sustainable sanitation alliance

Case study of sustainable sanitation projects

Partially-submersed Black Water Compact Treatment System for Floating Residences

Mamirauá Sustainable Development Reserve, Amazon, Brazil

Fig. 1: Project location

1 General data

Type of project:
Small-scale project, comprised of a septic tank and an anaerobic filter, for the treatment of black waters from a community-based tourism enterprise on a Sustainable Development Reserve (conservation area).

Project period:
Start of construction: June 2010
End of construction: January 2013
Start of operation: June 2010
Ongoing monitoring period planned for: January 2011 to December 2013
Project end: Ongoing

Project scale:
The treatment systems are installed in floating units located on a river to support community-based tourism. They were designed to be used by up to 6 people per day. A total of 7 toilets are installed, with 5 being exclusive to tourists, 1 for employees and 1 that is shared by both. The usable volume of the treatment units is 140 litres (septic tank) and 170 litres (anaerobic filter).
Average cost of each system components: € 560

Address of project location:
Uakari Lodge, at Mamirauá Sustainable Development Reserve, Amazon, Brazil. This region is a World Heritage Site (UNESCO) and a Wetland of International Importance (RAMSAR Site)

Planning and Executing Institution:
Mamirauá Sustainable Development Institute

Supporting agency:
Ministry of Science, Technology and Innovation, Brazilian Federal Government.

Instituto de Desenvolvimento Sustentável Mamirauá

Ministério da Ciência, Tecnologia e Inovação

GOVERNO FEDERAL BRASIL PÁTRIA EDUCADORA

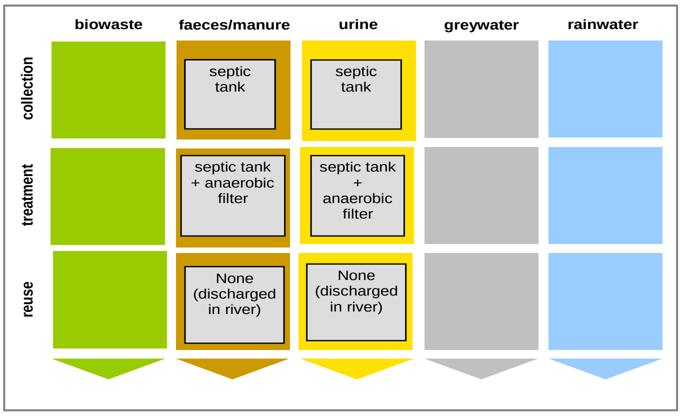

Fig. 2: Applied sanitation components in this project

2 Objective and motivation of the project

The majority of floating residences in the rural communities and cities of the Amazon do not have any kind of sanitation technology, resulting in daily impacts on the environment and on the health of the residents in these areas.

The overall objective of this project was to create a sewage treatment model that could work as a solution to the sanitation deficit of the floating residences. Furthermore the findings of the project could be transferred to other floating residences with similar challenges.

3 Location and conditions

The black water treatment system is installed at the Uakari Lodge, which is a community-based enterprise where local residents work as employees and managers. This business is located in the Mamirauá Sustainable Development Reserve (Mamirauá Reserve), which is a conservation area in Brazil. The key environmental feature of this area is the notable hydrological cycle, which leads to an annual water level variation of up to 10 metres. This significant variation is reflected in the way of life of communities in the area.

In response to the regular flood seasons, floating residences (houses built on water) are common. However, the majority of these homes do not have sewage treatment mechanisms and thus, the waste is discharged directly into the water bodies.

These environmental factors represent a social-environmental problem, since the communities have a strong dependency on surface waters in these areas (for drinking, cooking, washing clothes and kitchen utensils, for fishing, etc.), and few sanitation initiatives and solutions have been proposed.

According to the last demographic census, 10,867 people live in floating and stilt houses in the Mamirauá Reserve. They are spread among 200 communities with similar conditions with respect to sanitation. According to the Brazilian government, average household income in this area is below the poverty line, which worsens the problem. Therefore, the sanitation solutions in this areas must be not just technically viable, but affordable to the local communities.

