**36th WEDC International Conference, Nakuru, Kenya, 2013**

DELIVERING WATER, SANITATION AND HYGIENE SERVICES
IN AN UNCERTAIN ENVIRONMENT

# Using Reed-Bed System for Wastewater Treatment and Reuse in Urban Semi/Urban Community in Gaza- Palestine

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**REFEREED PAPER**

## Abstract

*The paper present decentralized wastewater treatment system in urban semi/urban community in Gaza Strip, Palestine using Reed Bed. The results showed appropriate practice for small communities or single households in remote areas with removal efficiency of about 80% of BOD. The applied system is a cost-effective system for disposal and treatment of wastewater and give opportunity for effluent reuse. The biological complexity of the system within the root zone of the reed bed result in a powerful water cleaning capability which is often much less constrained than in many chemical or physical treatment systems.*
***Keywords:*** *Wastewater Treatment, Urban Semi/urban Community, Gaza Strip, Palestine, Reed Bed.*

## Background

Gaza Strip is a densely populated area. Nowadays, more than 1,700,000 inhabitants live in 365 Km2. The environment situation is deteriorated due to limited natural resources **(PWA, 2011)**. Three wastewater treatment plants were constructed in the area to serve the population which are overloaded and poor managed. The percentage of population connected to sewer networks in Palestine counts for approximately 52% while cesspits and septic tanks receive the rest (**PCBS, 2011).** It is not trouble-free to find a solution, which allows good management of wastewater at reasonable cost spicily in area which is not connected with communal sewer network. A Reed bed system for wastewater and sludge treatment is an innovative process **(Nassar, et al 2006)**. The system is a combination of traditional septic tank and natural wetland. It is widely used throughout Europe, Asia, and Australia, and in more than 50 locations in the United States **(Nassar, et al 2009)** Reed bed technology features low construction costs and minimal day-to-day operation and maintenance costs **(Keefer, 2000).** The system reduces wastewater contaminants, minimizes solids, and provides sufficient storage time for stabilization of bio-solids prior to disposal.

Reeds act in many ways to alter the character of organic solids present in the wastewater **(Afifi, 2003).** Firstly, their root system provides oxygen, which boosts the population and activity of naturally occurring microorganisms, which, accelerate the biodegradation of organic material. Secondly, the plants grow rapidly in this nutrient-rich medium and absorb some of the minerals **(Nassar, et al 2009).** Thirdly, roots extend from the reed stems into the bio solids which create a system of channels in the bio solids, allowing for continuous drainage and preventing the formation of a semi- impermeable layer, which is typical in unplanted beds **(Mellstorm, 1994).**

The paper presents the results of decentralized reed bed system constructed for wastewater disposal and treatment for communities in Bani-Suheila area in Gaza Strip that are not connected to sewage network. The treatment unit served three to four households which producing up to 4 cubic meter of wastewater daily. The units are connected to septic tank and reed bed with a remit of using the treated effluent water from the reed-bed for agricultural purposes or for recharging the aquifer in the event of agricultural use of the effluent water is not possible.

The implemented work was expressed in the form of active participation of the urban community in the design of the septic tank + reed bed and supported from existing capacity within the leadership of local NGO, (PEF- Palestinian Environmental Friends). Oxfam GB was providing the funding of the project and was the overall implementer of the study. Oxfam has monitored the work closely through its Engineering and Hygiene Promotion team in Gaza.

## Treatment System Design

Five decentralized units were constructed in Bani Suheila area. Figure 1 Plan View present the general lay out diagram of used treatment system which consists of three parts as follows:

1. Septic Tank to remove of suspended solids through settling in 2 champers.
2. Vertical Flow Reed Bed unit which is responsible for the biological treatment.
3. Outlet facility for reuse of effluent in agriculture or groundwater recharge.

