested co-compost at Devanahalli

Parameter	Sample (F wet waste compost)	FCO standards (2023)
pH	7.95	6.0–8.5
Color	Black	-
Conductivity (as dsm-1) not more than	5.39	4.0 (FCO, 2013)
Particle size after passing through 4 mm IS sieve	Passes	Passes
Moisture per cent by weight, maximum	13.59	<25
Total Organic Carbon per cent by weight, minimum	50.17	14
Total Nitrogen (as N) per cent by weight, minimum	2.09	0.5
Total Phosphates (as P2O5) per cent by weight, minimum	2.21	0.5
Total Potash (as K2O) per cent by weight, minimum	0.42	0.5
Arsenic (as As2O3) (as mg/kg), maximum	-	10
Cadmium (as mg/kg), maximum	1.8	5
Chromium (as mg/kg), maximum	34.55	50
Copper (as mg/kg), maximum	351.14	300
Mercury (as mg/kg), maximum	-	0.15
Nickel (as mg/kg), maximum	44.96	50
Lead (as mg/kg), maximum	47.71	100
Zinc (as mg/kg), maximum	1660.17	1000
Odor	No foul odor	-
Bulk density (g/cm ³)	0.72	<1
C:N ratio	24	<20
Pathogen	-	Nil

Source: As provided by CDD

The table (see *Table 1*) provides a detailed physico-chemical analysis of co-compost sample: F wet waste compost (F meaning faecal). The sample has a pH of 7.95, which is ideal for compost application. The black color indicates proper decomposition, and the sample passes the 4 mm sieve, ensuring a fine texture. The moisture content is within the acceptable limit (13.59 per cent). The total organic carbon meets the Fertilizer Control Order (FCO) requirement of 14 per cent, with a value of 50.17 per cent. This indicates good organic content, which is beneficial for soil health and microbial activity. The total nitrogen, and phosphorus levels indicate nutrient availability for plants, although the sample shows a lower potash value than the prescribed limit.

The sample exhibits no foul odor, indicating proper decomposition. The bulk density (0.72 cm³) ensures good soil aeration and water retention. The carbon-to-nitrogen (C:N) ratio should ideally be <20 for composting, but the sample exceeds this criterion (24). It shows that the sample has less nitrogen to maintain C:N ratio.

In terms of heavy metals, all the heavy metal content is within the FCO, 2023 prescribed range, except for Zinc and Copper, which exceed the prescribed limits. The values for Arsenic and mercury were not available for the sample tested.

O&M requirements

The operation and maintenance (O&M) requirements for the composting facility involve regular maintenance of the machinery and other equipment, with activities conducted every three months to ensure smooth operation. In terms of staffing, the facility has a team of four members to manage composting operations. The monthly O&M costs for the project include expenses for human resources, electricity and the transportation of materials, which is about Rs 2 lakh per month, including the cost of operating the FSTP.

Market demand and revenue model

The demand for the co-compost product remains low, primarily due to a lack of awareness and information. Other contributing factors include logistical challenges, concerns about quality, economic viability and societal hesitation. The project's revenue model relies on direct sales, with co-compost priced at Rs 7 per kilogram, generating around Rs 15,000 in monthly revenue. However, as the initiative is still in its pilot phase, it has yet to achieve profitability. While the collection is relatively low against the production, the Integrated Waste Management (IWM) approach offers additional benefits, such as reducing the need for extra land and minimizing separate operational expenses.

CASE STUDY 2: Co-composting at Dhenkanal FSTP, Odisha, India

Dhenkanal is a town and municipality located in the Dhenkanal district of Odisha, India. It has a population of approximately 68,000 people, with around 13,600 households spread across an area of 30.92 square kilometers. The town experiences a tropical wet and dry climate.

The FSTP in Dhenkanal has a capacity of 27 kiloliters per day (KLD). The project is funded by the Bill and Melinda Gates Foundation, with Practical Action and

CDD India serving as the implementing agencies. Several organizations provide additional support, including BORDA, CPR, Practical Action, CDD India and the Orissa State Volunteers and Social Workers Association (OSVSWA).

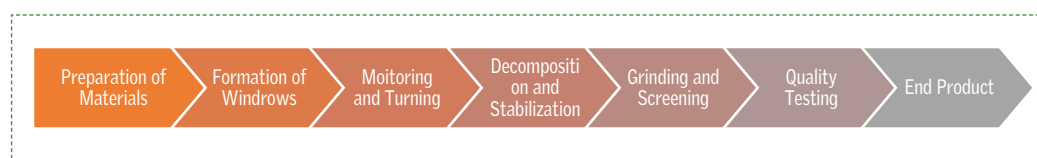
The Dhenkanal FSTP co-composting project was initiated in 2021. The project is supported by the Dhenkanal Municipality under the Housing and Urban Development Department, Government of Odisha. The initiative seeks to repurpose biosolids, which were previously stored or used for landfilling, addressing space constraints and growing demand. The Finish Services Management Company (FSMC) does the operations, provides technical support and quality assurance at FSTP. The project is part of the Finish Mondial Project, funded by WASTE in the Netherlands, without any government subsidy or grant.

