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# Technical Assessment of Faecal Sludge Management in the Rohingya Response

## Study presentation

**Anna Grieve and Paula Morcillo de Amuedo**

29th November 2022

OXFAM

WASH Sector Cox's Bazar

unicef

Australian Aid

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# Agenda

- Introduction
- Summary of study finding
- Recommendations/ next steps

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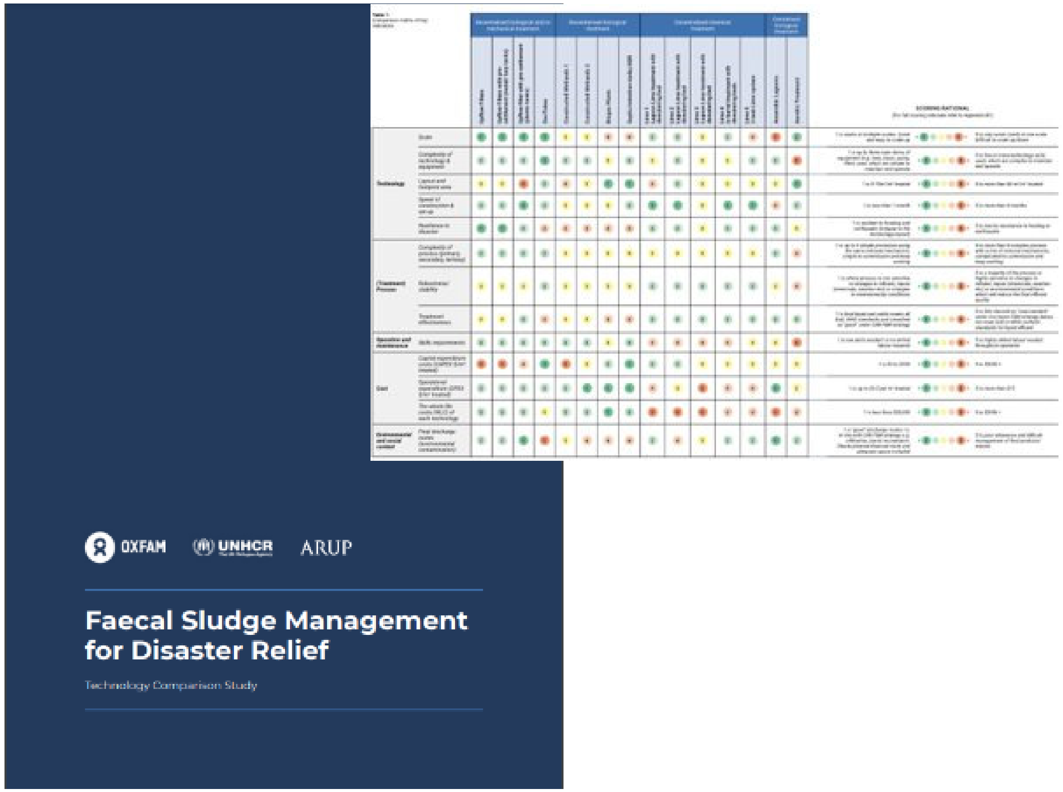
# Introduction

- **Faecal Sludge Management for Disaster Relief – Phase 1**
  - Technical study on 8 different FSM technologies for disaster relief
  - Technologies compared against indicators defined for emergency phase: cost, footprint area; speed of construction and commissioning; operation and maintenance issues; pathogen inactivation and resilience to natural disasters.



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# Introduction

- **Technical and Operational Assessment of FSM systems in CxB**
  - challenges that have emerged, operational performance and treatment effectiveness.
  - assessment of costs associated with the full FSM chain and understand key influencing factors

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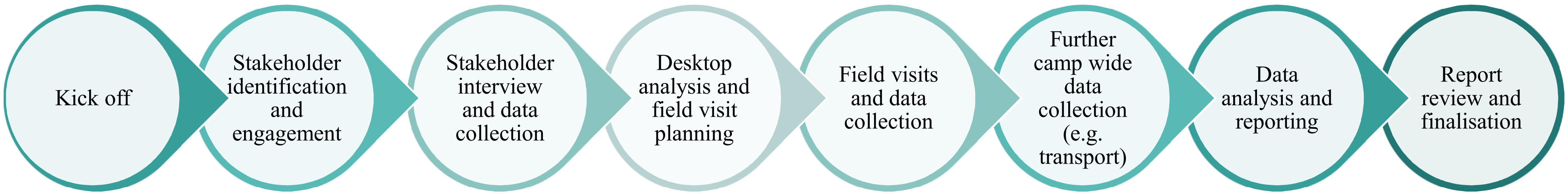
# Methodology



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# Response to brief

**Research questions** (costs and operational robustness are the key criteria)

## Question 1

Does the FSM chain meet the need? i.e., does each stage in the FSM chain have capacity to meet sludge generation, what are the bottlenecks and inefficiencies, and how can these be addressed?

