CASE STUDY 8

Use of rotating biological contactors

Banjarmasin, Indonesia

SNV

UTS Institute for Sustainable Futures

Background

Treatment selection and purpose

The Pekapuran Raya Waste Water Treatment Plant (WWTP) is one of seven WWTPs in Banjarmasin city that uses rotating biological contactors (RBCs) for the treatment of wastewater. The Pekapuran Raya plant has been in operation since 2008. All seven WWTPs in Banjarmasin city are owned by central government but are operated and maintained by PD PAL Banjarmasin, an independent government-owned company.

Several stakeholders were involved in selecting and designing the RBC technology and facility, including the local Public Works and Housing Office representatives, the provincial technical team of the Ministry of Public Works and Housing, the Director of PD PAL Banjarmasin, and a local consultant who designed the facility. The final decision on the technology and facility design was made by the Public Works and Housing Office in Banjarmasin. The decision was based on ease of operation, land area requirements, operational cost, and ability to meet the required effluent standards. The RBC technology requires operators to have mechanical maintenance skills, but no process control function skills. The technology does not require a large land area, which made it suitable for Banjarmasin city as it is densely populated and available land is scarce. The RBC requires electricity to operate, but compared to other mechanical technologies, the electricity requirements, and therefore operational costs, are lower.

> *The RBC technology was chosen because it is easy to operate, [it] does not need special skills to operate, and it does not require a big area. Land availability is quite an issue in Banjarmasin.*
>
> **HEAD OF TECHNICAL DIVISION, PD PAL BANJARMASIN**

Rotating Biological Contactor (RBC) Unit

Description of the system

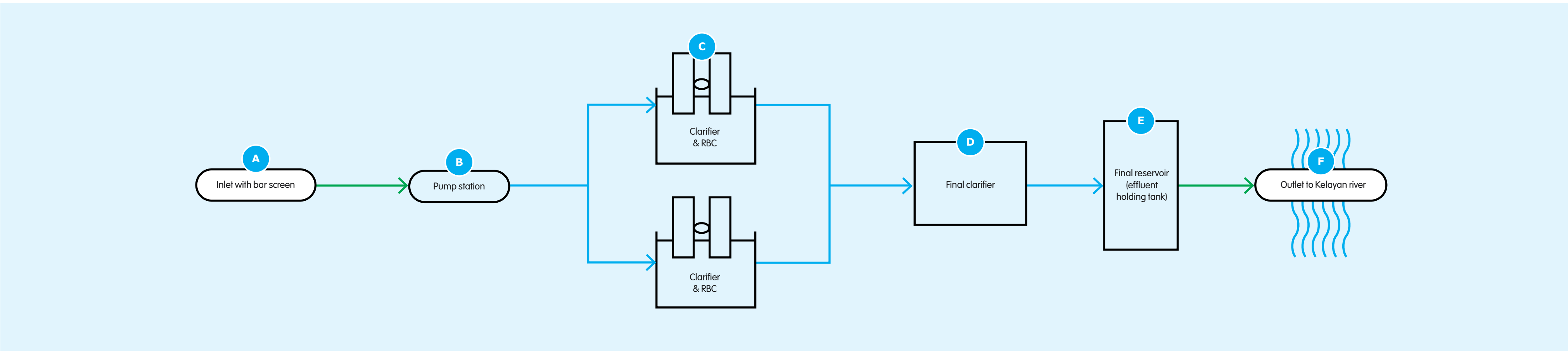
The wastewater at the Pekapuran Raya WWTP is treated using a biological treatment process, which relies on the RBCs for secondary treatment. The wastewater, which includes greywater and blackwater from households, hotels, restaurants, and offices, is delivered to the facility via a piped network. The treatment process is outlined in Figure 1.