KEY HIGHLIGHTS OF THE PROJECTS

- Type of process: Windrow composting
- Feedstock/raw material used: Biosolids and organic waste
- Ratio of biosolid to organic waste: 1:4
- Area of the plant: 1.5 acres
- Number of windrow beds: 4
- Turning frequency: Every seven days
- Maturity period/process time: 45–55 days
- Quantity of co-compost produced: 0.5–1T/month

Flow diagram

Figure 3: Windrow composting process flow diagram at Dhenkanal FSTP



Source: CSE

Windrow composting procedure

Raw material

The organic waste is collected from households in the town, and the treated biosolid is transported from Dhenkanal FSTP to the co-composting centers situated 1–1.5 km away. At the center, the organic waste is segregated, and the treated biosolids are further shredded separately.

Pile formation phase

Windrow beds are formed using shredded biosolids and organic waste placed alternately in a 1:4 ratio. The dimensions of each windrow are 3 ft in length, 5 ft in width and 4 ft in height. The pile is arranged in a sandwich manner, with the 4-ft height divided into three equal sized layers (approximately 1.33 ft each). Each layer comprises of organic waste overlaid with bio-solids. There are four beds in total, and the quantity of raw material used is 1,200 kg of organic (wet) waste and 300 kg of biosolids per bed.

Decomposition phase

It takes about 30–35 days for the pile to decompose. Each pile is turned upside down every seven days during the entire decomposition phase, with close monitoring of moisture and temperature. Moisture and temperature are monitored twice daily—in the morning and afternoon. During decomposition, the peak temperature should reach up to 65–70°C. After the peak temperature is achieved, it will begin to decline, and once it falls to 35°C, the decomposition phase is complete.

Maturation phase

After decomposition, the co-compost is kept in a heap for at least 10–15 days for pathogen removal, with close monitoring of temperature and moisture.

Final product

After grinding for five to seven days and then sieving, the final product is packed. It is then sold by the Dhenkanal municipality to line departments such as Forest, Agriculture and Horticulture. A sample is also sent for quality testing.



Raw Faecal Sludge



Dried Faecal Sludge



Segregated organic waste



Co-composting in Windrow method



Final Product

Process of sludge drying and its conversion into co-compost at Dhenkanal

Image credit: CSE



Final co-compost for sale in Dhenkanal

Image credit: CSE

Quality assurance

The co-compost is tested by the Odisha University of Agriculture and Technology to check its quality compliance in accordance with FCO standards. The tests ensure the quality of the compost, assessing factors such as its impact on soil quality and the ideal application rate for various crops.

Details of the sample

Name: FINISH SERVICES MANAGEMENT COMPANY PRIVATE LIMITED

Number of samples: 1

Date of sample: 10/09/2022

Date of analysis: 17/09/2022

Date of report: 17/09/2022

Table 2: Characteristics of tested co-compost at Dhenkanal as provided by FSMC)

Parameter	Sample (F wet waste compost)	FCO standards (2023)
pH	6.40	6.0-8.5
Color	Black	-
Conductivity (as dsm-1) not more than	-	4.0 (FCO, 2013)
Particle size after passing through 4mm IS sieve	-	Passes
Moisture per cent by weight, maximum	36.97	<25
Total Organic Carbon per cent by weight, minimum	22.0	14

Total Nitrogen (as N) per cent by weight, minimum	1.19	0.5
Total Phosphates (as P2O5) per cent by weight, minimum	0.92	0.5
Total Potash (as K2O) per cent by weight, minimum	0.37	0.5
Arsenic (as As2O3) (as mg/kg), maximum	-	10
Cadmium (as mg/kg), maximum	-	5
Chromium (as mg/kg), maximum	-	50
Copper (as mg/kg), maximum	-	300
Mercury (as mg/kg), maximum	-	0.15
Nickel (as mg/kg), maximum	-	50
Lead (as mg/kg), maximum	-	100
Zinc (as mg/kg), maximum	-	1000
Odor	No foul odor	-
Bulk density (g/cm ³)	0.79	<1
C:N ratio	18.5	<20
Pathogen	-	Nil
Faecal coliforms	900	1000 MPN per gram total dry solids (USEPA Class A biosolids)
<i>E. coli</i>	240	1000 per gram total dry solids (WHO, 2006)
<i>Salmonella</i>	Absent	3 MPN per 4 grams of total dry solids (USEPA Class A biosolids)
Helminth eggs	19	< 1 egg per 4 grams of total dry solids (USEPA Class A biosolids)

Source: CSE

The test report from the Dhenkanal FSTP evaluates multiple sludge and co-compost samples from Finish Services Management Company, Odisha using the Fertilizer Control Order (FCO) 1985 method. The co-compost sample has a moisture content of 36.9 per cent, exceeding the FCO limit of ≤ 25 per cent, which may affect its stability and usability. It meets the nitrogen (1.19 per cent), phosphorus (0.98 per cent), and organic carbon (22 per cent) standards but falls slightly short on potassium (0.37 per cent vs. the required ≥ 0.4 per cent). It has a C: N ratio of 18.5, which meets the standards of < 20 .

