GUIDANCE NOTE

Reuse and Recycling of Faecal Sludge-derived Biosolids in Agriculture

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ACRONYMS

AMRUT	Atal Mission for Rejuvenation and Urban Transformation
EPA	Environmental Protection Agency
FS&S	Faecal Sludge and Septage
FSM	Faecal Sludge Management
FSTP	Faecal Sludge Treatment Plant
OSS	On-Site Sanitation
SBM	Swachh Bharat Mission
WHO	World Health Organization

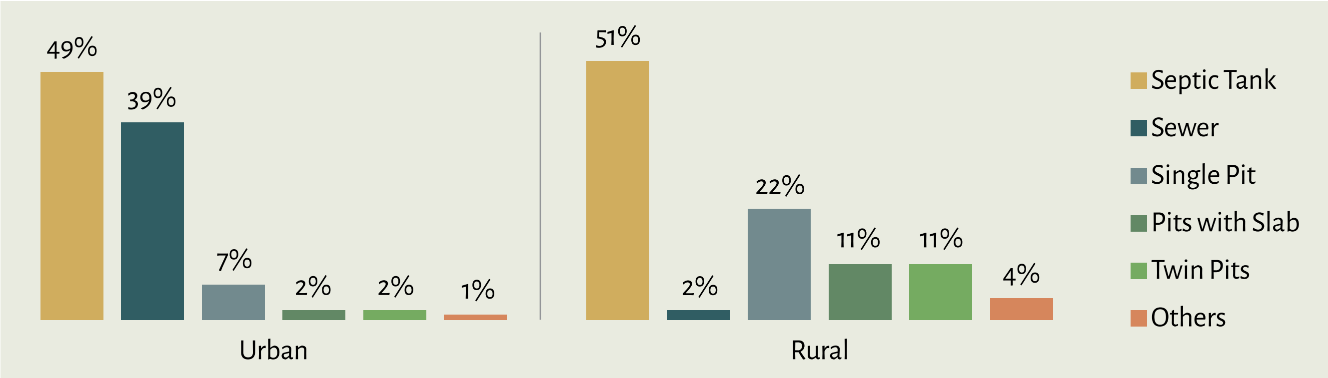
Recycling of wastewater treatment by-products valorised in policy, but national regulations lag behind

The launch of the Swachh Bharat Mission in 2014 reinvigorated the national sanitation priorities, brining them unprecedented attention. Over its five years, the programme expanded its focus from the construction of toilet facilities to also incorporate concerns of wastewater management. In one of its most critical interventions, the government took note of the entrenched reliance on on-site sanitation facilities like septic tanks and pits (Figure 1) and issued the National Policy of Faecal Sludge and Septage Management in 2017. Consequently, alongside the augmentation of centralized sewerage systems in Class I cities, the Policy in combination with schemes like the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and Swachh Bharat Mission (SBM) spurred action toward Faecal Sludge Management (FSM) through the creation of standalone faecal sludge and septage treatment plants (FSTPs). As per the latest estimates, more than four hundred FSTPs are in various stages of completion across the country. With 'circular economy' emerging as a lever to drive sustainable consumption and the protection of land and water resources globally, the recycling of end-products from these plants – treated wastewater and biosolids – has also been valorised domestically.

Wastewater, while being pathogenic (Table 1), is rich in nutrients like nitrogen and phosphorous, and organic matter. The recycling of both the treatment end-products - treated wastewater and biosolids - in agriculture enhances crop yields, reduces the burden of synthetic fertilizers, mitigates risks posed by water scarcity, and brings down the costs of production, thereby boosting farmer incomes (WHO, 2006a). Where farmers have been aware of these benefits, informal markets have flourished, allowing cesspool operators and small-scale farmers in city peripheries and peri-urban areas to establish linkages (Biome Environmental Trust, 2018; Kvarnström et al., 2012). In fact, according to WHO, 10% of the world's population consumes foods produced on lands irrigated with wastewater.

Nonetheless, its use in agriculture cannot be allowed to continue unregulated for the safety of the farmers – who are at the highest risk of infections, surrounding communities, and the households consuming the produce (Fuhrimann et al., 2014; WHO, 2006b). Balancing the benefits that accrue from its recycling with the risks it poses to public health, therefore, emerges as an imperative for regulatory and policy guidance (Fuhrimann et al., 2014). Such an

Figure 1 Types of wastewater management systems at the household-level (Source: NSS 76th Round)



initiative is not only directly aligned with Goal 6 – Clean Water and Sanitation, but also relates to the Sustainable Development Goals 2030: Goal 2 – Zero Hunger, Goal 3 – Good Health and Well-being and Goal 12 – Responsible Consumption and Production.

The 2017 amendment to the Environment (Protection) Rules, 1986, in revising standards for the effluent from sewage treatment plants, also promoted its recycling. As per the Rules, 'reuse/recycling of treated effluent shall be encouraged and in cases where part of the treated effluent is reused and recycled involving the possibility of human contact, standards, as specified above, shall apply', and further, 'these standards shall be applicable for discharge into water bodies as well as for land disposal/applications'. Despite clarity in regulation and benchmarks set through tools like the Open Defecation Free (ODF) Water Plus framework and state-level policies on FSM and wastewater recycling, cities reuse only a negligible of water (Niti Aayog, 2018). On the other hand, the regulatory lacuna still existing concerning biosolids can deter local action in accessing opportunities for resource recovery and recycling formally.