As shown in Figure 1 the treatment process starts with step A, which is the inlet from the main sewer pipe delivering wastewater to the facility. Step B is the sewage pump station, which pumps the wastewater from seven metres below the ground to the processing unit. A bar screen before the pump station unit screens solid waste from the wastewater as part of the primary treatment process. In Step C, two clarifiers and two RBC units (8.15m long) are used for secondary treatment of the wastewater. The RBC consists of a series of closely spaced, parallel discs mounted on a rotating shaft, which is supported just above the surface of the wastewater. Microorganisms grow on the surface of the discs where biological degradation of the wastewater pollutants takes place. The rotating packs of disks, known as the media, are placed in a tank and rotate at 2-5 revolutions per minute. The shaft is aligned so that the discs rotate at right angles to the wastewater flow, with approximately 40% of the disc area immersed in the wastewater.[1]

Bar screen with submersible pump

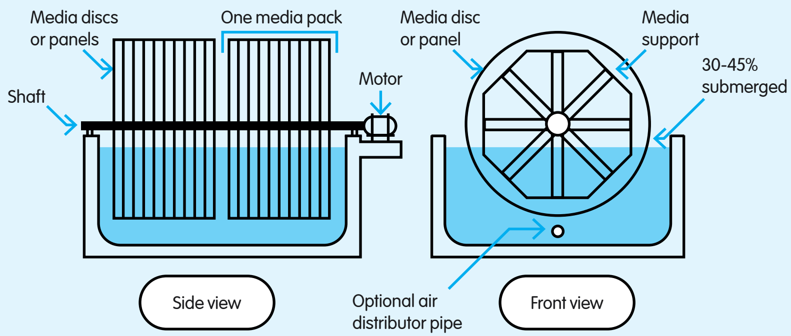
Raw sewage pump station

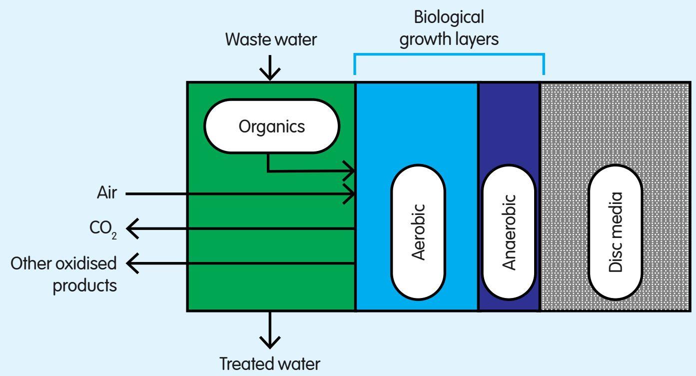
Figure 1. Treatment process at the Pekapuran Raya WWTP,[2] adapted by SNV



[1] R.L. Antonie, *Fixed biological surfaces – wastewater treatment: the rotating biological contractor*, CRC Press, 2018, https://doi.org/10.1201/9781351072045 (accessed 25 November 2020).
[2] Schematic diagram of treatment process based on SNV's site visit in 2019.

Figure 2. Schematic diagram of a typical RBC (left) and a schematic cross-section of the contact face of the bed media in an RBC (right),[3] adapted by SNV





The treatment process continues with the final clarifier (Step D in Figure 2), which is a settling tank designed to separate solids from water by allowing heavy suspended solids to settle to the bottom and clarified water to overflow at the top. Powdered chlorine is added as a disinfectant. The sludge layer produced at the bottom of the clarifier is desludged and disposed of at the Basirih Faecal Sludge Treatment Plant (FSTP) in Banjarmasin. Step E of the treatment plant consists of the final reservoir where the processed wastewater is held for 3-6 hours before release into the Kelayan River (Step F). Samples of the effluent are tested for quality before final disposal. Some water from the outlet is reused to water plants at the WWTP. Water is collected through a separate pipe and filtered so that it meets suitable quality standards for watering non-edible plants.