The test reports for heavy metals are unavailable and therefore could not be interpreted. However, the microbiological reports show the presence of faecal coliform (900 MPN/g), *E. coli* (240 MPN/g) and *Salmonella* (absent), all of which meet USEPA and WHO standards. Helminth eggs (19 eggs/g), however, exceed

the limits set by USEPA for class A biosolids, necessitating further treatment of the sludge or improvements in the current process of co-composting.

O&M requirements

The O&M requirements for the composting facility include regular maintenance of the machinery and other equipment. The monthly O&M costs for the facility—covering expenses for human resources, electricity, lab testing, capacity building, equipment/PPE kits, and miscellaneous items—amount to about Rs 3.1 lakh per month overall, including the FSTP.

Market demand and revenue model

The co-compost is primarily sold to government line departments, such as Forestry and Horticulture, at Rs 20 per kg. In the fiscal year 2023–2024, six tonnes of co-compost were sold, generating Rs 1,20,000. The municipality shares 40 per cent of the revenue with FSMC. The project is currently not profitable, operating at a loss with monthly costs exceeding revenue, and it is still in the validation stage to increase product uptake and market acceptance.⁹

CASE STUDY 3: Co-composting at Periyanaickenpalayam FSTP, Coimbatore, Tamil Nadu, India

Periyanaickenpalayam is an industrial city and a suburb of Coimbatore, located in the Indian state of Tamil Nadu. The entire population of Periyanaickenpalayam and Narasimmanaikenpalayam is around 29,830 and approximately 8,903 households. The city experiences a tropical wet and dry (Savanna) climate.

The FSTP in Periyanaickenpalayam has a treatment capacity of 50 kiloliters per day (KLD). The plant has been operational since October 2019. A 25 KLD capacity plant was constructed in 2019, and an additional 25 KLD plant was constructed in 2022. The first phase of the project (25 KLD) was supported by the Bill and Melinda Gates Foundation, while the second 25 KLD phase was funded by the urban local body (ULB). The plant was managed by TNUSSP for the first two years and was later taken over by the ULB. The Government of Tamil Nadu and the Indian Institute for Human Settlements (IIHS) provide technical support to ensure effective sanitation management and infrastructure development in the city.

In the initial period following construction, the Periyanaicken Palayam FSTP was a clustered FSTP. The clustering included all ULBs located within a 10–12 km radius of the treatment facility for ease of operation. In this case, Periyanaicken

Palayam (PNP) serves as the host ULB, with four additional ULBs included as cluster ULBs to serve their population.

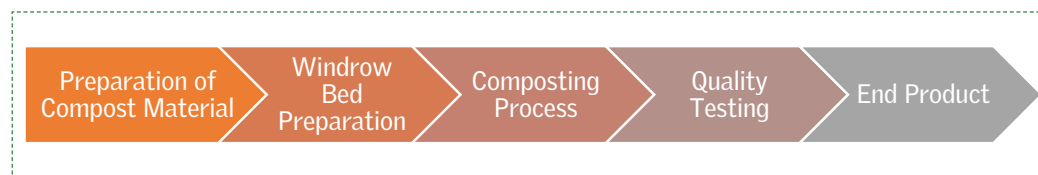
PNP co-composting facility is located in the Resource Recovery Park of PNP and the facility handles about 400 kg of organic waste daily. The project is part of Tamil Nadu's Sanitation Mission (Muzhu Sugadhara Tamizhagam), supported by the Bill and Melinda Gates Foundation (BMGF) through the Tamil Nadu Urban Sanitation Support Programme (TNUSSP), under the Department of Municipal Administration and Water Supply (MAWS).

KEY HIGHLIGHTS OF THE PROJECTS

- Type of process: Windrow composting
- Feedstock/raw material used: Dried faecal sludge and organic municipal solid waste
- Ratio of sludge to other materials: 1:3
- Area of the plant: 4,675 sq.m (1.16 acres)
- Number of windrow beds: 45
- Turning frequency: Every seven days
- Maturity period/process time: 45–60 days
- Quantity of co-compost produced: 6T/Month (200kg/day)

Flow diagram

Figure 4: Windrow composting process flow diagram at PNP FSTP



Source: CSE

Windrow composting procedure

Raw material

Organic waste from hotels and markets, along with the treated faecal sludge, is used for the process of co-composting. The raw materials are mixed in a ratio of 1:3, i.e., one part biosolids to three parts organic waste.

Pile formation phase

Before preparing the bed, the solid waste is properly segregated to ensure that no plastics or other hard substances present. It is further processed through the

shredder machine along with dried sludge. Both materials are layered alternately in a sandwich manner.

