CASE STUDY 1

Mechanised and conventional faecal sludge treatment

Duri Kosambi,
Indonesia

Background

Treatment selection and purpose

The Duri Kosambi Faecal Sludge Treatment Plant (FSTP) is one of two FSTPs operating in Jakarta. The other plant is the Pulo Gebang FSTP. Both are managed by PD PAL Jaya, a city-owned sewage management company.

The Duri Kosambi FSTP consists of a conventional system (non-mechanised) built in 1983, and a mechanised system built in 2013. The plant treats faecal sludge from septic tanks. The main criteria for the selection and design of the FSTP were cost and land availability. When the conventional system was built, the technology was chosen because of its lower operating costs. When the plant needed expansion, land availability was limited, and so a mechanical system which needed less space was chosen. PD PAL's former Director explained that the municipality paid for the construction of the treatment plant, but PD PAL has had to make additional investments since it took over management and operation in 2016 (i.e., faecal sludge trucks, vacuum trucks, computers and related systems, pump, screen, etc.). PD PAL self-finances all operation and maintenance (O&M) costs.

> *The main reason for selecting the technology is the operating cost. The conventional system has the cheapest operating cost - so we built one in 1983. By 2013 we needed to increase the treatment capacity. Because conventional systems require a large area, we decided to use the mechanical system as an alternative to cope with the low land area availability.*
>
> **FORMER PD PAL JAYA DIRECTOR**

Mechanical sludge screening from vacuum trucks

Description of the system

A flow diagram of the treatment plant is shown in Figure 1. Trucks transport septage from septic tanks to the treatment plant. There are two sludge receiving areas – one for the conventional system and one for the mechanical system.

Table 1 shows Duri Kosambi FSTP's design and operational capacity. PD PAL spends approximately 50% of its operational costs on labour, with other major costs including electricity and chemicals for the treatment system. The remaining costs are for water, meals, vitamins, health insurance, employment insurance, uniforms, and safety equipment.

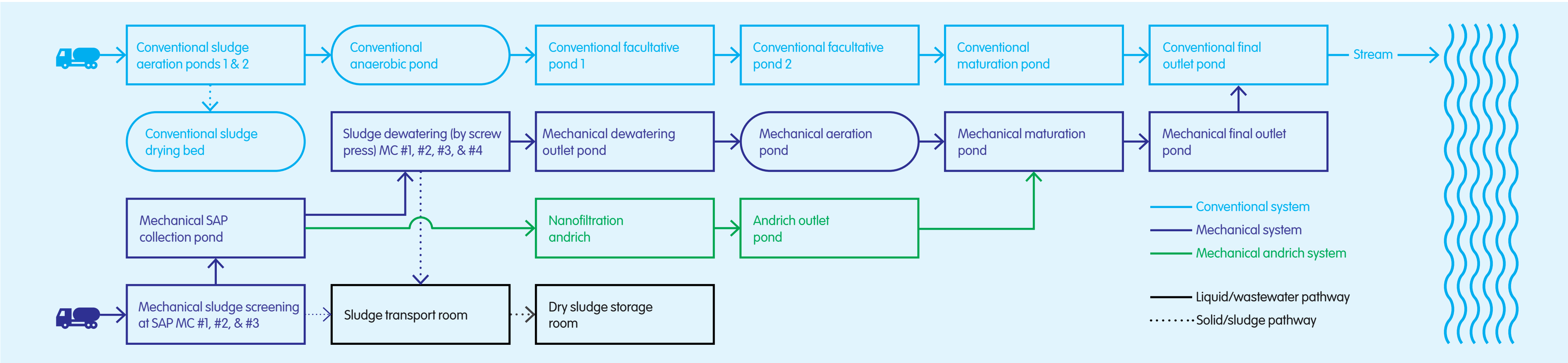
Table 1. Capacity and operating costs of Duri Kosambi FSTP

	Conventional system	Mechanical system
Design capacity	300 m^3 of sludge/day	600 m^3 of sludge/day
Operating capacity	140-200 m^3 of sludge/day	

Conventional maturation outlet

Mechanical sludge screening using Huber acceptance plant

Figure 1. Block flow diagram of Duri Kosambi FSTP[1]



[1] Block flow diagram drawn by SNV based on site visit interviews.