Table 1. Capacity and operating costs of Pekapuran Raya WWTP

	Pekapuran Raya WWTP
Design capacity	2,500 m^3/day of greywater and blackwater
Operating capacity	250-500 m^3/day of greywater and blackwater
Operating costs	US$ 84,000 per year for all seven WWTPs operated by PD PAL Banjarmasin

Regulatory environment and compliance

National and regional government environmental standards for influent and effluent quality are followed at the Pekapuran Raya WWTP, with regular testing conducted to comply with these regulations. The influent and effluent quality are checked monthly against the Ministry of Environment Effluent Standard (Peraturan Menteri Lingkungan Hidup No. 68/2016) and the Regency of South Kalimantan Effluent Standard (Peraturan Gubernur Kalimantan Selatan No. 36 Tahun 2008). Some daily checks are undertaken, including pH, temperature, and Dissolved Oxygen (DO). Monthly testing is conducted by a City Environment Agency laboratory and the Provincial Environment Agency laboratory conducts random sampling of the facility's influent and effluent quality 2-3 times per year. The quality of waste inputs has been found to be quite consistent, with some occasional spikes in Biochemical Oxygen Demand (BOD). Further analysis to understand BOD spikes has not been conducted to date.

> *The performance of the treatment facilities is consistent in that the effluent quality is always below the regulated effluent standard. One time, before the current regulation was enacted in 2016, the number of E. coli spiked. However, since the new effluent standard only checks the total coliform parameter, the E. coli amount is not measured anymore. Currently, to ensure that the total coliform parameter is below effluent standard, the dosing of chlorine disinfectant is adjusted.*
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> **SECTION HEAD OF PIPE NETWORKS DIVISION, PD PAL BANJARMASIN**

[3] M.R. Beychok, *Aqueous waste from petroleum and petrochemical plants, 1st edition*, John Wiley & Sons Ltd., 1967, p. 262.

Table 2. Influent and effluent quality for the Pekapuran Raya WWTP

Parameter	Input	Output	Ministry of Environment Effluent Standard (Permen LHK 68/2016)	Regency of South Kalimantan Effluent Standard (Pergub 36/2008)
Temperature (°C)	28.5	28.3	–	–
pH	7.06	7.53	6-9	6-9
Total Suspended Solid (TSS) (mg/l)	25	6	30	100
Biochemical Oxygen Demand (BOD) (mg/l)	45.48	9.74	30	100
Chemical Oxygen Demand (COD) (mg/l)	115.99	24.84	100	–
Grease and oil (mg/l)	1.3	0.5	5	10
Ammonia (mg/l)	26.19	10.58	10	–
Total coliform (MPN/100 ml sample)	2,940	2,400	3,000	–

Operation and maintenance: realities, challenges, and opportunities

Realities of running the treatment plant

Construction considerations

During the construction of the WWTPs the environmental impacts were assessed to ensure quality standards were met and public objections considered.

The city of Banjarmasin is relatively flat. It is crossed by many rivers and has numerous swamps. Due to changing river tides, flooding is common and the swampy conditions cause soft soils. Therefore, in building the seven WWTPs, all structures were constructed on strong and deep piles above ground to prevent flooding. The Provincial Technical Team from the Ministry of Public Works and Housing ensured that the planning and construction quality criteria were met, as stipulated in the Ministry of Public Works and Housing Regulation No. 4 2017 on Waste Water Management.

Generally, none of the WWTPs experienced any challenges during construction, except for the newest WWTP where there were public objections to its development. PD PAL Banjarmasin addressed their concerns through regular information sessions, explaining that the WWTP would improve cleanliness and lead to better health outcomes for the community. Since that time, PD PAL Banjarmasin has been able to obtain a land ownership certificate. The land has been cleared, the WWTP has been constructed, and it will begin operations shortly.