The dimensions of the windrow bed are 8 feet x 4 feet x 5 feet. The 5 feet height of the pile is divided into three to four equal layers. Each layer comprises organic waste overlaid with biosolids. The quantity of co-compost generated is approximately 6 tonnes per month.

Decomposition phase

It takes around 30 days for co-compost to decompose. Each pile is turned upside down after every 15 days during the entire decomposition phase, with close monitoring of moisture and temperature. To maintain the moisture content and temperature, water is sprinkled on the beds. During decomposition phase, the peak temperature should reach up to 65–70°C, where pathogens are deactivated.

Maturation phase and final product

It takes around 45–60 days for co-compost to mature. Once the co-compost is matured, it is turned and mixed well. It is further sent for grinding and sieving. The sieved co-compost is then stored in a storage room in the facility.



Solar drying and windrow beds



Co-composting process at PNP plant in Coimbatore
Image credit: CSE

Quality assurance

The co-compost was tested by multiple agencies, including Tamil Nadu Agriculture University (TNAU) and other agencies. Initial tests showed that the compost met Fertilizer Control Order (FCO) norms and was free of helminth eggs.

Table 3: Characteristics of tested co-compost at PNP

Parameter	Sample (F wet waste compost)	FCO standards (2023)
pH	6.8	6.0-8.5
Color	Dark brown	-
Conductivity (as dsm-1) not more than	6.88	4.0 (FCO, 2013)
Particle size after passing through 4mm IS sieve	96% material pass through 4.0mm IS sieve	Passes
Moisture percent by weight, maximum	3.32	<25
Total Organic Carbon percent by weight, minimum	11.42	14
Total Nitrogen (as N) percent by weight, minimum	1.41	0.5
Total Phosphates (as P2O5) percent by weight, minimum	4.04	0.5

Parameter	Sample (F wet waste compost)	FCO standards (2023)
Total Potash (as K ₂ O) percent by weight, minimum	0.001	0.5
Arsenic (as As ₂ O ₃) (as mg/kg), maximum	-	10
Cadmium (as mg/kg), maximum	3.44	5
Chromium (as mg/kg), maximum	41.48	50
Copper (as mg/kg), maximum	196	300
Mercury (as mg/kg), maximum	-	0.15
Nickel (as mg/kg), maximum	22.81	50
Lead (as mg/kg), maximum	55.4	100
Zinc (as mg/kg), maximum	1462	1000
Odor	Foul odor	-
Bulk Density (g/cm ³)	0.68	<1
C:N ratio	8	<20
Pathogen		Nil
Fecal coliforms	47 MPN/g	1000 MPN per gram total dry solids (USEPA Class A biosolids)
<i>E. coli</i>	47/g	1000 per gram total dry solids (WHO, 2006)
<i>Salmonella</i>	682385 MPN/4g	3 MPN per 4 grams of total dry solids (USEPA Class A biosolids)
Helminth eggs	-	< 1 egg per 4 grams of total dry solids (USEPA Class A biosolids)

Pathogens	CSE March 2022	CSE May 2022	CSE July 2022
Fecal coliforms	10 MPN/g	372 MPN/g	47 MPN/g
Salmonella spp.	52 MPN/4g	2068 MPN/4g	682385 MPN/4g
<i>E. coli</i>	3/g	3/g	47/g
Helminth eggs	<1/g	<1/g	

Source: CSE

The above test results provide an analysis of its physicochemical and microbiological properties analyzed by using FCO 1985 methods. The pH (6.80) falls within the acceptable 6.0–8.5 range, and the bulk density (0.68 g/cm³) meets the requirement of ≤ 1 g/cm³, ensuring good porosity. The moisture content (3.32 per cent) is well below the 25 per cent limit, which is beneficial for storage and handling. However, the electrical conductivity (6.88 dS/m) is significantly higher than the FCO limit of ≤ 4 dS/m, indicating excess salts that could affect plant growth. The co-compost emits a foul odor, suggesting incomplete decomposition or poor aeration. While the total nitrogen (1.41 per cent) and phosphates (4.04 per cent) meet the required

limits, the organic carbon (11.42 per cent) is slightly below the 14 per cent minimum, and the C:N ratio (8:1) is much lower than the recommended range of 20:1, indicating that the co-compost has not fully matured. Additionally, the total potash content (0.001 per cent) is far below the required 0.5 per cent, making the co-compost deficient in this essential nutrient.

Regarding heavy metals, the levels of cadmium (3.44 mg/kg), chromium (41.48 mg/kg), copper (196 mg/kg), nickel (22.81 mg/kg), lead (55.4 mg/kg) are all within permissible limits, ensuring that the co-compost is safe for agricultural use in terms of metal toxicity. Zinc (1462 mg/kg) values exceed the specified limits of 1000 mg/kg maximum.