Regulatory environment and compliance

During the design and planning of the Duri Kosambi FSTP, the main regulatory and compliance standard followed for effluent quality was the Governor's Regulation (*Pergub*) No. 122/2005 of 2005. Since 2016, a more stringent effluent quality regulation has been applied in Indonesia.[2] The 2016 regulations introduced more stringent standards for Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD), and oil and grease. The Chemical Oxygen Demand (COD) requirement is now less stringent; potassium manganate ($KMnO_4$) and Methylene Blue active substance (MBAS) are no longer regulated but coliform bacteria monitoring has been introduced. The most recent laboratory results for the Duri Kosambi FSTP showed that in some respects, effluent quality did not meet the standards, and there were no reports on concentrations of coliform bacteria, oil and grease, despite being covered by the new regulations.

To comply with the new 2016 effluent standards, PD PAL installed an additional filter at the outlet pipe of the maturation pond before the water enters the final outlet pond. PD PAL installed the new filter to minimise TSS concentrations. PD PAL also installed a blower for additional aeration in the final outlet pond. While these actions have improved Duri Kosambi's effluent quality performance, additional improvements to the treatment process are still needed to comply with the standards.

Table 2. Influent and effluent qualities of wastewater treated at Duri Kosambi FSTP plant in 2019, as compared to effluent standards

Parameter	Inlet	Outlet	Standard (No. 68/2016)	Method
pH	6, 45-7, 88 pH	7, 12-7, 61 pH	6-9 pH	SNI 06-6989.11-2004
Total suspended solids, TSS	340-8933, 33 mg/L	22, 5-84, 29 mg/L	30 mg/L	SNI 06-6989.26-2005
Biochemical oxygen demand, BOD_5	106, 38-646, 82 mg/L	2, 76-69, 79 mg/L	30 mg/L	Respirometric, 2005
Chemical oxygen demand, COD	687, 9-2780, 37 mg/L	41, 25-127, 67 mg/L	100 mg/L	Spectrophotometric, 2002
Total organic matter, $KMnO_4$	108, 04-568, 72 mg/L	54, 21-150, 50 mg/L	85 mg/L	SNI 06-6989.22-2004
Ammonia, NH3-N	108, 75-239, 25 mg/L	0, 45-29, 81 mg/L	10 mg/L	Spectrophotometric
Methylene blue active surfactant, MBAS	0, 74-2, 69 mg/L	0, 13-0, 78 mg/L	2 mg/L	Spectrophotometric

Operation and maintenance: realities, challenges, and opportunities

Realities of running the treatment plant

Distribution of sludge at acceptance

The distribution of the incoming sludge into the two systems (conventional and mechanical) is determined by the number of trucks and the amount of sludge received. If, for example, five trucks arrive simultaneously, the sludge is distributed between the conventional and mechanical systems to facilitate a speedy acceptance process. If fewer trucks arrive on any given day, then all the sludge is directed towards the conventional system, as the operating costs of energy and chemical requirements are much lower than for the mechanical system.

The distribution of sludge also depends on maintenance and operation schedules. If the mechanical system is under maintenance, all sludge goes to the conventional system, and vice versa. Furthermore, sludge can only be discharged into the mechanical system in the morning as the trained machine operators required for this task are only present in the mornings, whereas the conventional system requires hardly any supervision.

[2] *Regulation of Ministry of Environment and Forestry of the Government of Indonesia* (2016) Permen LHK No. 68/2016

Staffing requirements

Sixty people work at the Duri Kosambi and Pulo Gebang FSTPs. There are eight permanent staff who manage both FSTPs and 26 non-permanent staff working at Duri Kosambi only. The 26 staff include 13 operators (two for the conventional system, four for the mechanical system, one for an Andrich pre-treatment system currently being trialled, and six recording inflows) and 13 workers responsible for security, administration, driving, and cleaning. Most operators have a high school or vocational school qualification. Since staff and operators do not work after hours, PD PAL relies on the security guard to prevent after-hours entry to the facility, handle emergency issues, and report any problems (such as power outages) or technological disruptions (such as the blower ceasing to function).

Staff at the facility have all received training on Occupational Health and Safety (OHS), asset management, and general operation of the treatment plant from the Ministry of Public Works. The operators received training in the operation of the treatment plant from a USAID-funded water and sanitation urban development programme, with some receiving additional administrative training as well. Operators are all equipped with safety uniforms, helmets, boots, and gloves, and are trained in using the safety equipment. However, no specific OHS Standard Operating Procedure (SOP) exists at the facility for the handling of untreated and treated effluent and sludge.

