Low-Cost Innovative Solutions for Treating Public Market Wastewater in the Philippines: *Deploying Hybrid Anaerobic/Aerobic Cocopeat Filtration Systems*

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Abstract
Public markets in the Philippines and around Asia pose significant challenges for wastewater treatment due to the relatively high strength of the discharges and variability of flows. The Muntinlupa Public Market, located in Muntinlupa City in the southern part of Metro Manila, is one of the largest public markets in the metropolitan area with 1,448 stalls and 24 hours a day operation. With support from the U.S. Agency for International Development for planning and design, the city constructed a treatment facility which began operating in February 2006. The wastewater treatment system is an innovative combination of anaerobic and aerobic treatment coupled with filtration using cocopeat media to meet local discharge standards. It also includes a water recycling system that will allow re-use of the treated effluent for flushing toilets, watering plants and street cleaning. This technology is being applied elsewhere in the Philippines and is suitable for other locations in the region.

1. Market Wastewater
Wastewater from public markets is generated from distinct sources and activities. These include:

- Meat, poultry, fish preparation and sales
- Fruit and vegetable (produce) sales
- Prepared food stalls
- Public restrooms

When combined into a common outfall, the resulting wastewater mixture typically contains high levels of organic material, suspended solids, fats, oils and grease. It commonly contains two to three times the organic matter and solids typically found in residential wastewater, classifying market sources as “high strength.”

To effectively manage high-strength wastewater, treatment infrastructure must be designed and sized not only to address hydraulic loading in terms of volume (cubic meters per day), but also organic loading, which is expressed in terms of kilograms of BOD (Biochemical Oxygen Demand) per day, and solids loading, which is expressed in terms of Total Suspended Solids (TSS). Additionally, appropriate pre-treatment devices are required to remove fats, oils and grease from prepared food stalls, and the high percentage of solids associated with butchering and produce preparation and sales activities. Such devices typically include septic tanks, grease interceptors, grit chambers and bar screens.

2. Design Considerations

When the Muntinlupa Public Market Wastewater Treatment Facility was designed, the market had 1,448 stalls with approximately 4,800 active vendors and workers and an average of 4,500 daily customers. The average wastewater output was a flow of 210 cubic meters of sewage per day with a BOD of approximately 600 milligrams per liter (mg/L). Suspended solids and fats, oil and grease were also quite high. The discharge outfall flowed to the Alabang River which drains into Laguna Lake, an important fishery and future water supply for Metro Manila. The discharge limit into Laguna Lake was 50 mg/L BOD.

3. Site Specific Challenges

Developing an effective wastewater management strategy for the Muntinlupa Public Market required careful consideration and planning to overcome several site-specific constraints:

- Limited available space for wastewater treatment infrastructure. The identified site for the wastewater system was limited to 160 square meters and was used as a parking lot and delivery area.
- Relative elevation of the outfall in relation to the area designated for treatment
- Unconsolidated and unstable fill material containing garbage in the treatment area along with seasonally saturated soils

Perhaps the most innovative aspect of the Muntinlupa Public Market wastewater system is that the treatment facility is located entirely underneath the area designated for parking and deliveries. The ability to contain the wastewater system underneath the parking lot was the driving factor in selecting the treatment technology. In order to accomplish this, the main reactor tank was designed by a structural engineer to withstand the heavy loads from cars and delivery trucks that utilize the parking area. The resulting tank lid is a slab of concrete and steel 15 centimeters thick.

Developing the sewer system was also a challenge as the relatively low elevation of the outlet required that wastewater be pumped up to the inlet of the treatment system. This required the installation of a pump tank with trash screening and duplexing pumps. While raw wastewater pumping systems are common in sewage treatment, this component added significantly to capital expenditures and operation and maintenance (O&M) costs that were not anticipated during the initial project planning for the system.

Finally, installing the site-built tankage in an area of unconsolidated fill and trash was a challenge in both excavation and worker safety. Pouring concrete for the main tank required that the soils underlying the tank be compacted and stabilized prior to construction. Additionally, these unstable soil conditions resulted in the need for shoring to protect workers during the initial installation activities for the tank.