However, the microbiological results raise significant concerns. While faecal coliform levels remain within the acceptable range (47 MPN/g), the presence of Salmonella in (682385 MPN/4g) makes the co-compost highly unsafe to be used in crops which are consumed directly or unprocessed. Additionally, presence of E. coli in July 2022 (47/g) exceeds safety limits, further confirming the pathogen risk. The Helminth egg count is within acceptable limits.

In summary, while the co-compost meets major FCO requirements for pH, nitrogen, phosphorus, moisture, and heavy metal safety, issues with high conductivity, foul odor, low organic carbon, a low C:N ratio, severe potassium deficiency, and the presence of pathogens (Salmonella and E. coli) make it non-compliant for safe agricultural use, especially for food crops that are consumed directly or unprocessed. To improve quality, measures such as reducing salinity, enhancing carbon content and adjusting aeration for better stabilization are necessary. Additionally, longer composting periods, heat treatment or lime stabilization should be implemented to eliminate pathogens before the co-compost can be safely applied to crops.

O&M requirements

The O&M requirements for the composting facility include routine maintenance of machinery and equipment, carried out quarterly to ensure efficient operations. The facility is staffed by a team of six, with two members dedicated to the segregation of organic waste and the remaining four responsible for managing the composting process. The monthly O&M expenses, which cover costs for human resources (HR), electricity and material transportation, amount to approximately Rs 1.4 lakhs per month, including the FSTP. These costs are shared among five surrounding ULBs.

Market demand and revenue model

The co-compost produced contributes to the circular economy and is sold to farmers and households. It also meets internal needs of the treatment plants. Field trials conducted by TNAU demonstrated significant agricultural benefits, suggesting strong market potential for co-compost. Currently, the regular co-compost is priced at Rs 3 per kilogram, while vermi-compost is sold at Rs 10 per kilogram. On average, monthly co-compost sales amount to Rs 18,000.

CASE STUDY 4: Co-composting at Sakhipur FSTP, Bangladesh

Sakhipur is a town located in the Tangail District of Bangladesh, with a population of approximately 33,940 people and around 6,800 households. The town covers an area of 13.7 square kilometers and experiences a sub-tropical climate, characterized by hot, humid summers, a distinct monsoon season and mild winters.

The FSTP in Sakhipur has a capacity of 5 kiloliters per day (KLD). The project is funded by WaterAid Bangladesh, with potential support from international donors. The implementation is overseen by the Sakhipur Municipality, with additional support from the Local Government Engineering Department (LGED) and technical guidance from non-governmental organizations such as Practical Action Bangladesh.¹⁰

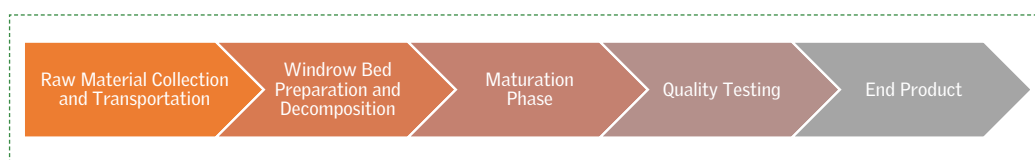
The Sakhipur FSTP is capable of handling 5 KLD and integrates organic waste treatment to produce co-compost.

KEY HIGHLIGHTS OF THE PROJECTS

- Type of process: Windrow composting
- Feedstock/raw material used: Organic waste, dried sludge and saw dust
- Ratio of organic waste to biosolid to saw dust: 3:1:1
- Area of the plant: 0.3 acres
- Turning frequency: 7-10 days
- Maturity period/process time: 56-60 days
- Quantity of co-compost produced: 2T/Month

Flow diagram

Figure 5: Windrow composting process flow diagram at Sakhipur FSTP



Source: CSE

Raw material

Households in Sakhipur primarily use on-site sanitation systems like septic tanks and pit latrines. When these systems fill up, the sludge is collected using vacuum tankers. The municipality operates this service four days a week, collecting approximately 16,000 to 20,000 liters of faecal sludge weekly. Solid waste is collected from households and markets, focusing on organic materials suitable for co-composting.

Pile formation and decomposition phase

Organic waste (three parts) is mixed with biosolid (one part) and saw dust (one part) in a 3:1:1 ratio to achieve an optimal carbon-to-nitrogen balance, which is essential for effective co-composting.

Layers of biosolid, organic waste and sawdust are arranged in a sandwich form to prepare the windrow beds. Sawdust is added to maintain 60 per cent moisture in the mixture. During composting, a temperature of 50–60°C is maintained.

The windrows are turned regularly to maintain oxygen levels, and water is added as needed to maintain appropriate moisture content, promoting microbial activity. During the eight weeks of composting, the moisture content reduces from 55–60 per cent to 25–30 per cent, and drops to 20–25 per cent during the maturation process.¹¹

Maturation phase and final product

After the decomposition phase, the material is left to mature, allowing further stabilization and pathogen reduction. The entire process takes around eight weeks (56 days).

The co-compost is screened through a sieve to produce final co-compost.