Fig. 3: Floating home with a partially-submersed black water treatment system.

4 Project history

The black water treatment project was initiated at Uakari Lodge. Since the lodge was established in 1999, various sanitation models have been tested. However, the design of these systems and their technical features did not allow for effective functioning. The key problems were foul odour and rapid clogging. As the tourism enterprise is located on a water body, the treatment system had to be adapted in such a way that the discharge of waste into the river would not cause contamination, since the lodge itself, as well as various nearby communities, use the surface water in their daily activities.

After defining the system, the intention was to encourage its use as a model for sustainable sanitation technology which is compatible with the Amazon floodplain and other areas.

The primary positive feature of the system is its type of installation. The entire system is affixed to the actual structure of the floating residence, thus ensuring it is not completely immersed during flood periods. When the water rises, the house also rises along with the system. As a result, the cost of construction is more affordable and there is less possibility of wear related to the constant movement of the water currents and waves.

5 Technologies applied

The compact black water treatment system comprises two treatment units: a septic tank and an anaerobic filter. Both are reused polyvinyl plastic (PVC) tanks, each with a volume of 200 litres. These tanks reside within a wood frame. Apart from the tanks and the wood, there are also PVC hydro-sanitary components. All of the materials are easily found on the local market.

The wood used in the system comes from the local area and is very water resistant. As the system is partially submersed, the type of material is essential and the local wood has proved itself to be especially robust.

Research about this technology shows the following characteristics (Table 1):

Table 1: Characteristics of raw effluent and removal efficiency

	Turbidity (NTU)	**BOD (mg.L^{-1})**	**COD (mg.L^{-1})**
Raw Effluent (average)	4432,8	10402,1	19582,1
Treated Effluent (average)	182,1	335,3	951,8
Efficiency Removal (%)	95,9%	96,8%	95,1%

As presented, the overall efficiency removal of the system is high. Even if a certain load of turbidity and organic material (BOD and COD) is lost, the system is considered technically viable considering the quality of the raw effluent, which is very concentrated. In fact, it can remove a great amount of organic load (>95%).

The construction of the systems, including materials and labour, was paid for by the Mamirauá Institute for Sustainable Development (a research institution that works in the region), in collaboration with the Uakari Lodge. The labour required was provided by lodge employees who are residents of the local conservation unit. The fact that the residents themselves were responsible for building the system ensured their motivation to use the unknown technology.

This type of technology was selected, because it is a viable option for floating residences and, at the same time, resilient to the typical floods and drought periods experienced in the Amazon *várzea* (floodplain). In such conditions, where the units of treatment are partially submersed at the river, the system is considered resilient, as it resists to such conditions for many years.

6 Design information

In order for the technology to be installed in a floating residence, it was essential to affix it to the structure in such a way that the system would always be part of the house, regardless of the water level. It was also necessary to find a material resistant both to water and to the local conditions of floods and droughts.

'Piranheira' wood (*Piranhea trifoliata*), which is locally known as a hard wood that is highly water resistant, was recommended by the community members and therefore chosen as the construction material.

The lifetime of the system components is estimated at 25 years for the wood structure, according to the builders; 40 years for the PCV components, according to the literature; 2 years for bamboo filters. Due to the contact with water, it is probable that the materials have to be exchanged earlier.

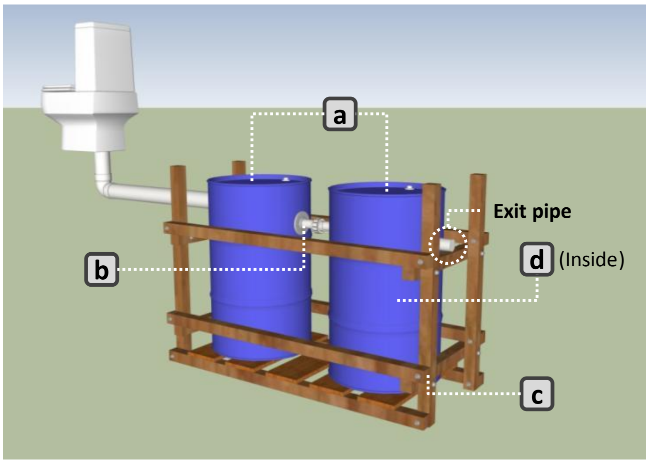

Fig. 4: Schematic drawing of a black water floating treatment system in the Amazon *várzea*.