## Question 2

Which type of FSTP is performing best against most assessment parameters? Including reasoning for improving or decommissioning FSTPs.

## Question 3

Which mode of transport is most cost effective and resilient?

## Question 4

Does the containment type influence the sludge chain and which containment is best?

## Question 5

Is the centralised or decentralised approach of FSM more cost effective?

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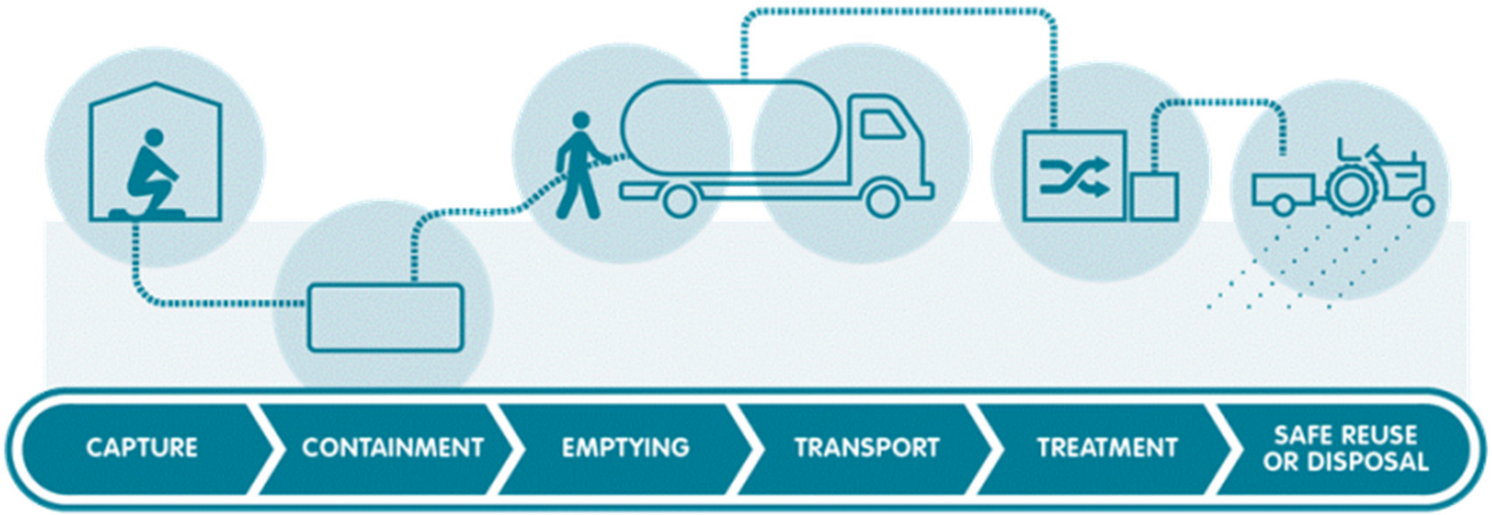
# Summary of study findings

**FSM chain**

- Approach
- Key findings, constraints and opportunities
- Moving to best practice (for discussion in Q&A)



# Latrines / containment

**Approach**

- Data on latrine types and database of locations provided by WASH sector.
- Qualitative data from visits to the 20 FSTPs on type of latrines in the FSTP catchment, frequency of desludging, seasonal and location variations, and main issues.

# Latrines / containment

**Key findings**

- 49,530 latrines units in CxB
- Latrines are desludged more often because of insufficient capacity, mixed use (black and grey water), operational defects and/or poor infiltration.
- A higher volume of sludge associated with rainy season (infiltration and low lying areas).
- Public health risk during wet season (latrine overflowing and poorer latrine maintenance).

# Latrines / containment

**Moving to best practices**

- Uncertainty in the type of latrines, recommendation to rationalise types in line with the Unified/Standard Design for latrines.
- **A tracking system of containment capacity** and emptying to allow a desludging schedule to be better managed and lead to prompt desludging and efficient maintenance of the units' volume