This guidance note, reviewing international biosolids regulations, is intended as an aid for policymakers and regulators at the national and state level in developing a biosolids utilization standard, which is easy to interpret and implement, promotes their scientific and safe reuse in agriculture, and ensures the protection of the health of the users, the local communities, the consumers, and the environment at large. The Note is concerned with faecal-sludge derived biosolids, although may also refer to those from sewage treatment where the two have been discussed jointly in the relevant documents.

Table 1 Commonly-occurring pathogens in wastewater and their survival time in different environmental media (Carr, 2001)

Organism	Pathogen survival (time in days unless otherwise indicated)			
	Freshwater	Saltwater	Soil	Crops
Viruses	11–304	11–871	6–180	0.4–25
Salmonellae	<10	<10	15–100	5–50
Cholera	30	285	<20	<5
Faecal coliforms	<10	<6	<100	<50
Protozoan cysts	176	1yr	75	ND
Ascaris eggs	1.5yr*	2*	1–2 yr	<60
Tapeworm eggs	63*	168*	7 months	<60
Trematodes	30-180	<2	<1*	130**

ND No data; * Not considered an important transmission pathway; ** Aquatic macrophytes
Note: Differing survival times for each organism (or group of organisms) may be related to temperature.

Approaches to regulation vary from country to country underpinned by a uniform set of guiding principles

India: A dedicated regulatory framework for faecal sludge-derived biosolids absent

The Swachha Bharat Mission invigorated the national agenda on sanitation and in the five years since its inception in 2014, central and state governments have rallied to eliminate open defecation through the construction of toilet facilities. Owing to the limitations of the centralized sewerage network, an increase in dependence on on-site sanitation (OSS) systems has been concomitant to the rapid gains in access to individual toilets. In recognition of this continuing dependence on OSS, the Ministry of Housing and Urban Affairs promulgated the National Policy on Faecal Sludge and Septage Management in 2017. The policy itself was preceded by supporting documentation such as the Advisory Note: Septage Management in Urban India, 2013, and the Primer on Faecal Sludge and Septage Management, 2016. These documents, alongside the Manual on Sewerage and Sewage Treatment Systems, 2013, published by the Central Public Health and Environmental Engineering Organization (CPHEEO), discuss the issue of biosolids recycling in agriculture.

Manual on Sewerage and Sewage Treatment Systems, 2013

The Manual considers three main recycling applications for biosolids, (i) as a material for immobilized bricks (suitable only for chemically precipitated sludge which is fully dried before its use for non-load bearing paver blocks),(ii) as a soil filler, and (iii) as a fuel. While decreeing that sludge must be dewatered to a solids content of 35 per cent or higher before being transported, it also sets out the type of processing the sludge has undergone as the basis for recommending management options. In doing so, it comments on crop restriction and on-farm biosolids application methods as risk management measures (Table 2). It is only in the context of dewatered septage sludge that the Manual makes a reference to a quantitative criteria for quality, wherein it prescribes that ‘for dewatered septage/sludge agricultural application, it should satisfy the Class A biosolids criteria set out by the

United States Environmental Protection Agency (EPA) either by lime stabilisation, solar drying or composting'.

The EPA criteria for its classification of 'Class A' biosolids makes a repeated appearance in other Indian guidelines too and requires that at least one of the following two conditions be met (i) when the biosolids are used or disposed, (ii) when the biosolids are prepared for salt or give-away in a bag or other container for land application, or (iii) when the biosolids or biosolids-derived products are being prepared to meet the requirements for 'Exceptional Quality' biosolids -

- faecal coliform less than 1,000 most probable numbers (MPN) per gram total solids (dry-weight basis), or
- Salmonella sp. bacteria less than 3 MPN per 4 grams of total solids (dry-weight basis),

Advisory Note: Septage Management in Urban India, 2013

The Advisory, like the Manual, adopts the aforementioned US EPA Class A biosolids criteria concerning faecal coliform and Salmonella sp., and additionally, makes a note of the World Health Organization's recommended limits on Helminth egg and E coli concentration for the use of treated septage in agriculture –

- Helminth eggs less than 1 per gram total solids, and
- E coli less than 1000 MPN per gram total solids

Furthermore, it refers to the Municipal Solid Waste Rules (MSW Rules), 2000, for a standard on the quality of compost. While making these references, the Advisory provides for the possibility of the Central Pollution Control Board creating relevant standards.

Primer on Faecal Sludge and Septage Management, 2016

The Primer subsumes all the parameters, viz. faecal coliform, Salmonella sp., Helminth eggs, and E coli, mentioned in the Advisory along with the corresponding limits as conditions for the use of dewatered septage as fertilizer. Like the Advisory, it defers to the MSW Rules for acceptable compost quality.

Table 2 CPHEEO recommendations for managing various types of sludge

Type of Sludge	Prescribed Management Protocol
raw sewage sludge	- 'raw sludge as a soil filler directly on land for raising crops...is not desirable'
liquid sewage sludge	- 'liquid sludge either raw or digested is unsafe to use...If used, it must be thoroughly incorporated into the soil and land should be given rest, so that biological transformation of organic material takes place' - 'it should be used in such a way as to avoid all possible direct human contact'
dewatered septage sludge	- 'for dewatered septage/sludge agricultural application, it should satisfy the Class A biosolids criteria of US EPA either by lime stabilisation, solar drying or composting'
sewage sludge from drying beds	- 'sludge from drying beds should be ploughed into the soil before raising the crops. Top dressing of soil with sludge should be prohibited.' - 'dried sludge may be used for lawns and for growing deep-rooted cash crops and fodder grasses where direct contact with the edible part is minimum'
heat-dried sewage sludge	- 'heat-dried sludge is the safest from the public health point of view. Though deficient in humus, it is convenient in handling and distribution.' - 'dried sludge can be used as manure/soil conditioners' - 'dried sludge pellets can also be used as a fuel source in coal-fired power plants and in cement kilns'

National Policy on Faecal Sludge and Septage Management, 2017

The National Policy draws from various existing laws and regulations, including the Water (Prevention and Control of Pollution) Act, 1974, and the Solid Waste Management (SWM) Rules, 2016 under the Environment (Protection) Act, 1986, for its legislative and regulatory authority in ensuring the safe disposal of post-processed faecal sludge and septage. The Policy states that 'the SWM Rules 2016 will also apply for disposal and treatment of faecal sludge and septage, before or after processing, at landfills and for use as compost'.