The systems were built by a sanitation researcher in collaboration with support of community residents. The key components of the system are:

a. two 200 litre tanks
b. PVC tubes and connections
c. external wood structure
d. different types of filtering materials (crushed stone, bamboo and brick fragments).

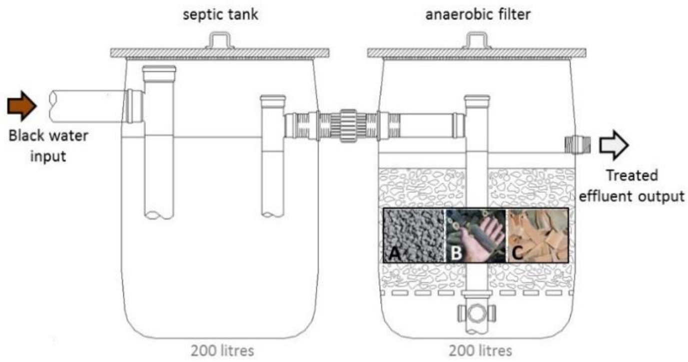

Fig. 5: Cross section of black water floating treatment system.

All of these materials were acquired on the local market in the nearest city (Tefé-AM).

7 Type and level of reuse

The configuration of the technology does not allow reuse of sub-products. However, this type of system is adaptable to the *várzea* environment and is one of the only models put forward as a solution to the lack of sanitation in these regions.

8 Further project components

The black water treatment technology was the focus of the scientific research that was conducted over a period of 3 years from initial design to environmental monitoring. The technical components of the system have already been assessed, such as efficiency, viability, etc.

However, the social implications of the technology must be verified, such as acceptance and use by community members. A research project is currently dealing with this issue.

The expectation is that this type of treatment can be used by floating homes in the Amazon or similar environments.

9 Costs and economics

The project was financed by the Mamirauá Institute (IDSM-OS) with a grant from the Ministry of Science, Technology and Innovation (MCTI).

The community users did not contribute to the purchase of the materials. Instead, some received a daily salary for their work in building and installing the system. However, the labour cost can be disregarded as this work can be done as contribution by the community, reducing the installation costs. In general, the residents are familiar with carpentry.

The costs of the wood for the system's external structure, which is presented in Table 2, were based on market prices in the nearest city. This was not an expense incurred for this project as the communities donated the wood to build the systems. It should be noted that the wood represents close to 33% of the entire system, including all the materials and components. It is therefore a crucial component to make the project low-cost.

The total cost of the system to meet a family's needs is only 5% of the total cost of a generic floating residence. Furthermore, the annual cost of the system (depreciation and maintenance expenses) also represents 5% of the average annual income (€2.700) of the families in the *várzea* area, which shows the economic viability of the technology.

Table 2. Black Water treatment System Costs

Component description	Price in Euro (2014)
Tanks, tubes and connections	144
Consumable materials	16
Components for lid	40
Components for external wood structure	264
Toilet	96
Total for materials	**560**
Labour (assembly and installation)	104
Total for treatment system	**664**
Total for the Project (7 systems) in EUROS	**4.648**

Considering the availability of timber resources at community's surroundings, the wood structure could be the user´s counterpart. This way, the system then costs € 296 (53% of original cost), and subsequently would be more cost-effective.

With this cost reduction, the economic viability would increase, and the family could then implement the system. In fact, it is family's responsibility to stablish its acquisition priorities.

10 Operation and maintenance

The technology does not require any kind of operation as the system functions automatically, as the effluent flows through gravity.

Maintenance is considerably simplified and involves annually removing approximately 80% of the sludge from the tanks (the rest is kept in the tank to accelerate the development of bacteria responsible for treatment.). The periodicity of sludge removal is based on the practice.

This should be removed preferably with the support of a manual pump, followed by the disposal of waste in shallow excavated ditches. These procedures are carried out by previously trained employees.