| Possible latrine grouping – for consideration by WASH sector | Type of latrine as noted in current available data | Unified/Standard Design for latrines in Rohingya settlements |
|---|---|---|
| **Group A - emergency/temporary latrines** | - Emergency latrine<br>- Emergency<br>- Mobile Latrine | Not included |
| **Group B - single pit** | - Direct pit with soak pit (1 or 2)<br>- Direct Pit (1 or 2)<br>- Direct pit offset pit (2)<br>- Single Pit offset<br>- Household Latrine<br>- Single Pit<br>- Disabled friendly latrine | Type 1 and 2 |
| **Group C - larger pits** | - Twin Pit offset (3 or 5)<br>- Twin Pit Latrine (3,4 or 5)<br>- Bio-Fill Latrine<br>- Bio-gas Plant (7)<br>- Communal Latrine<br>- Four pit<br>- Triple pit<br>- Two latrine and one Bathing Shed<br>- Institutional Latrine | Type 3, 4 and 5<br>(bio gas type 7) |
| **Group D – tanks or very large pits** | - Septic tank (6)<br>- Holding Tank<br>- Septic tank latrine and bathing facility<br>- Tank<br>- 5th Pit | Type 6 and 8 |
| **Unknown and would need more details to be allocated to group** | - Durable Latrine<br>- Durable<br>- Semi durable<br>- Latrine (Sub type Unknown) | Unknown |

Table 4: Possible grouping for latrine types

# Transfer / transport

**Approach**

- Stakeholders provided data via request form, no site visits
- Data collected on transportation mode (single and mixed)
- Transportation modes identified in CXB were: vactug, IFSTN, pit transfer/temporary pipe, manual desludging.
- Data covered 68% of the total camps' area.

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# Transfer / transport

**Key findings**

- 29,718m$^3$ of FS in transit per month (26% average increase in wet season)
- Most used is pit transfer/temporary pipe
- IFSTN had lower operational cost per m3 transported (note limited data set)