Solid Waste Management Rules, 2016

The SWM Rules apply to characteristically urban areas (whether or not administratively urban), viz. urban local bodies, outgrowths in urban agglomerations, census towns, industrial townships, and any other notified areas. They include 'silt removed or collected from the surface drains' as solid waste, but do not explicitly include any toilet-related wastes, faecal sludge or septage, in their ambit.

In regard to compost, the Rules direct local authorities in statutory towns and village panchayats of census towns and urban agglomerations to substitute chemical fertilizers with compost in all parks and gardens under the purview of public authorities within two years of the Rules' issue. The Rules, through their Schedule II, list process instructions for composting and specifications for compost quality (Table 3).

Table 3 Specifications for compost quality in Solid Waste Management Rules, 2016

Parameter	Recommended Limit (upper, unless stated otherwise)
Arsenic (mg/Kg)	10
Cadmium (mg/Kg)	5
Chromium (mg/Kg)	50
Copper (mg/Kg)	300
Lead (mg/Kg)	100
Mercury (mg/Kg)	0.15
Nickel (mg/Kg)	50
Zinc (mg/Kg)	1000
C/N	20
pH	6.5-7.5
Moisture (% by weight)	15-25
Bulk Density (g/cm3)	1
Total Organic Carbon (% by weight)	>12
Total Nitrogen (as N) (% by weight)	>0.8
Total Phosphate (as P2O5) (% by weight)	>0.4
Total Potassium (as K2O) (% by weight)	>0.4
Colour	Dark brown to black
Door	Absence of foul odour
Particle Size	Minimum 90% material should pass through 4.0 mm IS sieve
Conductivity (as dsm-1)	4

The latter draw directly from the Fertilizer Control Order, 2009 and Fertilizer Control Order (FCO), 2013 . If the quality criteria prescribed are unmet, the Rules stipulate that the compost shall not be used for food crops.

Box 1 Lack of standards as a challenge to fostering recycling and reuse of biosolids in Dhenkanal, Odisha

The municipalities of Angul and Dhenkanal in Odisha have been two of the first few small towns across the country to institute FSM systems, including the construction of Faecal Sludge Treatment Plants (FSTPs). The FSTPs, based on passive treatment technology and utilizing unplanted sludge drying beds, have been designed to treat 27 KLD and 18 KLD of septage in Dhenkanal and Angul, respectively. The former is expected to produce 1.5 tons of biosolids per day, and the latter 1 ton of biosolids per day. Preliminary analysis of the end product characteristics reveals that 2-10 kgs phosphorous, 20-50 kgs organic nitrogen and 100-250 kgs organic carbon in Angul and 3-15 kgs phosphorous, 30-75 kgs organic nitrogen and 150-375 kgs carbon in Dhenkanal is recoverable through the biosolids generated per day.

Upon the commissioning of the plant in Dhenkanal, the FSTP operator began to sell the recovered biosolids at the rate of INR 2 per kg to local farmers. However, the state government intervened to stop the sale and reuse of biosolids – both to farmers and the Horticulture Department – owing to the lack of a nationally-ratified framework for their quality criteria and assurance. In the absence of such a framework and owing to the resulting local concentration of accountability, the state-level actors are unwilling to take on the related risks to public and environmental health. However, noting the value of biosolids as a soil conditioner, the state has allowed the Forest and Environment Department to use them in plantations and on forest land.

World Health Organisation: Trading-off between infrastructure and regulatory burden

The World Health Organisation's Multi-Barrier Approach, drawing directly from the Stockholm Framework for developing guidelines for the management of water-related infectious diseases, focuses on meeting health-based targets through a variety of protection measures at various steps along the process cycle. Instead of recommending thresholds for quality-related parameters at the treatment stage, the Approach calls for combining treatment measures with non-treatment measures downstream to contain risks overall. In doing so, the Approach provides for the various treatment pathways – some more complex than others – leading to the same reuse and recycling outcome (Table 4). The health-based target takes the form of Disability-Adjusted Life Years (DALY) with an upper limit of 10-6 DALY, translating to a 6 log unit reduction in E. Coli. Remnant risks are further managed by adopting the optimal on-farm application method, cropping and harvesting of produce, hygiene at the household level, and other best practices.

For large-scale systems (including those for faecal sludge), the guidelines recommend

- a Helminth concentration of <1 egg per gram total solids or per litre and
- an E. coli concentration of <1000MPN per 100 ml,

as acceptable.