The finished compost is tested to ensure it meets quality standards of Bangladesh and is free from pathogens.

The co-compost is then utilized by local farmers as a soil conditioner, enhancing soil fertility and structure.

Quality assurance

Table 4: Characteristics of tested co-compost at Sakhipur FSTP

Parameter	Observed value	Bangladesh standards
Color	Dark grey	Dark grey to black
Physical condition	Non-granular form	Non-granular form
Odor	Absence of foul odor	Absence of foul odor
Moisture (%)	15.05%	15.0–20.0%
pH	7.8	6.0–8.5
Organic Carbon (%)	16.50%	10.0–25.0%
Total Nitrogen (%)	0.83%	0.5–4.0%
C:N ratio	19.88:1	Maximum 20:1
Phosphorus (P) (%)	0.89%	0.5–3.0%
Potassium (K) (%)	1.14%	0.5–3.0%
Sulphur (SO ₄ -S) (%)	0.48%	0.1–0.5%
Zinc (Zn) (%)	0.047%	Maximum 0.10%
Copper (Cu) (%)	0.01%	Maximum 0.05%
Lead (Pb) (ppm)	0.33 ppm	Maximum 30.00 ppm
Cadmium (Cd) (ppm)	2.84 ppm	Maximum 5.00 ppm
Chromium (Cr) (ppm)	11.33 ppm	Maximum 50.00 ppm
Nickel (Ni) (ppm)	6.64 ppm	Maximum 30.00 ppm

Source: WaterAid Bangladesh

The co-compost sample analysis shows that it meets all Bangladesh government standards, making it suitable for agricultural use. The sample has a dark grey color, non-granular form, and no foul odor, indicating proper decomposition and stabilization. The moisture content (15.05 per cent) falls within the required 15–20 per cent range, ensuring good co-compost quality. The pH (7.8) is well within the acceptable range of 6.0–8.5, making it suitable for soil application. The organic carbon content (16.5 per cent) meets the 10–25 per cent requirement, ensuring adequate organic matter for soil enrichment. The total nitrogen (0.83 per cent), phosphorus (0.89 per cent) and potassium (1.14 per cent) all fall within the required limits, indicating that the co-compost provides essential nutrients for plant growth. Additionally, the C:N ratio (19.88:1) is close to the upper limit of 20:1, confirming a well-balanced decomposition process.

The sample also meets the heavy metal limits as specified in the standards. The levels of zinc (0.047 per cent), copper (0.01 per cent), lead (0.33 ppm), cadmium (2.84 ppm), chromium (11.33 ppm) and nickel (6.64 ppm) are all within permissible limits, ensuring the co-compost is safe for agricultural application. The presence of sulphur (0.48 per cent) is also within the acceptable range of 0.1–0.5 per cent.

The pathogen analysis data is not available to find out the presence of pathogens in the co-compost.

Overall, the available results shows that the co-compost is fully compliant with the government standards and is safe for soil application without requiring any modifications. However, regular monitoring is recommended to maintain quality and ensure continued compliance. This co-compost is well-suited for agricultural use, providing essential nutrients while being free from hazardous contaminants.

O&M requirements

The monthly O&M expenses, which include costs for HR, electricity and material transportation, total around Rs 17.3 lakh per month, including the operations of the FSTP. Operation of the co-composting plant is labor-intensive—with a plant supervisor, two solid waste segregators and three personnel working with the Vacutug. Solid waste sorting is the costliest activity, accounting for around 30 per cent of the total operation and maintenance cost.

Market demand and revenue model

The plant can produce 24 tonnes of co-compost annually by processing 1,200 tonnes of faecal sludge and 125 tonnes of solid waste. The co-compost generated is sold to farmers, with the current price set at Rs 10 per kg. Co-compost is available in five package sizes— 1 kg, 3 kg, 5 kg and 50 kg. On average, monthly sales of co-compost reach about Rs 5 lakhs.



Sakhipur FSTP windrow pits for co-composting



*Sakhi Compost: The end product produced at the Sakhipur co-compost plant
Image credits: CSE*

7. Conclusion and analysis

India has over 1,034 FSTPs, generating approximately 250 tonnes of biosolids daily, of which only 33 per cent is reused, while the remaining 67 per cent is either stockpiled within treatment facilities or disposed of in open areas. This study highlights co-composting as a viable reuse strategy in India and Bangladesh, demonstrating its potential for effective waste management, resource recovery and integration into the circular economy. A comparative analysis of case studies provides insights into various aspects, including capacity, quality, quantity, composting methods, input proportions and maturation time.

In India, co-composting is still at the pilot stage, primarily utilizing windrow composting, a method well-suited for urban areas with organized waste collection systems. Depending on availability of area, this process is either carried out within the treatment facility or at a separate site, each with its own set of advantages and limitations. Devanahalli, Periyanaickenpalayam (PNP) and Sakhipur exemplify integrated waste management systems that optimize costs by eliminating the need for additional infrastructure, whereas Dhenkanal presents a financially viable model. Strengthening such initiatives and ensuring the stability of existing facilities will require robust governmental support. Following table (see *Table 5*) highlights a comparative analysis of all the above-mentioned case studies.