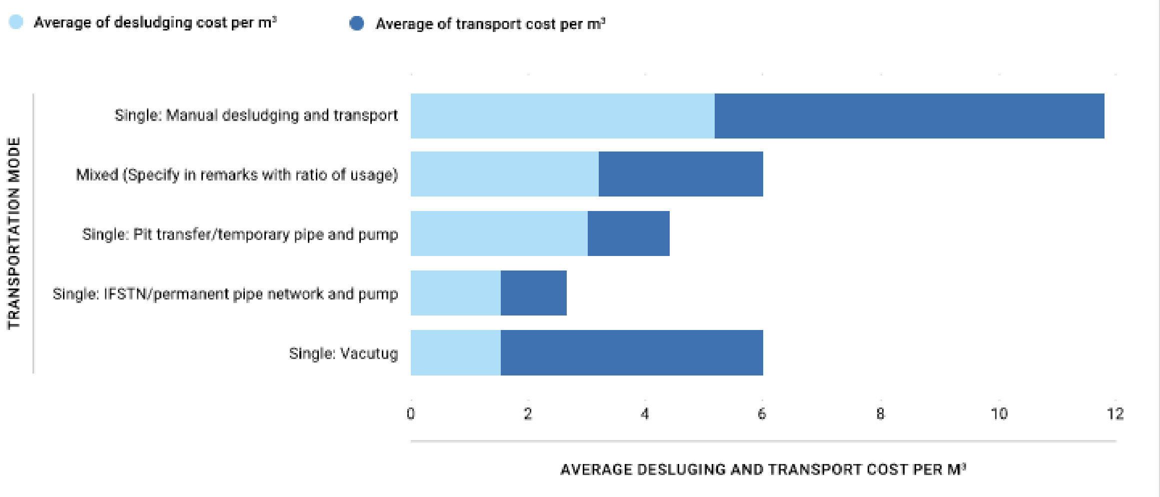



**Figure 13: Monthly desludging and transportation costs per m$^3$ of sludge and Transportation Mode (USD/m$^3$/month)**

# Transfer / transport

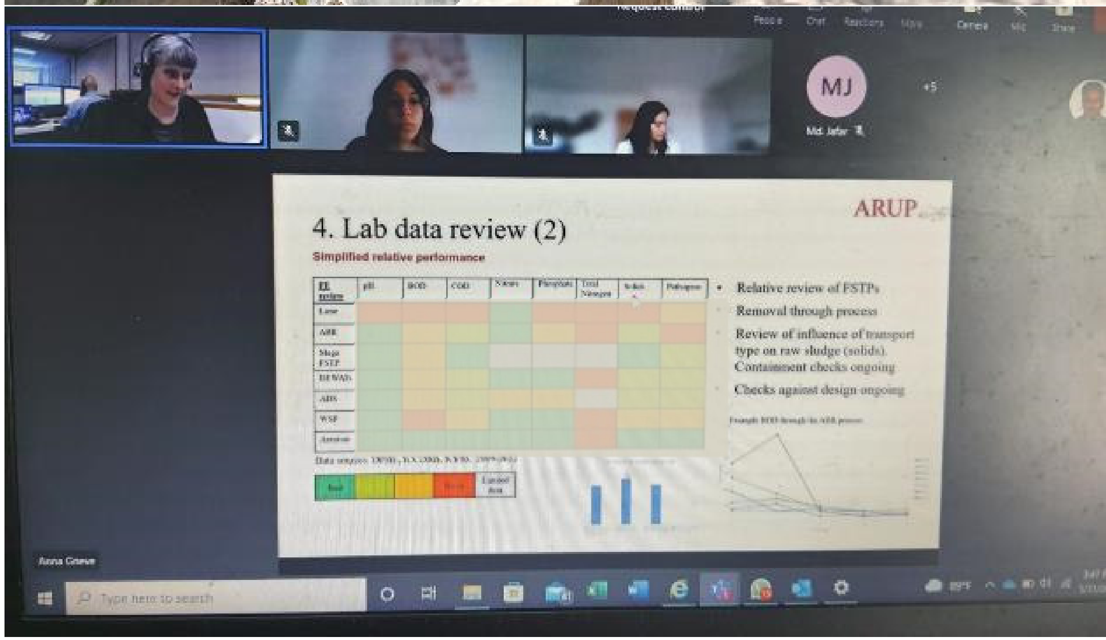
**Moving to best practice**

- Simplified pipe network showed lowest OPEX - additional analysis (& data) required to determine key governing factors/ tipping points i.e. a simplified network is cost effective…..
  - At what population density?
  - At what flow rate?
  - Or if X% of network is pumped?
- Move away from manual transfer

# Treatment / FSTPs

**Approach**

- Information collected via stakeholder interviews and field visits
- Information collected on: Design, cost (capex & opex), footprint, scalability, commissioning/de commissioning, skills, O&M, treatment performance, sustainability and resilience.
- Qualitative and qualitative analysis undertaken



# Treatment / FSTPs

**Key findings**

- Total treatment capacity = 879m$^3$/day over 164 sites/ FSTPs
- Approx sludge production = 995m$^3$/day (estimated sludge generation rate 1.1 l/h/day)
- Some sludge retained in the chain and some ‘lost’, so concluded FSTP capacity approx. = demand

Note: wet/dry seasonal variation, 8 out of 20 visited were slightly underutilised (due to commissioning/ decommissioning and quality control)

# Treatment / FSTPs

**Key findings – high level summary**

| PARAMETERS | Centralised | Lime | ABR | Aeration | WSP | ADS | UFF | DEWATS |
|---|---|---|---|---|---|---|---|---|
| **Design Capacity $m^3$/day** | 165 ave (150 to 180) | 7 ave (5 to 10) | 10 ave (6 to 15) | 23 ave (15 to 30) | 3.25 ave (2.5 to 4) | 5 | 3 ave (3) | 4.5 ave (3 to 6) |
| **Treatment area $m^2/m^3$** | 45 ave (33 to 58) | 47 ave (17 to 98) | 49 ave (9 to 175) | 23 ave (18 to 28) | 13.5 ave (9 to 18) | 61 | 28 ave (28) | 29.5 ave (20 to 39) |
| **Scalability** | Medium | Medium | Low | High | Low | Medium | High | High |
| **Capex UDS $/ $m^3$** | 5,517 ave (4,646 to 6,388) | 2,891 ave (1,554 to 4,060) | 5,758 ave (1,564 to 13,907) | 3,983 ave (3,333 to 4,633) | 5,244 ave (2,600 to 7,888) | 1,392 | 8,133 ave (8,133) | 3,555 ave (3,555) |
| **Opex UDS $/ $m^3$*** | 3.65 ave (0.60 to 6.7) | 5.94 ave (3.44 to 9.57) | 11.7 ave (0.4 to 44.2) | 29.46 ave (26.75 to 31.4) | 3.3 ave (2.6 to 4) | 0.39 | 4 ave (1.4 to 7.22) | 0.8 ave (0.69 to 0.91) |
| **Whole life cost** | 653 ave (474 to 831) | 2,188 ave (1,607 to 2,858) | 3,063 ave (419 to 8,530) | 3,579 ave (1,553 to 5,604) | 1,584 ave (1,248 to 1,921) | 306 | 939 ave (939) | 500 ave (453 to 548) |
| **Construction time (months)** | 12 | 1.3 ave (1 to 2) | 4.5 ave (2 to 8) | 9 ave (8 to 10) | 2.5 ave (2 to 3) | 2 | 1.5 ave (1.5) | 1 ave ( 1) |
| **Complexity of process** | Medium | Medium | Low | High | Low | Low | Low | Low |
| **Treatment performance** | Good | Poor | Poor (for pathogens) | Good | Medium | Medium | Medium | Medium |