Fig. 5: Ditch previously excavated to receive sludge that results from tank maintenance. A) ditch with sludge. B) sawdust being added. C) sawdust. D) ditch covered with soil.

The maintenance costs for the systems are low and comprise the cost of building the pump and the labour force. Until now the users have not invested on the manual pump construction, which is basically made of PVC components, available on local market. The pump costs are around €136. Currently maintenance and emptying is done by buckets.

Table 3. Annual maintenance costs of treatment system.

Maintenance item	Price in Euro (2014)
Manpower to dig hole (1 work day).	26
Fuel to sludge transport	19
ANNUAL MAINTENANCE COSTS	**45**

11 Practical experience and lessons learnt

The community residents involved in the technology installation process at the Uakari Lodge expressed interest in replicating the sewage treatment mechanisms in their own homes, as they understood their viability and that it could offer positive results for their family and community.

However, the system has some limitations, and can be divide into:

Maintenance:

- Maintenance of the system requires several people to be involved, primarily to dig the hole to the right dimensions to hold the sludge from the septic tank. Furthermore, the work itself causes some resistance due to the disagreeable odours and appearance, resulting in users not wanting to carry out the task.

Material availability:

- The availability of the PVC hydro-sanitation components is variable and limited to commercial centres, resulting in reduced accessibility for remote communities to replacement parts when required (it should be noted that the *várzea* areas in the Brazilian Amazon are vast and transportation is mainly only possible by small boat).

Structure:

- The wood used in the external structure should be sufficiently water resistant to sustain immersion for long periods, and wood with this characteristic can be difficult to find.
- Careful planning must be done in the positioning of the outlet pipe to prevent the effluent outlet level from being below the surface level of the river (submerged) and water from entering the system.
- The floatation devices of the floating residence should be in good condition such that they are able to sustain the weight of the entire system, which is considerably heavy. The hydraulic connections should be carefully constructed, particularly the one which connects the toilet with the system, since the movement of the floating residence (caused by the movement of the water) can damage this connection over time. This should be continually monitored.

Despite the limitations of this technology, it can be regarded as a potential model for use in situations similar to this study, with floating houses, where there is not any type of conventional treatment technologies.

The local users must be encouraged to replicate the system by awareness campaigns and social mobilization. It is also important that the community engages in the search for external financing to implement the system.

12 Sustainability assessment and long-term impacts

A basic assessment (Table 4) was carried out to indicate in which of the five sustainability criteria for sanitation (according to the SuSanA Vision Document 1) this project has its strengths and which aspects were not emphasised (weaknesses).

Table 4. Qualitative indication of sustainability of the system. A cross in the respective column shows assessment of the relative sustainability of the project (+ means: strong point of the project; o means: average strength for this aspect and – means: no emphasis on this aspect for this project).

	collection and transport			treatment			transport and reuse		
Sustainability criteria:	+	o	-	+	o	-	+	o	-
• health and hygiene		X			X				X
• environmental and natural resources		X		X					X
• technology and operation		X		X				X	
• finance and economics	X			X				X	
• socio-cultural and institutional	X			X					X

Given that *ribeirinho*[1] communities in the Amazon have no access to conventional sewer networks, the proposed technology may be adopted by government as a social technology option that can minimize the problems caused by lack of sanitation in these areas. In summary, the government should consider the adoption of this model in their political policies as a technology alternative to resolve sanitation problems in floodplain areas.

[1] *Ribeirinho* is the term used to designate residents of rural Amazonia, generally living near or along water courses, who have traditionally maintained a peasant economic mode of production.

13 Available documents and references

Scientific article that discusses obstacles in Amazon *várzea* environments regarding the implementation of sanitation technologies:

- http://www.uakari.org.br/index.php/UAKARI/article/view/85
- http://www.iwaponline.com/wpt/010/wpt0100143.htm

Symposium Abstract about the technology's performance:

- http://www.mamiraua.org/cms/content/public/documents/55ec459f-0c87-43e1-a765-26dad271810b_livro_resumos_sap2012-3.pdf

14 Institutions, organisations and contact persons

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