Table 4 Treatment pathways for achieving different end-products (Harada, Strande, & Fujii, 2016)

End-product	Treatment Technology
Soil Conditioner	Untreated faecal sludge
	Sludge from drying beds
	Compost
	Pelletizing process
	Digestate from anaerobic digestion
	Residual from Black Soldier fly
Reclaimed Water	Untreated liquid faecal sludge
	Treatment plant effluent
Protein	Black Soldier fly process
Fodder and Plants	Planted drying beds
Fish and Plants	Stabilization ponds or effluent for aquaculture
Building Materials	Incorporation of dried sludge
Biofuels	Biogas from anaerobic digestion Incineration/co-combustion
	Biodiesel from faecal sludge
	Pelletized faecal sludge

Among the non-treatment barriers that the Approach recommends are:

(i) Storage and Application - Biosolids should be stored without the addition of any fresh sludge for a period dependent on the type of treatment process it has undergone. For instance, sludge must be stored for at least a week at a temperature greater than 50 deg. Celsius, if composting. Regardless of the treatment type, the guidelines recommend working the biosolids thoroughly into the soil at the time of application.

(ii) Crop Restriction – The application of faecal sludge-derived biosolids should be restricted to non-food crops or those which are processed prior to consumption like wheat and potatoes.

(iii) Die-off Period - Biosolids application should be withheld at least a month before harvesting to allow any active pathogens – both virus and bacteria - present on the surface of the crops to die-off. The rate of die-off is strongly influenced by climatic conditions such as temperature, humidity, sunlight intensity, among others, but the guidelines suggest that conservatively a reduction by 4 log units per during a month can be expected. Significant pathogen reduction can be achieved by the time the produce is ready for consumption in this manner.

(iv) Peeling and Cooking - Washing the produce with water before consumption brings down any remnant contamination by a single log unit while using a weak disinfectant solution to wash and rinsing with clean water results in two log units of reduction. Peeling of root crops before consumption effects a pathogen reduction of two log units and cooking at temperatures nearing the boiling of water (100 deg. Celsius) causes complete pathogen destruction.

Moreover, the Approach deploys three modes of monitoring to ensure the efficacy of the combination of treatment and non-treatment barriers,

(i) validation, or initial testing to establish that the system and all its components are able to meet the prescribed health-based target

(ii) operational monitoring, or routine monitoring of easily-measurable parameters to diagnose operational issues

(iii) verification monitoring, or longer-term periodic monitoring for parameters such as E. coli or helminth eggs for establishing the sustained performance of the system

Box 2 Lessons from the implementation of the Multi-Barrier Approach in Nepal

Noting that in the absence of formal treatment and institutional systems, farmers in Nepal utilize raw or untreated faecal sludge for agriculture, the SNV Netherlands Development Organization piloted the WHO Multi-Barrier Approach alongside fermentation of faecal sludge as an on-farm treatment method. The study was conducted as two separate pilots in 2015 and 2016 in the peri-urban municipal wards of the Birendranagar municipality in farms growing both low-growing (pumpkin) and high-growing crops (cow pea, bottle gourd, bitter gourd).

While facile in its protocol, and land and material requirements, the treatment itself did not meet the pathogen reduction requirements with a presence of E. coli levels of up to 105 MPN/100 ml, as well as, that of Helminth eggs and Salmonella sp. in the final treatment product. Accordingly, stakeholders adopted non-treatment barriers like (i) adoption of personal protective equipment when handling raw and treated faecal sludge and hygienic practices like handwashing, (ii) safe practices for fertilization application to crops through 'fertigation', and (iii) allowing a pathogen die-off period of one month prior to harvesting, during on-farm application.

The study found the success of the non-treatment barriers strongly contingent on the institutionalization and sustainability of the recommended on-farm practices and concluded that non-treatment barriers could not be relied upon as a substitute for treatment of faecal sludge in the long-term for its safe use a fertilizer, given the challenges of regular reinforcement and sustained behavior change.

Bangladesh: Addressing long-term ecosystem concerns alongside immediate biosolids application

Bangladesh developed its 'Standards and Guidelines for Sludge Management' in 2015. The standard classifies sludge into the categories of A, B, and C, depending on their point of origin since it covers both domestic and industrial sludge management. It defines Category A as comprising 'Municipal sludge including comparable sludge' or 'sludge produced in a sewage treatment plant treating only domestic or urban wastewater' and regards 'septic tank sludge' as a non-hazardous 'municipal waste'.

Quality Requirements

The standard considers co-fermentation, composting, agricultural use, controlled landfill, thermal incineration, landfilling, and recycling in brick/cement/asphalt making as all viable routes for managing Category A sludge. For agricultural use, the standard specifies limits on the concentration of contaminants (Table 5) but doesn't further subcategorise the sludge based on its characteristics.

Table 5 Specifications of pollutant and pathogen concentrations for the use of sludge in agriculture as per the Standards and Guidelines for Sludge Management, Bangladesh

Parameter	Recommended limit	
	in sludge (mg/kg dry substance, unless specified otherwise)	in soil* (mg/kg dry substance, unless specified otherwise)
Pb (Lead)	900	100
Cd (Cadmium)	10	1.5
Cr (Chromium)	900	100
Cu (Copper)	800	60
Ni (Nickel)	200	50
Hg (Mercury)	8	1
Zn (Zinc)	2500	200
As (Arsenic)		40
Salmonella	None	
Helminth Ova	0.25 (or one viable ova/4g)	

*Soil of the agricultural land before application of sludge

Application Requirements

In ensuring that no harm accrues in the long run, the standard demands testing the soil for metal concentrations prior to sludge application (Table 5), and then repeatedly at 10-yearly intervals. It sets out a rigorous quality monitoring protocol for the sludge, stating that sewage sludge may only be surrendered for agricultural or horticultural application if,

(i) the soil has been tested for its pH and levels of plant-available phosphate, magnesium, and potassium

(ii) the land is not - used for the growing of fruit and vegetables; a permanent grassland; used for the purposes for forestry; utilized for parks, playgrounds, or similar areas