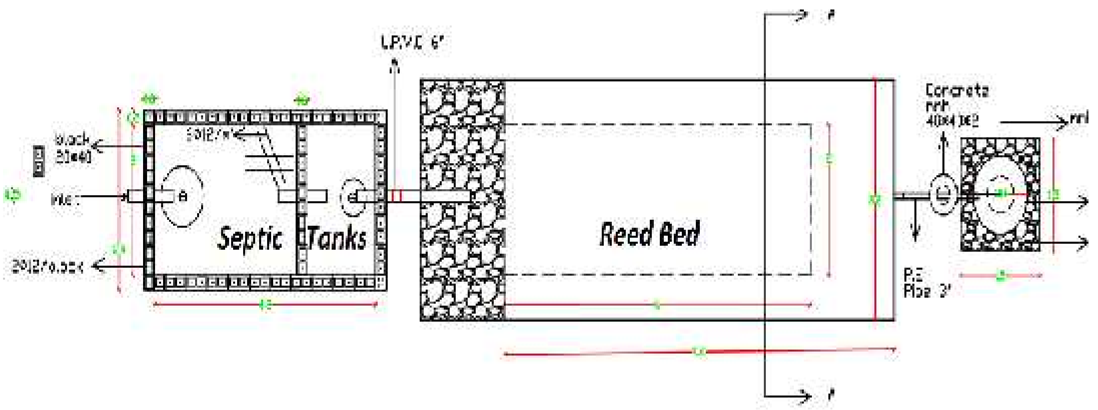


**Figure 1. General lay Out Diagram of Used Reed Bed Treatment System - Plan View**

### Septic Tank:

The tank has the total volume of 16 m3 (4*2*2) m3 with two Chambers, the first chamber is 2/3 of the total volume with detention time 2 days and the second chamber is 1/3 of total volume with detention time 1 day. Based on available land dimension, some modification was needed to be adjusted to fit the space at the site. Anaerobic digesting of settled organic material is planed which lead to reduce the accumulated sludge and expand the time needed for sludge removal.

### Reed Bed:

The main design criteria for the biological unit of the reed bed is the retention time in the bed. The bed has the general dimension of (9*2*1.5 m) with a total volume of around 27 m3. Some modification was needed to be adjusted to fit the space at the site. The design offer relatively high detention time (up to 2 days) which offer better treatment opportunity. The settled wastewater influent introduced on the top layer of the bed as evenly as possible into a gravel layer and the inflow followed vertically. It is important to prevent surfacing of effluent and the escape of odors. Therefore, the inlet pipe covered with aggregate. Large (3 "- 4 " ) diameter rocks placed around the inlet and outlet pipes to allow the effluent to disperse easily and quickly, to minimize clogging and make checking for root intrusion easier.

The reed basin lined with plastic sheet cover made of geo-membrane and filed with different aggregates dimensions as follows (from the bottom to upper layer):

- The Bottom layer is a gravel of 45 cm thickness and gravel size (3-4cm).
- The next layer is gravel of 25 cm thickness and gravel size (2.5-3 cm).
- The second next layer is kurkar of 25 cm thickness
- The upper layer is a sand clay soil of 55 cm thickness
- The top soil planted with local reed type (*Phragmites Communis*) with about 25 plants for each sq.m.

### Outlet facility:

A flexible reuse system was added to the out let of each unit In case of available of agricultural area, the beneficiaries can reuse the treated wastewater for irrigation. In case of absence of agricultural area, the treated effluent used for recharge of Ground Water (GW) through around 1 m3 of gravel system as presented in Figure 2.

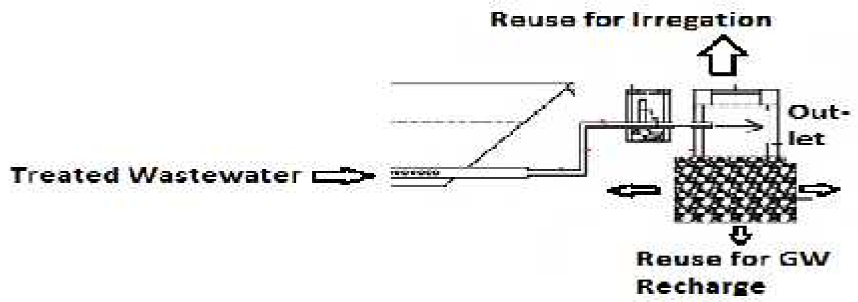


**Figure 2. Flexible Reuse Out Let System For Irrigation or GW Recharge**

## Selection of Beneficiaries and Final Units Design

During the Mobilization stage a field surveys was conducted to select the targeted areas and communities taking into consideration the sustainability, accountability, transparency and community participation. The most important selection criteria of the beneficiaries were:

- Need for disposal and treatment facility
- Presence of negative impacts that result from existing system
- Available of appropriate area for implementation of the project
- Available of appropriate ground slope.

## Monitoring and Follow Up

The system started the operation on August, 2012 and it gained about one month to have the first effluent. A monitoring protocol was cited for the influent and effluent in specific location of the system (see figure 3) and samples were collected in two weeks interval. Three sampling location points were identified as follows:

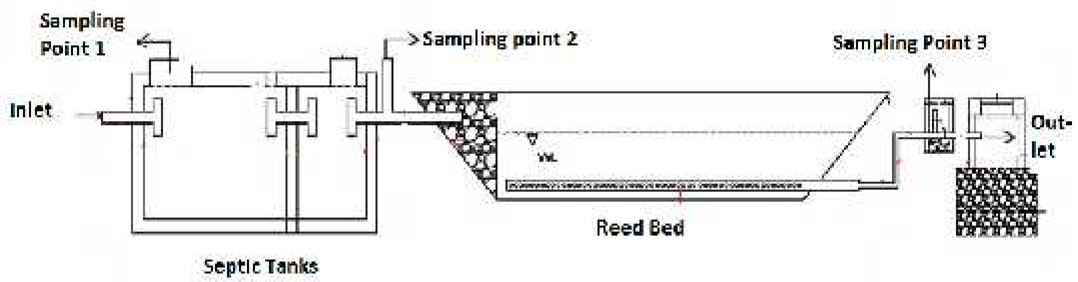


**Figure 3. Different sampling point locations for Monitoring**

- Point 1: Row wastewater coming from houses to septic tank which gives reference for the level of wastewater strength,
- Point 2: Out let from septic tank (inlet to Reed Bed) which gives an induction for removal efficiency of suspended solid in the septic tanks,
- Point 3: Reed Bed out let which gives an indication for removal and treatment efficiency of the total treatment system

The monitoring program consists of the main parameters , include chemical, biological and physical parameters to assess the system performance.

## Results and Discussion

The following results present one of the treatment units. The related parameters were measured from September and November 2012. Table 1 present the average values of the tested parameters in the three locations.

| Table 1: Average Values of Tested Parameters in the Three Locations of Sampling | | | | |
|---|---|---|---|---|
| **Parameters** | **Sampling point 1** | **Sampling point 2** | **Sampling point 3** | **Removal %** |
| pH value | 6.8 | 6.9 | 7.1 | - |
| Electrical conductivity m/s | 2100 | 2100 | 2007 | - |
| Biochemical Oxygen Demand (BOD) mg/l | 1050 | 497 | 222 | 78.8 |
| Chemical Oxygen Demand (COD) mg/l | 2207 | 883 | 415 | 81.2 |
| Fecal Coliform (FC) u/100ml | ..$10^9$ | ..$10^7$ | ..$10^5$ | 99.9 (4 logs) |
| Imhoff (settlable solids) ml/l | 27.8 | 0.5 | 0.08 | 99.7 |
| Total Slid (TS) mg/l | 1800 | 1500 | 1450 | 19.5 |
| Total Suspended Solids (TSS) mg/l | 352 | 300 | 177 | 49,7 |
| TKN mg/l | 110 | 85 | 50 | 54.5 |

The initial monitoring results of the system showed a very promising treatment efficiency. The BOD and COD average removal in septic tank and reed bed unit are more 78% and 81% respectively. It is expected that the efficiency will be increased with time as plant (Phragmites) will grow up and build up strong root nets system. The removal efficiency of most municipal treatment plants in Gaza Strip are around 60% (PWA, 2012).