Table 5: Comparative analysis of the co-composting at various sites

Parameter	Devanahalli, Karnataka	Dhenkanal, Odisha	PNP Coimbatore, Tamil Nadu	Sakhipur, Bangladesh
Plant capacity	6 KLD	27 KLD	50 KLD	5 KLD
Climate	Semi-arid, dry zone	Tropical wet and dry	Tropical wet and dry	Sub-tropical
Co-composting process	Windrow composting	Windrow composting	Windrow composting	Windrow composting
Raw material mix ratio	1:2 (treated biosolids: organic waste)	1:4 (treated biosolids: organic waste)	1:3 (treated biosolids: organic waste)	1:3:1 (treated biosolids: organic waste: sawdust)
Area requirement	0.25 acres	1.5 acres	1.16 acres	0.3 acres
Turning frequency	Every 15 days	Every 7 days	Every 7 days	Every 7-10 days
Maturity period	75-80 days	45-55 days	45-60 days	56-60 days
Quantity of co-compost produced	2.5-3 T/month	0.5-1T/month	6T/month	2T/month
CapEx (funding source)	TMC, Bill & Melinda Gates Foundation	Finish Mondial Project, WASTE Netherlands	TNUSSP, BMGF	WaterAid Bangladesh
OpEx (monthly costs incl FSTP)	Rs 2 lakh	Rs 3.1 lakh	Rs 1.4 lakh	Rs 17.3 lakh
Market demand & revenue model	Farmers, Rs 7/kg, Rs 15,000/month revenue	Government departments, Rs 20/kg, Rs 1.2 lakh/year revenue	Farmers & households, Rs 3/kg co-compost, Rs 10/kg vermi-compost, Rs 18,000/month revenue	Farmers, Rs 10/kg, Rs 5 lakh/year revenue

Source: CSE

Currently, all co-composting plants in India evaluate their co-compost against Fertilizer Control Order (FCO) standards, operating with mixing ratios ranging from 1:2 to 1:4. While each plant meets certain FCO parameters, some challenges persist, such as an elevated C:N ratio at Devanahalli, pathogen presence at PNP, and low potassium content at Dhenkanal. If treated to comply fully with FCO standards, co-compost could be widely applied in agriculture and other land-based activities.

From an economic perspective, all plants are trying to commercialize their co-compost. The Sakhipur facility in Bangladesh demonstrates strong financial efficiency, generating an annual revenue of approximately Rs 5 lakh, largely due to government-supported standards. Meanwhile, Dhenkanal, with a revenue of Rs 1.2 lakh per month, demonstrating benefits from packaged co-compost sales and third-party operations. While revenue generation is promising, its long-term sustainability still remains a big question.

Although these plants have set a mark as best practices in the market, co-composting plants continue to face common challenges, such as regulatory inconsistencies and varying quality standards hinders large-scale adoption and farmer hesitancy to use co-compost limits financial viability. Additionally, low awareness about the product restricts market expansion, and its relatively higher cost compared to conventional alternatives poses further commercialization difficulties. Addressing these challenges through policy support, quality assurance and market awareness initiatives can help unlock the full potential of co-composting in sustainable waste management.

To effectively address these challenges and promote and scale co-composting initiatives, establishing robust policies and national standards is crucial for driving adoption from the macro to the micro level. Enhancing market mechanisms through government procurement, farmer incentives and awareness campaigns can help create demand and improve financial viability. Capacity-building efforts, including targeted training programmes for ULBs, plant operators and farmers, ensure the optimization of composting techniques and safe handling practices. Additionally, financial incentives such as sustainable business models or dedicated funding mechanisms must be explored to reduce operational costs and enhance profitability, making co-composting a viable long-term solution.

Annexure

Fertilizer Control Order (FCO) standards, India

Parameters	Organic compost (FCO 2009)	Phosphate-rich organic manure (FCO 2013)	Organic manure (FCO 2023)
Arsenic (mg/Kg)	10	10	10
Cadmium (mg/Kg)	5	5	5
Chromium (mg/Kg)	50	50	50
Copper (mg/Kg)	300	300	300
Lead (mg/Kg)	100	100	100
Mercury (mg/Kg)	0.15	0.15	0.15
Nickel (mg/Kg)	50	50	50
Zinc (mg/Kg)	1000	1000	1000
C/N ratio	<20	Less than 20:1	<20
pH	6.5-7.5	(1:5 solution) maximum 6.7	6.0-8.5
Moisture, percent by weight, maximum	15.0-25.0	25	Max 25
Bulk density (g/cm ³)	<1.0	Less than 1.6	<1.0
Total Organic Carbon, percent by weight, minimum	12	7.9	14
Total Nitrogen (as N), percent by weight, minimum	0.8	0.4	0.5
Total Phosphate (as P ₂ O ₅) percent by weight, minimum	0.4	10.4	0.5
Total Potassium (as K ₂ O), percent by weight, minimum	0.4	-	0.5
Color	Dark brown to black	-	-
Odor	Absence of foul odor	-	-
Particle size	Minimum 90% material should pass through 4.0 mm IS sieve	Minimum 90% material should pass through 4.0 mm IS sieve	Minimum 90% material should pass through 4.0 mm IS sieve
Pathogen	-	-	Nil

*Compost (final product) exceeding the above stated concentration limits shall not be used for food crops. However, it may be utilized for purposes other than growing food crops.