(iii) sludge is applied prior to sowing with subsequent deep tillage in the case that land is used for growing field forage or plants with edible parts used as feedstuff

(iv) samples of the sewage sludge are analysed at intervals of at most six months by a body appointed by the responsible authority to establish the contents of lead, cadmium, chromium, copper, nickel, mercury, arsenic and zinc, the sum of organic halogen compounds as absorbed organically bound halogens (AOX), total and ammonia, nitrogen, phosphate, potassium, magnesium as well as the dried residue, organic substance, basifying substances, the pH value, salmonella and helminth ova

(v) prior to the first time of application and thereafter, at intervals of at most two years samples of the sewage sludge are analysed for the contents of the persistent organic pollutants – polychlorinated biphenyls and polychlorinateddibenzodioxins (PCDDs) and dibenzofurans (PCDFs)

The recommended buffer zones between the area of application and any water receptors in the vicinity are,

- Depth to aquifer => 5 m
- Distance from surface water/borehole => 200 m

The aforementioned requirements are applied specifically to sludge and not sludge-derived compost, but the standard specifies soil application rates for both,

- < 3 ton dry substance sewage sludge per ha in 3 years
- < 10 ton dry substance sludge compost per ha in 3 years

If these rates are exceeded, as in the case of land applications such as filling material for flood prevention and substrate for re-cultivation of mining sites or covering landfill sites, the standard mandates seeking permission from the responsible authority in agreement with the Soil Resource Development Institute (SRDI) and the Department of Environment (DoE).

Administrative Requirements

The standard requires the producers of sludge, viz. plant operators, to submit a sludge management plan to the Department of Environment as part of the process to seek environmental clearance – regardless of disposal or recycling route being adopted. In particular for agricultural use, the operator of the treatment plant or an authorized third party, i.e. the farmer must notify the relevant authorities of the intended application at the latest two weeks prior to it. Furthermore, the operators are expected to maintain detailed records of,

(i) total sludge volume generated and quantity supplied for agriculture

(ii) mode of treatment and properties of sludge

(iii) name and address of the recipients of sludge, plot-specific designation of the area of land on which the sludge is applied, and

(iv) results of the soil analyses, broken down by plot.

Additionally, the sludge must be characterized through periodic testing at intervals of at most six months (reducible to two months) for pollutant and pathogen concentrations.

South Africa: Flexibility and facileness – a critical balance

The South African 'Guidelines for the Utilisation and Disposal of Wastewater Sludge' were issued in 2006 and comprise five volumes , each dealing with a specific type of recycling route. Wastewater sludge, also referred to as 'sludge', itself is defined to explicitly include sludge from septic tanks and other on-site containment units, as well as, processed sludge .

Quality Requirements

The standard classifies sludge based on its physicochemical and microbiological characteristics, unlike the Bangladesh standard, which makes the distinction based on the origin of the sludge. It rates sludge on a three-point scale individually for stability (1,2,3), pollutant concentration (a,b,c), and microbiological contamination (A, B, C) (Table 6). The three scores combine, therefore, into 27 unique categories which form the basis of prescription on recycling applications.

As per the guidelines, only sludge which does not fall under Class c of pollutant concentration and Class 3 of stability is eligible for agricultural use. If eligible, the microbiological class of the sludge determines the rigor of restrictions it should comply with, including those on crop type and public access. The 'A1a'-type sludge can be distributed to the public for unrestricted use. If composted or pelletized sludge is commercially sold, the standard requires that the product is of A1a quality registered as a fertilizer with the Department of Agriculture in line with the stipulations under the relevant Acts.

Table 6 Specifications for pollutant and microbiological class as per the Guidelines for the Utilisation and Disposal of Wastewater Sludge, South Africa

Parameter	Recommended Limit (upper, unless stated otherwise)		
Microbiological Class	A (unrestricted use quality)	B (general use quality)	C (limited quality)
Faecal coliform (CFU/dry gram solids)	1000 (5 log reduction)	1 x 106 (2 log reduction)	1 x 107 (no reduction)
Helminth ova (Viable ova/ dry gram solids)	0.25 (or one ova/4g)	1	>4
Stability Class	1	2	3
Prescribed vector attraction reduction options	Compliance with one of the options on a 90 percentile basis	Compliance with one of the options on a 75 percentile basis	No stabilisation or vector attraction reduction options required
Pollutant Class**	a	b	c
As (Arsenic) (in mg/kg)	40	40 - 75	>75
Cd (Cadmium) (in mg/kg)	40	40 - 85	>85
Cr (Chromium) (in mg/kg)	1200	1200 - 3000	>3000
Cu (Copper) (in mg/kg)	1500	1500 - 4300	>4300
Pb (Lead) (in mg/kg)	300	300 - 840	>840
Hg (Mercury) (in mg/kg)	15	15 - 55	>55
Ni (Nickel) (in mg/kg)	420	420	>420
Zn (Zinc) (in mg/kg)	2800	2800 - 7500	>7500

**90% of tested samples should comply to fulfil the criteria
The criteria also specifies monitoring and sampling requirements along with this target values,

Application Requirements

The sludge that falls under class A of microbiological contamination)may be employed across all types of crops. On the other hand, Class B sludge can only be applied to,

- Crops with edible parts that do not touch the soil/sludge mixture, e.g. fruits growing on trees or vines, grains, cotton
- Crops with harvested parts that touch the soil/sludge mixture, e.g. melons, strawberries, eggplant, tomatoes, lettuce, and
- Crops with harvested parts below the soil surface, e.g. potatoes, peanuts

with the recommended die-off periods, but not to vegetables consumed raw. On the other hand, Class C sludge may not be used for fertilizing soils growing vegetables that are – consumed raw; low-growing; or, harvested from below the soil surface. Wherever else the sludge is applied, the standard recommends restricted public access and a die-off period of 90 days.