# Treatment / FSTPs

**Key findings - treatment performance (liquid and solid effluent quality**

- A majority of FSTPs fall below the Bangladesh DoE effluent standards for most parameters, hence the effluent can pose a risk to human health and the environment.
- But *safe* disposal routes?
- Risk assessment of contamination of ground water is required to properly design the FSTP and define the capacity of the treatment and associated FSM chain

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# Summary of study

## FSM chain – Treatment (4)

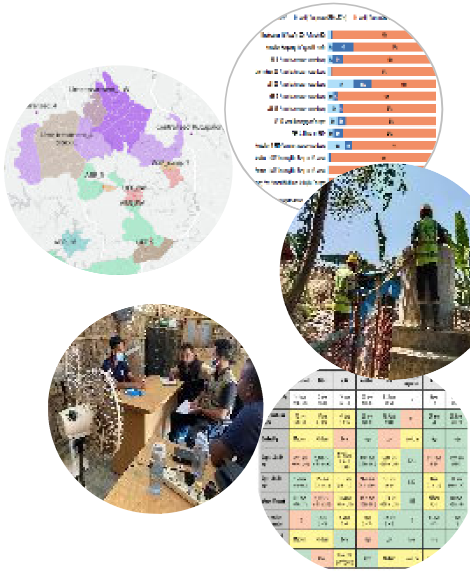
| Worst (5) | 4 | 3 | 2 | Best (1) |
|---|---|---|---|---|