> *We have not faced any public rejection up until our last Sultan Adam WWTP that was built in 2012. The community around Sultan Adam WWTP refused to connect their household pipe to the main pipe network because they did not want the WWTP to be built close to their houses. They perceive[d] that WWTP [to be] dirty and will have a bad smell.*
>
> **HEAD OF TECHNICAL DIVISION, PD PAL BANJARMASIN**

Inlet automatic flowmeter

Outlet pipe

RBC bearing

Continuous operation and maintenance of the facility

Several typical operation and maintenance (O&M) activities are required to ensure the smooth and continuous functioning of the Pekapuran Raya WWTP. These activities include:

- daily bar screen cleaning to remove debris and effluent checks of pH, temperature and dissolved oxygen;
- monthly influent and effluent laboratory quality checks and maintaining RBC motor parts; and
- quarterly checks of clarifiers to assess desludging requirements.

Power failures of 2-3 hours are common in Banjarmasin, which requires the facility to have a diesel power generator to ensure continuous operation of the WWTP. The power generator in use has an 80-100kVa capacity, which is sufficient to manage all the WWTP operations during outages.

Staffing and training

A small operator team of five ensures the continued operation of the Pekapuran Raya WWTP. One operator is the team coordinator. As the operators also perform security functions for the facility, they are provided with accommodation on the facility grounds.

A standard operating and maintenance procedure was developed for the facility by the vendor, Enviro, who supplied the RBC technology. The operators received on-the-job training from Enviro when the WWTP began operation in 2008. Additional training for all WWTP operators in Indonesia was provided by the Ministry of Public Works and Housing. However, not all operators who currently work at the Pekapuran Raya WWTP were employed at that time. As such, on-the-job training is provided to new recruits by existing operators. The peer-learning training sessions focus on the mechanical and electrical O&M of the facility.

Challenges of operation and maintenance

Limitations in operating and maintaining the WWTP

Ensuring continuous O&M of the RBC technology is essential for the overall functioning of the WWTP. However, the operators have found that some of the tasks involved are challenging. Critical elements of the RBC technology, which must be maintained include the shaft that keeps the bacteria media intact, and the bearing that keeps the RBC rotating. For the current operator, changing or repairing the bearing of the RBC can take up to one month. The facility does not have the required budget to hire an RBC technical expert, who would, reportedly, do the job much more quickly. As a result, such tasks unnecessarily hinder operations. Further, the occasional cleaning and desludging of the RBC basin is necessary, which requires one of the RBC units and clarifiers to be switched off to allow access.

> *When it comes the time to clean the sludge generated in [the] RBC basin, the RBC needs to be stopped and lifted so that the workers can desludge and clean the sludge chamber. This requires quite a long time, though we can operate the other RBC pairs. But to have the sludge chamber redesigned to improve access for cleaning and desludging would be really nice.*
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> **SECTION HEAD OF PIPE NETWORKS DIVISION, PD PAL BANJARMASIN**

Adjustments to the final clarifier and outlet flowmeter would optimise the treatment process. The final clarifier requires powdered chlorine to be added to ensure that the total coliform level meets the required effluent quality standards. However, powdered chlorine sometimes clogs the disinfectant tube, and manual dosing has led to inaccurate amounts being added. Switching to a liquid disinfectant could prevent clogging and inaccurate dosing. Within the outlet pipe, a mechanical flowmeter often gets clogged by sediment. Replacing this with a non-mechanical flowmeter could address this problem.

Occupational health and safety (OHS) considerations

While OHS measures are part of the Pekapuran Raya WWTP's standard operating guidelines, the extent to which they are upheld varies. Personal protective equipment such as safety jumpsuits, hard helmets, hard boots, and gloves are provided to facility staff, however many operators do not use these items due to the hot weather and inconvenience they experience in wearing them. To combat this problem, the management team of PD PAL Banjarmasin runs frequent awareness sessions about the importance of protective clothing. Some occupational hazards were also observed during the research field visit, such as the lack of a rigid railing around the RBC basin to prevent people from falling in. Such considerations do not appear to have been part of the facility's OHS design considerations.