While the standard does not associate any restrictions in relation to the stability class of the sludge (provided it is not the lowest, in which case the use of biosolids in agriculture is prohibited), it recommends testing the soil for existing metal concentrations to determine whether sludge may be applied to the land. Depending on the soil characteristics, sludge application use may be permissible with soil analysis for pollutant concentrations at an interval of two years or five years, or impermissible.

The sludge application rate should not exceed 10 tons dry mass per ha per year, but in case the agronomic demand is higher, farmers can seek approval from the Department of Water Affairs and Forestry. Nonetheless, the standard requires confirming the nitrogen, phosphorous, and potassium content of the sludge before each planting season.

Like the Bangladesh standard, the South Africa standard also prescribes buffer zone as per,

- Depth to aquifer => 5 m, and
- Distance from surface water/borehole => 200 m

but which may be relaxed contingent on proof that groundwater and surface water are adequately protected. Additionally, the standard also provides for a 500 meter buffer from habitations.

Administrative Requirements

The standard expects the producer of the sludge to keep detailed records on sludge characteristics and classification, details of the sludge management process, and nutrient status of the soil. Depending on the biosolids production rate, it demands periodic sludge testing at a maximum rate of once per month to a minimum of once per year.

United States of America: A precursor to newer standards

The US EPA's Part 503 Rule, issued in 1993 as The Standards for the Disposal or Use of Sewage Sludge, is a federal rule offering guidance on the management of biosolids resulting from 'wastewater treatment' processes. The Rule defines biosolids , the key terminology it adopts, as a 'primarily organic solid product produced by wastewater treatment processes that can be beneficially recycled'. The requirements under the Rule further apply to biosolids-derived compost.

Quality Requirements

Unlike the extensive categorisation of sludge under the South African standards, the 503 Rules understands it through the following key classes,

(i) Exceptional Quality (EQ) biosolids, unregulated for use, whether used or sold in bulk (marketed or sold to manufacture of products that contain biosolids) or smaller quantities (indicatively a load of one metric ton or less) through low pollutant concentration (Table 7) and compliance with Class A pathogen reduction limits, and

(ii) Pollutant Concentration (PC) biosolids, subject to site management practices and other general requirements, falling under Class B of pathogen reduction and exhibiting pollutant concentrations similar to EQ solids.

Failing to meet the requirement for low pollutant concentration, as in for EQ and PC biosolids, but being under the overall concentration limits, biosolids can still be used in bulk or smaller quantities . The Cumulative Pollutant Loading Rate (CPLR) and the Annual Pollutant Loading Rate (APLR) apply in the former and latter cases, respectively (Table 7).

Table 7 Specifications for pollutant concentrations, pathogen class, and type of land use intended by mode of biosolids application as per the Part 503 Rule, US EPA

Parameter	Recommended Limit (upper, unless stated otherwise)			
Pollutant	Ceiling Concentration Limits for All Biosolids Applied to Land (mg per kg dry solids)	Ceiling Concentration Limits for EQ and PC Biosolids (mg per kg dry solids)	Cumulative Pollutant Loading Rate (kg per ha)	Annual Pollutant Loading Rate (kg per ha per year)
As (Arsenic)	75	41	41	2
Cd (Cadmium)	85	39	39	1.9
Cr (Chromium)	3,000	1,200	3,000	150
Cu (Copper)	4,300	1,500	1,500	75
Pb (Lead)	840	300	300	15
Hg (Mercury)	57	17	17	0.85
Molybdenum (Mo)	75	-	-	
Ni (Nickel)	420	420	420	21
Selenium (Se)	100	36	100	5
Zn (Zinc)	7,500	2,800	2,800	140
Pathogen Class	Class A	Class A or B	Class A or B	Class A
Type of Land Intended	All*	All except lawns and home gardens	All except lawns and home gardens	All, but most likely lawns and home gardens

*includes agricultural land, forests, reclamation sites, and lawns and home gardens

Additionally, the biosolids must have undergone at least one of the ten prescribed vector attraction options and fall in either Class A or B of pathogen reduction (Table 8).

Table 8 Specifications for pathogen concentrations by pathogen class as per Part 503 Rule, US EPA

Parameter	Recommended Limit (upper, unless stated otherwise)	
	Class A	Class B
Faecal coliform (MPN/dry gram solids)*	1000	2 x 106 (MPN or CFU)
Salmonella sp. (MPN/dry gram solids)*	0.75 (3 MPN per 4 grams of total dry solids)	-

Application Requirements

Regardless of the mode of application, viz. bulk or bagged, or that of pollutant concentration, i.e. EQ, PC, or otherwise, as long as the biosolids conform to the Class A requirements, they are not subject to any site restrictions. These include crop restriction, those on grazing, and that of public access. On the other hand, all types of biosolid applications barring EQ must comply with the general requirements and management practices. Overall, the Rule recommends agronomic rates for applying biosolids to the soil. For PC and CPL biosolids, a buffer of 10 meters must be maintained between the intended area of application and any water sources in the vicinity.