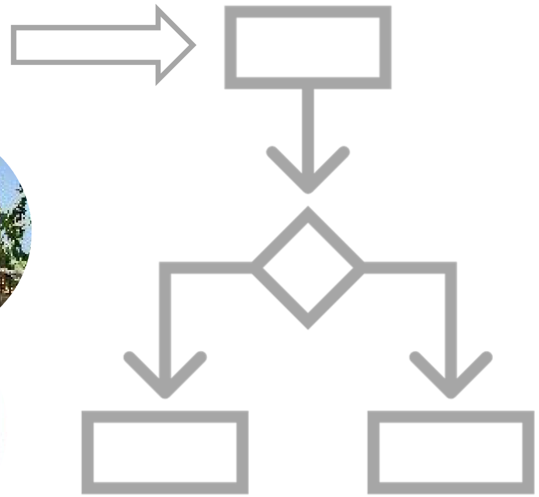
| | Data reviewed | pH | BOD (mg/l) | COD (mg/l) | Nitrate (mg/l) | Phosphate (mg/l) | Total Nitrogen (mg/l) | Solids | Pathogens | FE disposal route |
|---|---|---|---|---|---|---|---|---|---|---|
| DoE Standard | N/A | 6 to 9 | 30 | 200 | 250 | 35 | 15 | Suspended solids 100 mg/l | 1000 CFU/100ml | Surface water |
| Lime | Data for 26 LSP reviewed, most only available via DPHE from Feb 2022. Long term data was available for two (of the 26) FSTPs.<br>Three sites visited included in lab data review. | pH 7 to 13<br>Lime process will result in a high ph. | Range from 22-6500 mg/l. with most recent samples exceeded DoE standard. Limited long-term data (one site). Hard to tell seasonal variation. | Range from 50-48000 mg/l (generally in range 500 to 1000 mg/l) With most recent samples exceeded DoE standard. | All within standard. Influent already below standard. | Range from 0-225 mg/l<br>Majority of DPHE 2022 samples are passing.<br>One site with long-term data shows failing circa 75% of time.<br>Lime process has limited P removal. | Range from 180- 3700 mg/l<br>All samples failed. | Range from 1 to 800 mg/l.<br>Three sites with long-term monitoring available show general breach of standards and majority of DPHE 2022 samples fail | Long term shows camp 4 is close to target but still slightly over. Majority of DPHE 2022 data fails. Both long-term monitored plants (1E and4) show potential to remove helminth with zero and low numbers recorded i.e., some samples met this. | Largely infiltration. Some overflow from infiltration ponds (rain) or to surface water channel - needs proper design. |
| ABR | Data for 13 ABRs reviewed.<br>Five ABR FSTP have available data for intermittent stages in the process i.e., not just effluent. Note only one of the sites with full data was visited during the study. | Generally, within standard.<br>Consistently 7 to 10 through the process. | Range 100-250mg/l.<br>All sites effluent exceeded DoE standard, 1 outlier (1770 mg/l - could be an error but also shows high coliform, etc).<br>Majority (35% to 90%) reduction of BOD occurs in ABR (ahead of "filter inlet"). | Range 130 -1500mg/l<br>All sites effluent above standard, with two expectations (which are just below at 130 and 190 mg/l)..<br>Majority of COD removal (i.e., approx. 60%+ removal) occurs in ABR | All within standard. | Range 0-110mg/l generally higher than standard.<br>No obvious seasonal variation.<br>Removal in the ABR and filter. Filter is important (probably bound in solids which are removed here). | Range 25-2150 mg/l.<br>All fail on TN. | TSS typically 100 - 400 mg/l with circa 13% of FE samples pass solids standard. Majority removed in ABR (70%) then further reduction in filter and polishing pond. For the ABR visited generally 70 to 90% reduction through whole FSTP. | Only recent data (late 2021 and early 2022)<br>All over standard. | Largely infiltrated |
| Mega FSTP | Data for 1 FSTP reviewed. Data available from Nov 2020 to present. Site was visited during study. | Within standard | 40-240mg/l in FE. Reasonably consistent across year.<br>best | Range 85 to 850mg/l. Higher Sept to Nov (2020 and 2021). | All within standard. | All within standard. | Tn – | Range 0-175mg/l. TSS of FE within or close to standards majority of time.<br>Majority of solids, pathogens removed in Anaerobic lagoons step. | Pathogen in FE within or close to standards majority of time.<br>Generally in 0-8000cfu/ml E. coli. Majority of samples pass, perhaps some data errors. | |
| DEWATs | DEWATs sites were visited in camp 9 and 12. I,cddrb data from round 2 to 12 was used to inform this review. | Within standard | Generally fail<br>Range 50 to 1600 mg/l | Generally fail<br>Range 8 – 520 mg/l | Phosphate – Generally Within standard. 2/3rds of samples fail in later rounds of testing.<br>Range 15 to 200 mg/l | Nitrate Generally Within standard<br>Generally in range 1 to 40mg/l | All fail on TN. | Latest rounds of testing show two out of three sites within standards. Sites have improved from generally failing.Range 1 to 500mg/l, with some high spot samples (could be errors) | Majority of sites with 0 Helminth Eggs<br>E.Coli present in all sites in level about WHO standards for irrigation. | Infiltrated via infiltration bed |
| UFF | Two UFF sites were visited in camps 7 and 8W. | Within standard | Range 80 to 850mg/l. With some higher spot results. Failing BOD standards and relatively poorly performing. | Range 150 - 3000mg/l. Failing COD standards and relatively poorly performing. The smaller capacity have slightly lower solids removal hence lower BOD and COD removal. | All within standard with two exceptions. General range 8 – 100 mg/l | A majority within standard. 8-50mg/l. Some higher samples which correspond to other nutrient failures. | All fail on TN. | Range 20-850mg/l. breaching standards<br>Solids performance reasonably consistent over time. | E.coli range 600-23x10^6 plus cfu/100ml. Some sites, including one visited, show low value samples however performance is not consistent. | Infiltrated |
| ADS | Data from one site available, over long term and at intermittent process points as well as raw sludge and final effluent. This was for ad ADS in camp 26 which was visited during the study. | Within standard | Range 47-180mg/l<br>Breaching BOD standard but not significantly. Relatively low compared to other FSTP types. | Range 196-385mg/l<br>Breaching COD standard but not significantly. Relatively low compared to other FSTP types. | Range 5-270mg/l | Range 6-62mg/l<br>All passing the standard for nitrate and phosphate (with exceptions Aug and Sept 2021). | No data for TN. | TSS range 47-124mgl/ consistently good. TSS is below standards most of the time.<br>All stages act to remove solids, majority ahead of the constructed wetland (final) | Good Helminth removal (0) and 50:50- E. coli removal (0-20000cfu/100ml) | Low volume of liquid for disposal. Soak pit. |
| WSP | Monitoring data was available 13 WSPs FSTPs, managed and operated by four different NGOs. Two of the sites with available data were visited during this study (camp 7 and 8W). Only raw sludge and FE data was available with no intermediate site monitoring. Limited coliform data available. | Within standard | Range 10-1600mg/l Ave 300mg/l COD and BOD (and SS) improved removal over time but still above standards. | Range 16-2500mg/l.<br>Improved removal over time but still above standards | Ave 50mg/l. All passing the standard. | Range 2-20mg/l. All passing the standard. | All fail on TN. | TSS range 10-500mgl/ generally good (Ave 135mg/l). | Range 240 - 35mill+ cfu/100ml.<br>Limited data available. All FE results are high (i.e., above standard and relative to other FSTP types). | To natural drain (assume linked to surface water system) and soak pits |
| Aeration | Data from one FSTP. Sampling is conducted of raw sludge and effluent as well as at key point through the process flow. Long term monitoring data was provided for seven months of 2021 | Within standard Consistent around 8.5 | Assume good alongside COD results | FE range 80 – 600mg/l. Some evidence of seasonal variation – lower COD in FE between June to Sept. | 0mg/l for FE | FE higher than influent but still within standard (16mg/l) | | TS 500mg/l. but 0ml/l Sludge vol | All below 100 CFU/ml and show 'no growth after chlorination. | Surface water stream via banana plants |