> *If there is any power failure here, the mechanical system will be disrupted since it requires electricity to function. We are fortunate that we also have the conventional system in Duri Kosambi STP which does not require electricity. However, when the blower dies in the aeration tank during an electricity outage it will interrupt the aeration process.*
>
> **HEAD OF IPLT DURI KOSAMBI**

Operating costs vs. revenue

At present, the Operation and Maintenance (O&M) costs for both the Duri Kosambi and Pulo Gebang FSTPs exceed the revenue produced by the two facilities. The revenue that PD PAL earns from private desludging companies discharging faecal sludge into their facilities is US$ 1.80/m^3 of sludge. For its PD PAL-managed desludging service, PD PAL charges households US$ 11/m^3, with an average charge of US$ 22 per household. To cover the current income gap, PD PAL uses funding from its other business units, namely a sewerage service in central Jakarta.

The income gap is primarily due to the facilities operating below capacity. At the Duri Kosambi FSTP, 140-200 m^3/day of sludge is currently being processed, while the facility's capacity is 900 m^3/day. The facility is not expected to reach 100% capacity until 2050.[3] The underutilisation is being addressed through promotion and communications campaigns to inform households of the benefits of regular desludging. This is challenging, as many households prefer septic tanks that seep effluent into the ground over those that require desludging, and awareness of any need to empty their tanks is generally low.

Electricity supply and continuous maintenance

A constant power supply and continuous maintenance are crucial for ensuring that both the mechanical and conventional treatment systems function properly. A generator has been installed as a back-up for potential power failures. However, according to the former PD PAL Director, the generator is hardly required as power outages rarely occur in Jakarta. Power is quick to come back when they do occur.

Continuous maintenance of equipment and facilities requires significant financial and human resources to ensure optimisation of the treatment process. When PD PAL took over management and operation in 2016, interviews with staff and operators revealed that significant maintenance and repair work was required to restore the facility to its well-functioning condition. A current trial with an Andrich (mechanical) pre-treatment system is part of the optimisation and improvement efforts of PD PAL.

Challenges of operation and maintenance

Contamination of sludge received

One of the main operational challenges faced by the Duri Kosambi facility is the contamination of the received faecal sludge with oil and grease, likely discharged by restaurants into their septic tanks, as well as coarse sand and trash from household septic tanks. The facility sometimes also receives sludge containing artificial dyes, which operators are only able to detect after final treatment. As the facility is not designed to treat restaurant or industrial wastewater, these contaminants negatively affect the treatment plant's performance.

[3] JICA, *Masterplan of Wastewater Management in DKI Jakarta*, Jakarta, JICA, 2012.

Conventional aerobic pond

A Huber screw press unit in operation

To overcome these challenges, the SOPs state that operators should add 'chemicals' to the system, but the types of chemicals are not known. The SOPs also say that contaminated sludge should be isolated for mechanical treatment. Using the mechanical treatment ensures that oil and grease do not settle in the conventional pond system or clog the connecting pipes. At present, there is some discussion on whether fees for sludge disposal could be charged, not just on the basis of the quantity of sludge received, but also on the quality, given the impact of poor-quality sludge that flow into the system. However, PD PAL is reluctant to increase prices as doing so may further reduce the amount of sludge received.

Technological breakdowns and related capacity challenges

The most common operation and maintenance issues include failing pumps, blowers, and surface aerators; leaking and corroded pipes; ineffective conventional screening processes; and limited capacity to repair technologically demanding treatment units.

Sludge containing rough sand and gravel, which are not removed in the conventional screening process, causes damage to the piping and structures as it slowly scours the concrete in the conventional system. The treatment plant manager explained that ideally, the inlet system is re-designed to screen rubbish and settle out rough sands more effectively, and to take up less space. If these adjustments are made, the mechanical sludge acceptance plant would not be needed. All the processing could then be done by the conventional system. This would require fewer financial resources.

The most demanding treatment units to operate are the mechanical Huber's Screw Press Dewatering Units. The operators do not have the technical capacity to troubleshoot issues or repair damage, as operation and control are performed through an electrical control panel. Technicians from Huber's distributor office in Jakarta are required for these tasks, and all spare parts have to be ordered from Malaysia. Despite these challenges, the dewatering system has never been out of service as there are three units at the facility, each with a capacity of 150 m^3/day. So, if one unit is out of service, the other two can be relied on.