Administrative Requirements

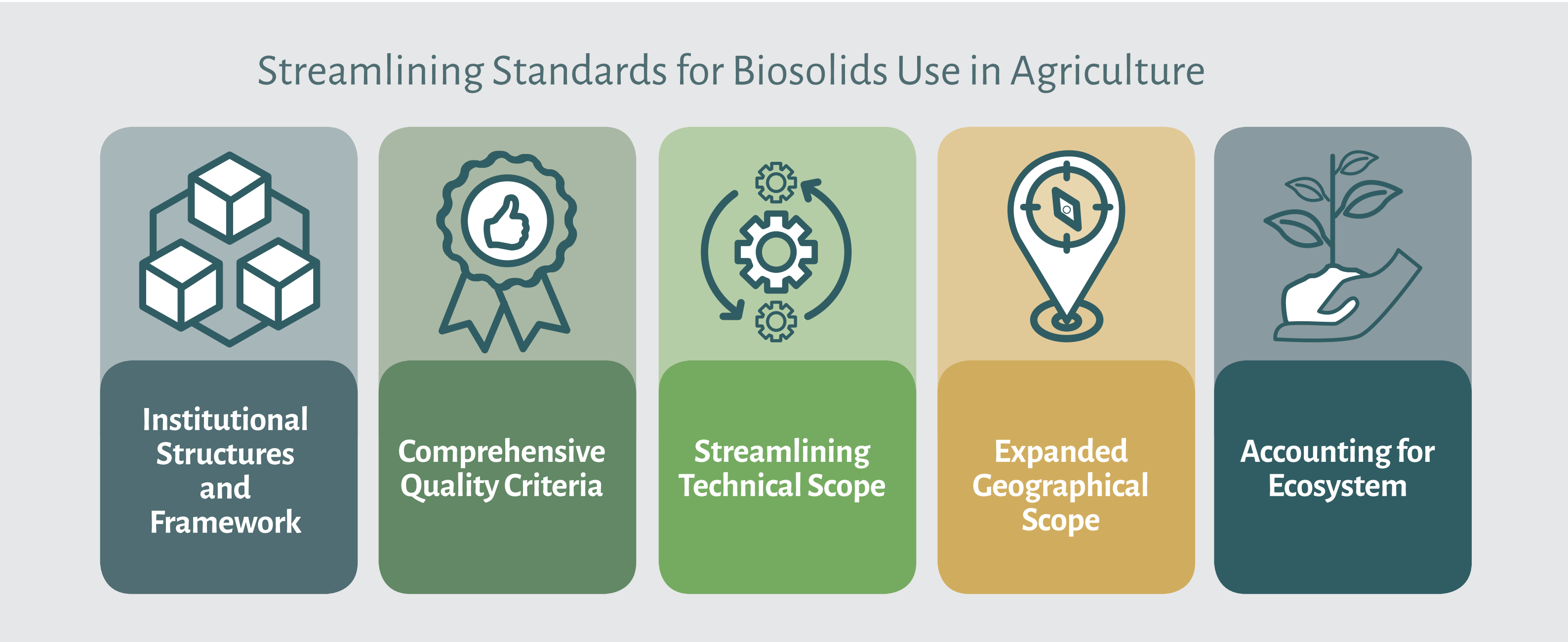
The Rule requires owners and operators of treatment facilities to obtain a permit covering biosolids use or disposal standards. All manners of biosolids and their applications are subject to monitoring, recordkeeping, and reporting requirements. The frequency of monitoring is a function of the biosolids production rate and ranges from once per year to once per month. Further, the Rule mandates labelling for APL biosolids.

Emerging Recommendations

In conclusion, the competent authorities and regulators in India recognize the risks associated with recycling of faecal sludge and septage-derived products and have attempted to address these issues albeit tangentially. These attempts, however, cannot substitute formal standards directly governing the subject and the present note makes the following recommendations in this regard:

- *First*, **the standard must consolidate and address various types of quality-related concerns under one governing document.** National and international regulations have been applied piecemeal in the Indian context, necessitating the development of a comprehensive quality criteria (Table 9). Currently, while the US EPA Class A Biosolids requirements drawn upon target the microbiological quality of 'biosolids', the FCO recommended limits under SWM Rules, 2016, don't and instead focus on concentration of heavy metals and characteristics such as moisture content, bulk density, carbon to nitrogen ratio, among others, for 'compost'.
- *Second*, **the standard must go beyond mere quality control to account for the interaction of the biosolids with the ecosystem to which they are being introduced.** The current guidance does not take into cognizance these complex interactions. Both the Bangladesh and South African standards discussed in the present note had similar approaches to accounting for the ecosystem - through specifying optimal application rates to control cumulative pollutant loading, as well as, buffer zones from water sources in the vicinity to prevent their contamination (Table 9).
- *Third*, **the standard must outline the institutional structures and frameworks at the national, state, and local level that will steer the enlisted processes.** Even though the current guidelines define quality control criteria – albeit disjointed, they do not specify these frameworks – a definite lacuna that a new standard can plug. The recycling of biosolids entails a diverse set of stakeholders and their interactions, such as producers of sludge, operators of treatment facilities, users of the biosolids, and communities consuming

Figure 2 Gaps in the Indian biosolids regulation



goods produced through use of the biosolids. Managing risks successfully at each stage calls for a clear demarcation of roles and responsibilities of all stakeholders, including regulatory bodies, and definitive requirements for quality control and monitoring. A new standard could adapt existing institutional frameworks designed for the regulation for wastewater and solid waste management.

- *Fourth*, **the standard should streamline the technical scope to enhance their applicability and target emerging needs like management of pit humus from twin pits**. The current directives employ multiple terms, viz. dewatered septage sludge, biosolids, compost, and others, in an unstructured manner. The SWM Rules, 2016, and Fertilizer Control Order, 2013, are the most specific and deal solely with waste-derived compost an do not make an explicit mention of faecal sludge and septage-derived products under their purview. Pit sludge, especially from twin pits, has been missing from the discourse thus far owing to broad-based assumptions regarding their treatment sufficiency. Given the proliferation of the technology under SBM, it is imperative to formally articulate protocols for the safe management of pit humus from twin pits, including standard operating procedures, through such a new standard.