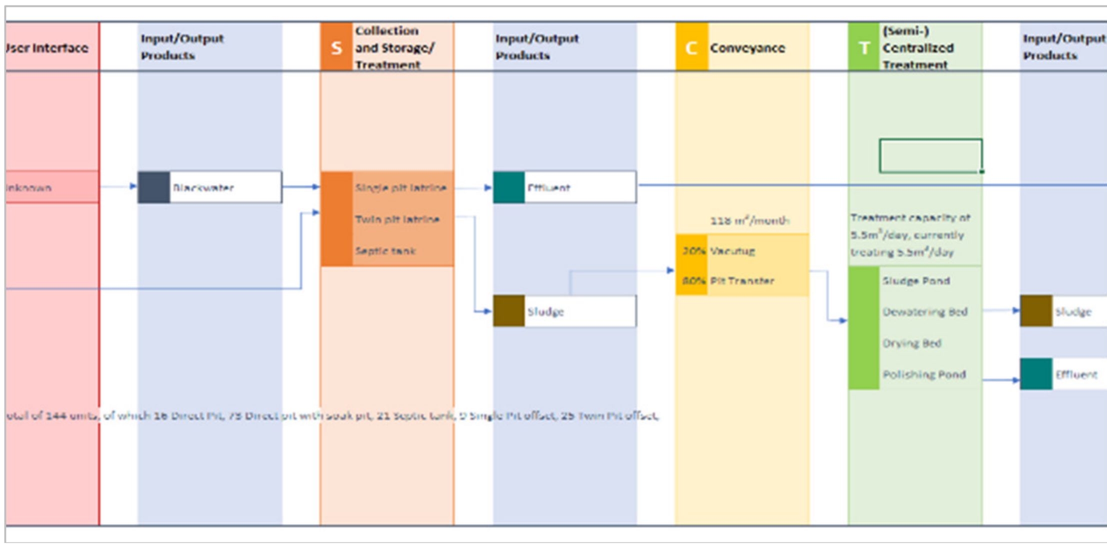
# Treatment / FSTPs

**Moving to best practice**

- Various site/ context specific recommendations (e.g. to inform longer term CxB FSM Strategy)
- **Decision tree for FSTP based on driver and context**
- Planning full FSM chain (existing design/ planning tools e.g. Shit flow diagrams, lessons learnt from CxB etc)







# Disposal / reuse

Key findings

- **Space limitation** was a constraint to safely disposed or reuse the final solids.
- Need to understand **market and acceptability for sludge products** (compost, gas etc) to understand if cost efficient
- Consolidation/**centralisation of solids treatment** can help 'free up' space at FSTP, *but additional processing needed?*

# Disposal / reuse

**Moving to best practice**

- Storage space must be adequate to allow pathogen die off
- Various guidelines on safe reuse and quality control (e.g. agri reuse and compost standards).
- Consider/ plan FSM chain from final disposal (land bank/market)

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# Conclusion

**Response to research questions**

## Question 1

Does the FSM chain meet the need? i.e., does each stage in the FSM chain have capacity to meet sludge generation, what are the bottlenecks and inefficiencies, and how can these be addressed?

## Question 2

Which type of FSTP is performing best against most assessment parameters? Including reasoning for improving or decommissioning FSTPs.

## Question 3

Which mode of transfer/transport is most cost effective and resilient?

## Question 4

Does the containment type influence the sludge chain and which containment is best?

## Question 5

Is the centralised or decentralised approach of FSM more cost effective?