> *We often receive sludge from the restaurant or food industry that contains high fat, grease, and oil which causes a bad smell throughout the system and clogs the pipes. We have to add some chemicals so that it won't cause a smell. Also, we are forced to operate the mechanical system on weekends rather than only the conventional system, to treat the sludge faster so that the fat, grease, and oil are not settled in the system.*
>
> **HEAD, DURI KOSAMBI FSTP**

Fuel briquettes

Opportunities for reuse and optimised treatment

Piloting the production of briquettes

At present, treated sludge from the Duri Kosambi FSTP is collected and stored at the facility. Pilot research is underway with the State Electricity Company to convert the treated sludge into briquettes for reuse as fuel. Two types of briquettes are being trialled. One consists entirely of treated sludge, and the other is a mixture of treated faecal sludge (80%) and organic waste (20%). The pilot research suggests that 12 kg of briquettes could produce 3,500–4,500 watts of electricity, which is approximately half of coal's calorific value. PD PAL is considering to sell these briquettes to a power plant based in Bogor, but the distance from Duri Kosambi to the power plant (more than 70 km) means that this is not currently financially viable, due to the significant transport costs. Furthermore, the low quality and calorific value of these briquettes, as well as the abundant supply of cheap Liquefied Petroleum Gas (LPG), means that the current market value of briquettes is low.

Andrich unit being operated

Andrich treatment system

In an effort to optimise and improve treatment performance at Duri Kosambi, an Andrich treatment system is currently being trialled as a pre-treatment system. Andrich is named after two Indonesian engineers who developed the system, Andri Oba and Chariunnas. The system consists of a nanofiltration membrane unit, which is equipped with a Dissolved Air Flotation (DAF) system. Water from the Sludge Acceptance Unit (SAP) effluent collection pond is pumped into a conventional DAF system and then filtered in the nanofiltration membrane unit. The effluent is then discharged into the Andrich outlet pond. From the outlet pond, the overflow enters the mechanical maturation pond and mixes with overflow from the mechanical aeration pond. The operating cost for the Andrich system is US$ 1.50/m^3 of sludge, with US$ 1 of this amount required for skilled labour. Besides its cheaper operating costs as compared to the existing two systems, the main benefit is the far superior quality of the effluent that is produced.

Informed choice considerations	Duri Kosambi FSTP in Jakarta, Indonesia, PD PAL Jaya (government-owned wastewater company)
Operating & design capacity	Design capacity = 900 m³/day Operating capacity = 140-200 m³/day
Revenue	Combined revenue (Duri Kosambi and Pulo Gebang FSTPs) = US$ 366,686/year (gap with operational expenditure [OPEX], met through PD-PAL offsite sewerage tariffs)
Energy requirements	Mechanical and conventional natural systems – the natural (or conventional system) is preferred, as the energy and chemical requirement costs are lower
Input characteristics	Sludge with pH = 6.9; TSS 2,100 mg/L; BOD 800 mg/L; COD 900 mg/L
Output characteristics	Effluent liquid quality (*Effluent limit as per environmental compliance standard Permen LHK 68/2016*): pH = 7.4-7.7 (*6-9*); TSS = *60-70 mg/L* (30 mg/L) (does not meet standard); BOD = 35-60 mg/L (*30*mg/L) (does not meet standard); and COD = 90-160 mg/L (*100* mg/L) (does not always meet standard) Coliform bacteria and oil and grease not reported on despite being regulated in the new regulations
Land requirement	Land area was a constraint therefore a mechanical system with a small footprint was chosen to complement the conventional natural system
Reuse	Currently piloting briquette production as an alternative fuel source; income potential is limited due to low quality of the briquettes and high transport costs, although doing so will avoid sludge disposal costs
Skills & human resources requirements	60 people total (Duri Kosambi and Pulo Gebang FSTP): 8 permanent staff at both FSTPs; 26 staff at Duri Kosambi FSTP; 13 operators (2 for the conventional system, 4 for the mechanical system, 1 for the Andrich system and 6 recording inflow); and 13 workers responsible for security, administration, driving, and cleaning
Technology/material (local) availability	Mechanical Huber's Screw Press Dewatering Units' spare parts not locally available in Indonesia, must be ordered from Malaysia

References

JICA, *Masterplan of Wastewater Management in DKI Jakarta*, Jakarta, JICA, 2012.

Regulation of Ministry of Environment and Forestry of the Government of Indonesia (2016) Permen LHK No. 68/2016

This paper is a chapter in a publication of nine case studies presenting real-life faecal sludge and wastewater treatment practices. The stories were narrated by plant owners, operators, SNV staff, and partners in Indonesia, Bangladesh, Kenya, Zambia, Malaysia, India, South Africa, and Benin. The full publication was reviewed by Antoinette Kome and Rajeev Munankami, and available for download at: https://snv.org/cms/sites/default/files/explore/download/2021-treatment-technologies-in-practice-snvisf-uts-full-publication.pdf.

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