- *Fifth*, **the standard should expand their geographical scope and have universal applicability.** The policy, guidelines, and rules, viz. the National Policy, the Advisory, and the Primer on FSM originated through MoHUA, and SWM Rules, 2016 that offer prescriptions on agricultural application of biosolids are largely urban in origin. In contrast, the need for intervention transcends the urban-rural divide and necessitates a revised regulatory framework to jointly govern the matter in both rural and urban areas through an expanded scope.

Table 9 A comparison of the the primary components of biosolids management in the various guidelines

Parameter	Bangladesh	South Africa	USA
Sludge Management Plan	X*	X**	X*
Sub-types of Sludge or Biosolids		X	X
Heavy Metal Concentration Limits	X	X	X
Pathogen Concentration Limits	X	X	X
Biosolids Application Rate Limits	X	X	
Crop Restriction	X	X	X
Pre-application Soil Testing	X		
Periodic Soil Monitoring	X	X	
Periodic Sludge Quality Monitoring	X	X	X
Groundwater Buffer	X	X	
Surface Water Buffer	X	X	X
Distance from Dwelling Units	X	X	

*permit requirement, **self-regulatory

Biosolids are nutrient-rich resources that can reduce reliance on and extraction of freshwater, supplant demand for chemical fertilizers, and remediate poor quality soils when recycled agriculturally. However, ambiguity in the prevailing regulatory environment confront these endeavours. Therefore, going forward, the concerned authorities should design a biosolids standard, reflecting on lessons from other countries (Table 9). For instance, one of the main points of differentiation among these international standards has been the approach to defining and classifying sludge. From a preliminary categorization based on the origin of the sludge, like in the case of Bangladesh, to the South African standard that allows for the possibility of 27 types differentiated through their physicochemical characteristics, regulators should choose a model balancing facileness of implementation with flexibility.

Furthermore, although the present note did not cover the direct land application of septage in its discussion, it will be an important area of concern as more peri-urban and rural areas adopt faecal sludge and septage management within the scope of their limited financial and technical capabilities.

REFERENCES

Census of India (2011)

NSS 76th Round (2018)

A Plain English Guide to the EPA Part 503 Biosolids Rule, 1994, United States Environmental Protection Agency

Advisory Note: Septage Management in Urban India, 2013, Ministry of Housing and Urban Development, India

Standards and Guidelines for Sludge Management, 2015, Department of Environment, Bangladesh

Fertilizer Control Order, 1985, Ministry of Agriculture and Rural Development, India.

Guidelines for the utilization and disposal of wastewater sludge - Volume 2, 2006, Department of Water Affairs and Forestry, South Africa

Manual on Sewerage and Sewage Treatment Systems, 2013, CPHEEO, Ministry of Housing and Urban Development, India

National Policy on Faecal Sludge and Septage Management, 2017, Ministry of Housing and Urban Development, India

Primer on Faecal Sludge and Septage Management, 2016

Solid Waste Management Rules, 2016, Ministry of Environment, Forest, and Climate Change, India

Biome Environmental Trust. (2018). Informal Sector Enterprises in Watsan and the Application of Sanitation Safety Planning Process as a Risk Management Tool for Small Towns.

Carr, R. M. (2001). Excreta-related infections and the role of sanitation in the control of transmission. In L. Fewtrell & J. Bartram (Eds.), Water quality: Guidelines, standards and health. Retrieved from https://www.semanticscholar.org/paper/Excreta-related-infections-and-the-role-of-in-the-Carr/011625aab704bd85a31a0268d96b6cc2ace609a8

Fuhrimann, S., Winkler, M. S., Schneeberger, P. H. H., Niwagaba, C. B., Buwule, J., Babu, M., … Cissé, G. (2014). Health risk assessment along the wastewater and faecal sludge management and reuse chain of Kampala, Uganda: a visualization. Geospatial Health, 9(1), 241. https://doi.org/10.4081/gh.2014.21

Harada, H., Strande, L., & Fujii, S. (2016). Challenges and Opportunities of Faecal Sludge Management for Global Sanitation. In T. Katsumi & S. Hashimoto (Eds.), owards Future Earth: Challenges and Progress of Global Environmental Studies (pp. 81–100).

Kvarnström, E., Verhagen, J., Nilsson, M., Srikantaiah, V., Ramachandran, S., & Singh, K. (2012). The business of the honey-suckers in Bengaluru (India) : the potentials and limitations of commercial faecal sludge recycling: an explorative case study. Retrieved from https://www.ircwash.org/OP48

Niti Aayog. (2018). Composite Water Management Index - A tool for water management.

WHO. (2006a). Guidelines for the safe use of wastewater, excreta and greywater - Volume 1. World Health Organization.

WHO. (2006b). Guidelines for the safe use of wastewater, excreta and greywater - Volume 2. World Health Organization.

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Sanitation programme at the Centre for Policy Research (CPR) is a multi-disciplinary research, outreach and policy support initiative. The programme seeks to improve the understanding of the reasons for poor sanitation, and to examine how these might be related to technology and service delivery models, institutions, governance and financial issues, and socio-economic dimensions. Based on research findings, it seeks to support national, state and city authorities develop policies and programmes for intervention with the goal of increasing access to inclusive, safe and sustainable sanitation. Initiated in 2013, the programme is primarily funded by the Bill and Melinda Gates Foundation (BMGF).

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