4. Technology Selection

The Muntinlupa Public Market Wastewater Treatment Facility use a combination of technologies including an anaerobic baffled reactor (ABR), sequencing batch reactor (SBR) and cocopeat filtration system to treat the wastewater to discharge standards. This combination of technologies was chosen for the following reasons:

- ABR technology is an effective and low-cost method of reducing BOD and TSS from high-strength wastewater.

- The ABR tank could be built onsite with a structural top cover designed to support the weight of delivery trucks that frequent the parking area.
- The SBR technology is a proven low-cost method of oxygenating anaerobic effluent to reduce BOD and the odors typically associated with anaerobic treatment.
- Cocopeat is a locally available waste byproduct that has shown potential as a biological filtration medium for wastewater effluent.

Other technologies effective in treating high-strength wastewater were considered for use in this project but were rejected for the following reasons:

1. Sewage lagoons – require a relatively large land area that was not available at this site.
2. Constructed wetlands – also requires a large land area and additional pre-treatment devices.
3. Activated sludge - high installation and O&M costs and could not be effectively installed below the parking area.
4. Trickling Filter – high installation and O&M costs and could not be effectively installed below the parking area.

The table below summarizes the technologies considered, approximate cost, anticipated O&M expenses and land area requirements:

Technology	Capital Cost	O&M/Month	Land Requirements	Remarks
ABR/SBR Hybrid	$140,000	$500	150 sq. meters	Selected
Lagoon	$80,000	$175	2000 sq. meters	Space constraint
Constructed Wetlands	$120,000	$175	1500 sq. meters	Space constraint
Activated Sludge	$200,000	$700	150 sq. meters	Cost and couldn't keep parking lot
Trickling Filter	$200,000	$700	150 sq. meters	Cost and couldn't keep parking lot

5. The Hybrid System: How it Functions

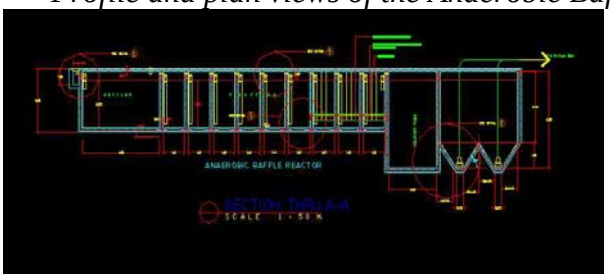
There were several discrete components to the Muntinlupa Public Market wastewater system. They are described below:

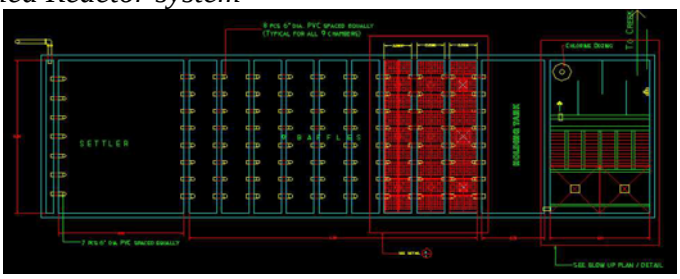
Sewer Collection System - Wastewater from the market's wet section (meat, fish, produce) is collected and screened, then combined with flows from the public toilets and prepared food stalls in a gravity sewer that flows to a pump tank where two alternating pumps (duplexing) are installed. The screenings are placed in covered receptacles and removed as solid waste weekly.

Anaerobic Baffled Reactor – The screened wastewater enters the ABR tank through the inlet structure, which directs the flow to the bottom of the first compartment. Due to the nature of wastewater under anaerobic conditions, a granulated sludge blanket is formed. As the wastewater flows up through the sludge blanket, the solids are trapped in the granulated sludge blanket where anaerobic bacteria consume the organics as food. The result is that a

partially clarified effluent flows up over the baffle to the next compartment where the same action is performed. In each subsequent compartment, the effluent is clarified further until the final compartment in which the anaerobic effluent is relatively free of suspended solids and the BOD level is greatly reduced. Because raw wastewater is delivered to the ABR under pressure, low volume pumps were required so the overflow rate did not exceed the settling rate of the sludge blanket.