Financial arrangements not yet covering all O&M costs

All capital expenditure (CAPEX) costs for the Pekapuran Raya WWTP were paid by the national government through the Ministry of Public Works and Housing. However, PD PAL Banjarmasin is currently unable to cover all of its O&M costs. The operational expenditure (OPEX) for each individual WWTP has never been calculated, but the combined cost for all seven WWTPs is US $84,000 per year. PD PAL Banjarmasin earns revenue from wastewater management services tariff paid by households and commercial businesses, which are approximately US$ 1 and US$ 6 per month, respectively. This revenue contributes to O&M costs. If customers also have a piped water connection, then their wastewater management tariff represents 25% of the water bill. The revenue recovered by PD PAL Banjarmasin is used to cover some O&M costs, including

Disinfectant dosing unit, with the final clarifier below the tiles pictured

laboratory testing, disinfectant procurement, electricity bills, desludging and sludge cleaning costs, as well as the cost of spare parts and oil for mechanical parts. At present, PD PAL Banjarmasin incurs a budget deficit of US$ 6,470 per month for the O&M costs of all seven WWTPs. The company is conducting awareness activities to inform the community of the benefits of connecting to the piped wastewater network, but further efforts are required to increase demand for wastewater services, which will in turn increase revenue.

Informed choice considerations	Pekapuran Raya WWTP in Indonesia (PD PAL Banjarmasin)
Operating & design capacity	Design capacity = 2,500 m^3/day of greywater and blackwater Operating capacity = 250-500m^3/day of greywater and blackwater
Costs and revenue	Capital expenditure, CAPEX = US$ 256,870 to build Pekapuran Raya WWTP and US$ 64,230 to build piped connections Operational expenditure, OPEX = US$ 84,000 per year for all seven WWTPs
Energy requirements	Mechanical system for RBC technology: energy supply is greatest OPEX
Input characteristics	Sludge with pH = 7.06; TSS 25 mg/L; BOD 45.48 mg/L; COD 115.99 mg/L; Total coliform 2940 MPN/100ml
Output characteristics	Effluent liquid quality (Effluent limit as per environmental compliance standard Peraturan Menteri Lingkungan Hidup No. 68 Tahun 2016): pH = 7.53 (*6-9*); TSS 6 mg/L (*30 mg/L*); BOD 9.74 mg/L (*30 mg/L*); COD 24.84 mg/L (*100 mg/L*); Total Coliform 2400 MPN/100ml (*3000 MPN/100ml*)
Land requirement	Land area was a constraint and therefore they chose a mechanical system with a small footprint
Reuse	Minimal reuse of treated water for facility gardening purposes only
Skills & human resources requirements	Five operators working in the facility who also perform security functions, and one operator acts as the coordinator
Technology/material local availability	The RBC bearing is locally available if it needs to be repaired or replaced, however the operator did not know if the RBC shaft was also locally available (may need to be imported); the contact media is not locally available and needs to be imported

References

Antonie, R.L., Fixed biological surfaces – *wastewater treatment: the rotating biological contractor*, CRC Press, 2018, https://doi.org/10.1201/9781351072045

Beychok, M.R., *Aqueous waste from petroleum and petrochemical plants, 1st edition*, John Wiley & Sons Ltd., 1967, p. 262.

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.

Citation: ISF-UTS and SNV, *Treatment technologies in practice: On-the-ground experiences of faecal sludge and wastewater treatment*, The Hague, SNV Netherlands Development Organisation, 2021.

Authors: Simone Soeters, Pierre Mukheibir, and Juliet Willetts

Contributors: Annisa Pramesti Putri (SNV in Indonesia) | Deris K. and Ivany Hadi Lesmana (PD PAL Kota Banjarmasin)

Photos: SNV

For more information, contact:

Antoinette Kome
Global Sector Head, WASH
SNV
akome@snv.org

Juliet Willetts
Professor & Research Director
ISF-UTS
Juliet.Willetts@uts.edu.au