Standards for compost in Bangladesh

Parameter	Government standard limit
Color	Dark grey to black
Physical condition	Non granular form
Odor	Absence of foul odor
Moisture (%)	15.0–20.0%
pH	6.0–8.5
Organic Carbon (%)	10.0–25.0%
Total Nitrogen (%)	0.5–4.0%
C:N ratio	Maximum 20:1
Phosphorus (P) (%)	0.5–3.0%
Potassium (K) (%)	0.5–3.0%
Sulphur (SO ₄ -S) (%)	0.1–0.5%
Zinc (Zn) (%)	Maximum 0.10%
Copper (Cu) (%)	Maximum 0.05%
Lead (Pb) (ppm)	Maximum 30.00 ppm
Cadmium (Cd) (ppm)	Maximum 5.00 ppm
Chromium (Cr) (ppm)	Maximum 50.00 ppm
Nickel (Ni) (ppm)	Maximum 30.00 ppm

References

- 1 Swachh Bharat Mission Urban Dashboard, 2025. Available at <https://sbmurban.org/>, as accessed on 29 December, 2025
- 2 Sunita Narain, Vinod Vijayan and others, 2023. *Biosolids - Quality Evaluation Of Faecal Sludge based Biosolids And Co-Compost In India To Ascertain Their Reuse And Resource Recovery Potential*, Centre for Science and Environment, New Delhi. Available at <https://www.cseindia.org/biosolids-11713>, as accessed on 29 December, 2025
- 3 Ibid
- 4 Iftekhhar Enayetullah and A.H.Md.Maqsood Sinha, 2013. *Co-Composting of Municipal Solid Waste and Faecal Sludge for Agriculture in Kushtia Municipality, Bangladesh*, Session 42: UNESCAP Special Session: Decentralized and Integrated Resource Recovery Centres in Developing Countries ISWA World Congress, Vienna. Available at https://www.unescap.org/sites/default/files/Co-Composting%20Kushtia_Waste%20Concern.pdf, as accessed on 29 December, 2025
- 5 Neha Agarwal, Ambarish Karunanithi and Anju Dwivedi, 2020. *Reuse and Recycling of Faecal Sludge-derived Biosolids in Agriculture*, Centre for Policy Research, New Delhi. Available at <https://cprindia.org/wp-content/uploads/2021/12/Reuse-and-Recycling-of-Faecal-Sludge-derived-Biosolids-in-Agriculture.pdf>, as accessed on 29 December, 2025
- 6 Ibid
- 7 Ibid
- 8 Gagana Shamanna, Girija Ramakrishna, and Rohini J, 2022. Findings from Co-Composting Operations at a Faecal Sludge Treatment Plant (FSTP), Devanahalli, India. Available at <chrome-extension://efaidnbmninnipcegjpcglecfindmkaj/https://cddindia.org/wp-content/uploads/2017/10/Findings-from-Co-Composting-Operations-FSTP-Devanahalli.pdf>, as accessed on 29 December, 2025
- 9 Sumita Singhal and Ravi K, 2023. *Waste to wealth: Challenges India needs to overcome to use biosolids for improving soil health, meeting SDGs*, Down to Earth. Available at <https://www.downtoearth.org.in/waste/waste-to-wealth-challenges-india-needs-to-overcome-to-use-biosolids-for-improving-soil-health-meeting-sdgs-91934>, as accessed on 29 December, 2025
- 10 Anon, 2019. *Faecal Sludge Management Landscape in South Asia – Case studies*, WaterAid. Available at <https://washmatters.wateraid.org/sites/g/files/jkxooof256/files/faecal-sludge-management-landscape-in-south-asia-case-studies.pdf>, as accessed on 29 December, 2025
- 11 Md. Ashiquzzaman Pavel, 2024. *The Sakhipur Faecal Sludge Treatment Plant (Co-Compost Plant): A Model for Sustainable Faecal Sludge Management in Bangladesh*, 7th International Conference on Civil Engineering for Sustainable Development (ICCESD 2024), Bangladesh. Available at http://www.iccesd.com/proc_2024/Papers/228.pdf, as accessed on 29 December, 2025



Centre for Science and Environment

41, Tughlakabad Institutional Area, New Delhi 110 062

Phone: 91-11-40616000 Fax: 91-11-29955879

E-mail: cse@cseindia.org Website: www.cseindia.org