Profile and plan views of the Anaerobic Baffled Reactor system



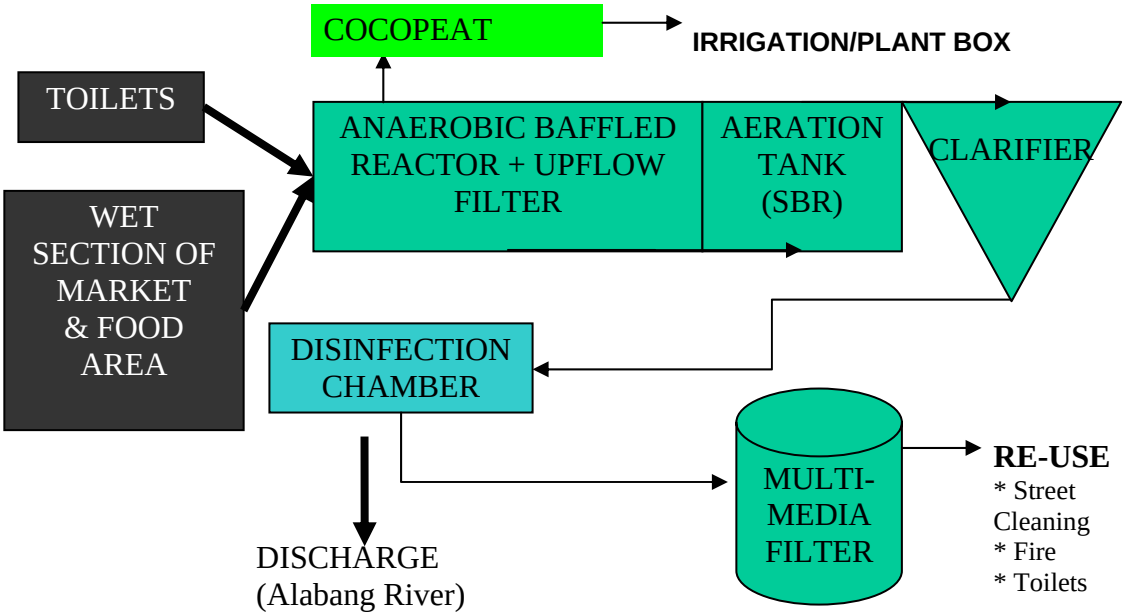


Sequencing Batch Reactor – Connected to the ABR is an aeration chamber with coarse bubble diffusers designed to impart dissolved oxygen to the effluent prior to discharge. The SBR is controlled by a process logic controller (PLC) that first aerates, then settles the wastewater under quiescent conditions, and finally discharges the supernatant to the media filtration system. The discharge structure is at a preset level and connected to a lamella clarifier, which is a settling tank with inclined plates to further reduce suspended solids. Due to funding constraints, only one blower is used to deliver atmospheric oxygen under pressure through the network of diffusers placed at the bottom of the aeration tank. Ideally, two blowers would be used and controlled by an alternating control panel equipped with an alarm that indicates if there is a malfunction.

To reduce foul odors, the aeration chamber is equipped with a simple venting system composed of a 4 inch PVC pipe with an exhaust fan, also controlled by the PLC, which extends to the roof level of a nearby building. There is a plan to use an activated carbon vent stack cover should the need for enhanced odor control ever arise.

Cocopeat Media Filtration – Cocopeat is a waste product of the coconut producing industry. It is obtained by shredding the coconut shell and removing the coir fibers. The remaining cocopeat is dried and then layered in a lined box with an effluent distribution piping network on top. Effluent is pumped from the aeration chamber through the piping network and distributed to the cocopeat through small holes drilled into the pipe. The pressure system is controlled by a timer that sends intermittent doses of effluent through the pipe. As the effluent flows through the cocopeat media, the downward flow draws atmospheric oxygen into the pore spaces in the media. This naturally aerated media filtration system provides a highly treated and polished effluent suitable for reuse.