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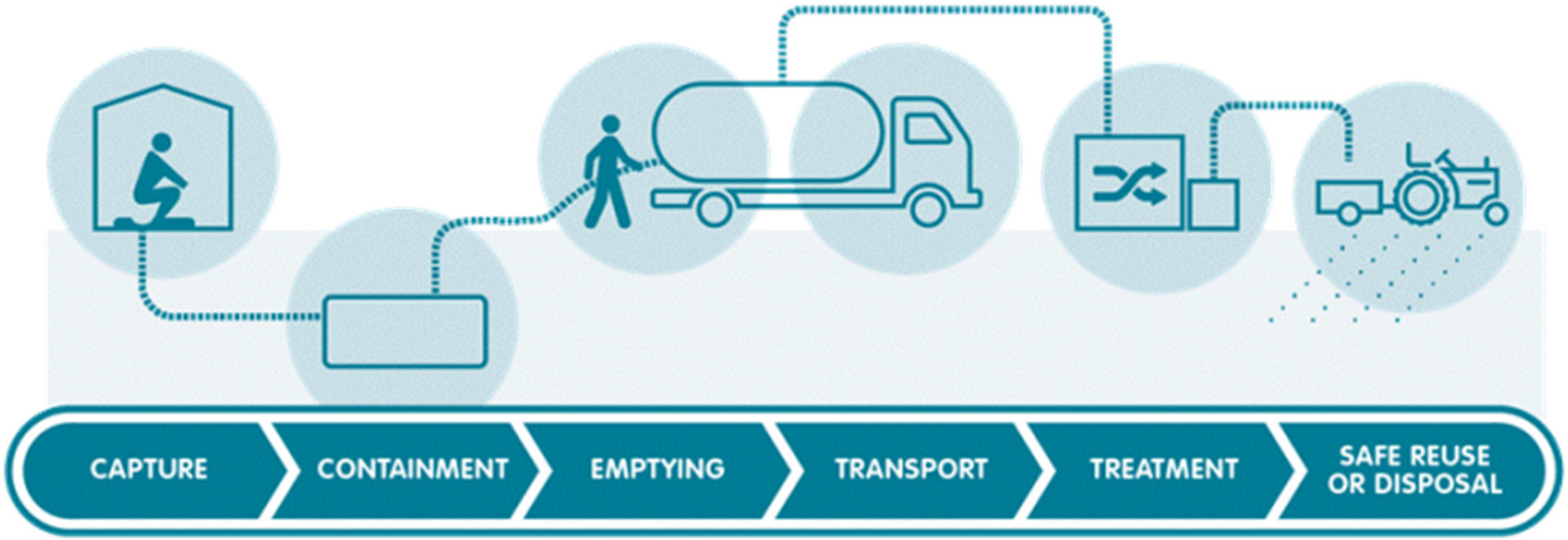
# Summary / recommendations

- Planning of whole FSM chain based on the governing design criteria i.e. phase of emergency, space available, capex, opex, FE quality, sustainability etc.



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# Summary / recommendations

**Illustration of considerations from CxB**

- Initial emergency phase – aeration and chemical treatment fastest to commission (&de commission) and can be modular, but higher opex
- Larger scale, multi process approach gave best FE quality but high capex (good WLC)
- Final (liquid) disposal footprint can be the pinch point to the FSM chain
- Low energy/ nature based treatment are likely to be more sustainable but has larger footprint and take time to commission
- Economies of scale for transfer and treatment – i.e. determining the tipping point for pipe network and centralised FSTP to be most cost effective

# Next steps

- FSTP decision tree for humanitarian context - being developed by Oxfam and Arup
- CxB FSM Strategy and long term planning - being developed by local WASH sector
- Opportunities for further assessments in CxB to draw internationally applicable lessons learnt (great knowledge/ data pool!)

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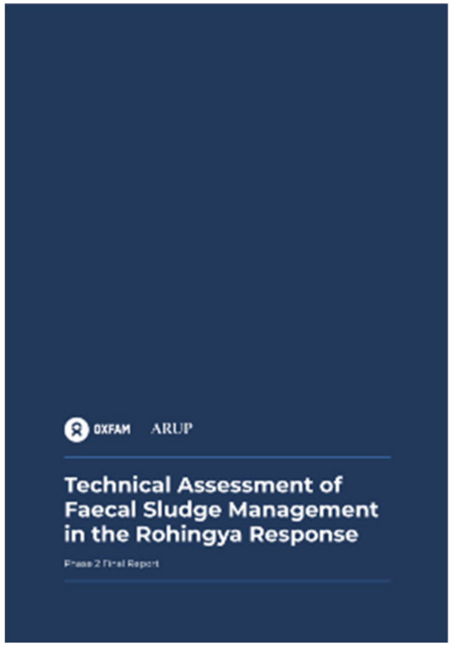
# Thank you and questions

Read the full report here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Phase 2 Final Report

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# Contacts

## Key study contacts

**Anna Grieve**

Senior Engineer

Project Manager (Arup)

**Safwatul Haque Niloy**

Sanitation Coordinator (Oxfam)

Project Manager (Oxfam)

**Paula de Amuedo**

Consultant, International Development

Stakeholder Engagement and Civil Engineer (Arup)

**Mariana Gonvcalves**

Wastewater Engineer and Modeller

Wastewater Engineer (Arup)

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