Muntinlupa Public Market Wastewater Treatment System Flow ("Hybrid Design System")



6. Effluent Reuse

Effluent from the Muntinlupa Public Market is disinfected so that it will be suitable for reuse and recycling for the public toilets, floor washing and dust control. To accomplish disinfection, effluent passes through a chlorination chamber where a liquid chlorine solution is mixed with the treated effluent to impart a chlorine residual to the wastewater. Chlorinated effluent is then pumped to a storage pressure tank where it receives the appropriate chlorine contact time to ensure full disinfection and is available for reuse on a demand basis.

7. Financing

The full cost to construct the wastewater system was 6.8 million pesos (approximately US$136,000). During the first year of operations, O&M costs for operations staff, electricity, repair parts and consumables were approximately 27,000 pesos per month ($540). The reuse of the treated effluent resulted in a savings of 15,000 pesos per month ($300) in electricity costs because less water needed to be pumped from underground. This partially offset the O&M costs. To recoup the capital costs of the system, the City has implemented a full cost recovery plan in which stall owners are charged a user fee of 5 pesos ($0.10) per day per stall. This will cover the O&M costs and result in full cost recovery in approximately 3 years. The user fee has been collected since June 2006 and there have been no complaints, presumably because the market is well run and the project has been thoroughly discussed with the market vendor association.

8. Social Marketing Campaigns

Awareness of sanitation and wastewater treatment issues is very low throughout the Philippines and must be elevated to build support for pilot projects and willingness to pay required user's fees. Social marketing uses commercial marketing and advertising techniques to get people's attention, communicate a set of discreet, easily understood messages and encourage them to take a specific action or change a behavior, such as urging people to have their septic tanks desludged. In Muntinlupa the city and the LINAW team developed a campaign plan with target audiences and messages and then developed a mascot, fliers, posters, newspaper ads and a video

about the market treatment facility that was aired on a local cable TV station. They launched the campaign at a large shopping mall with an exhibit and event that featured a live mascot and back up dancers who put on a show and then handed out fliers. Meetings were also held with the market vendors' association to discuss the project with them, answer their questions and get their support. The vendors welcomed the project because they take pride in the numerous awards the market has received, including Most Outstanding Healthy Market in the National Capital Region for 2003-2004 and *Huwarang Palengke sa* 2004 (best market award).

9. Lessons Learned

Since the commissioning of the treatment system on February 24, 2006, there have been several lessons learned. These include:

1. The constraints with the site at the Muntinlupa Public Market, while considerable, are not atypical of public markets in the Philippines and elsewhere in Asia, especially those located in densely populated city centers. As word of the success of the Muntinlupa project spreads, several other Philippine cities are replicating it for their markets and two resorts have already built similar systems based on the design. Many are experiencing similar constraints including very limited land area, unstable or seasonally saturated soils, and the need for raw wastewater pumping. Considering these factors during the initial stages of project development is advisable.
2. It is possible for local government units to develop wastewater treatment systems using their own resources to meet stringent effluent discharge standards.
3. Full cost recovery of public investments in wastewater treatment infrastructure is an achievable goal when low-cost, low-maintenance systems are used.
4. Public participation. A key factor to the success of the project is believed to be the significant effort in public participation driven by an intensive social marketing campaign. This effort, lead by the LINAW project, included a multimedia outreach effort to increase awareness of wastewater issues and demand for treatment facilities and increase willingness to pay user fees.

10. Conclusion

The Muntinlupa Public Market wastewater project is a functioning model of low-cost, low-maintenance treatment technologies that are combined to provide sustainable wastewater treatment for high-strength flows. Using a combination of public outreach to drive the demand, and full cost recovery mechanisms to pay for the system, this approach brings the technology within the reach of many communities within the Philippines and throughout the region.

Acknowledgements

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