The removal of the biological indicator (FC) is significant and reach around 4 logs (99%). The level of FC in the effluent will be the improved and decreased with time as plant is growing. This level is suitable for reuse trees based on the FAO guidelines.

Reed bed treatment systems can still remove more than 50% of the nitrogen load as TKN mostly in septic tank and around %50 of TSS. Photograph 1 shoed visually the treated wastewater from different sampling locations. The final effluent (sampling location 3) present a relatively obvious level comparing with other sampling locations. The removal efficiency expected to be improved with time.


**Photograph 1. Effluent of Treat Wastewater from Different Sampling Locations**

The results showed that the treatment effectiveness improved with time of operation. **Figure** 4 presented the BOD level in the three sampling location in the monitoring period. The BOD removal in septic tank and reed bed unit was limited at the begin of the operation and has improved remarkably after around one month of operation. It is expected that the efficiency of the system will continue increase in the first year of plant growing. The COD show a similar approach as BOD and presented in **Figure 5.**

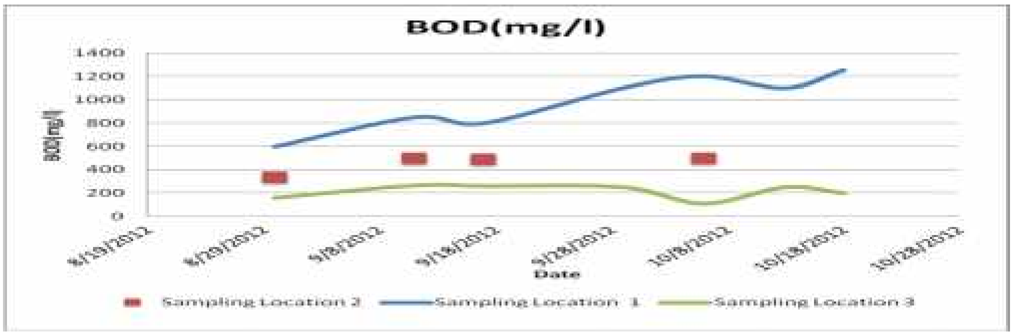


**Figure 4. BOD Level in the Three Sampling Location in Monitoring Period**

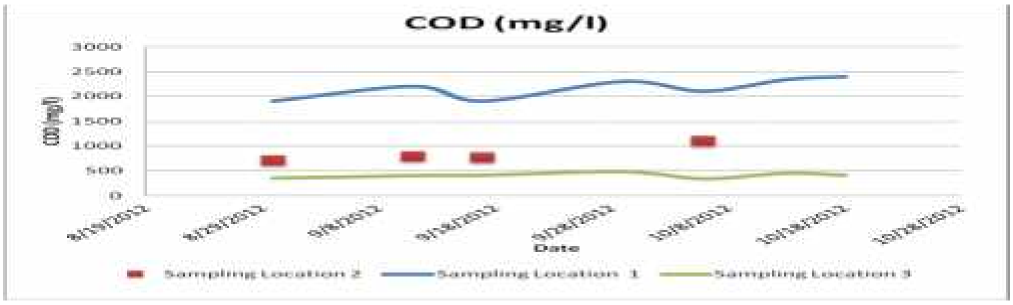


**Figure 5. COD level in the three sampling location in the monitoring period**

**Figure -6** represent the FC level and removal in monitoring period. The removal of the biological indicator (FC) is significant and reach around four logs to five logs within the first month of the operation period. The removal efficiency in the red bed increased comparing with removal level in septic tank. The biodiversity and population of micro-organizes in Rhizo-spare area will be increased with time as plant is growing and the level of Oxygen transfer enhance in the red bed hydro-morph structure. The level of FC removal in Stabilization Bond System with retention time around 20 days reach 4 log. Comparing with implemented system – Reed Bed- with a retention time around 4 days, is significant and this level is suitable for reuse in agriculture based on the FAO guidelines.

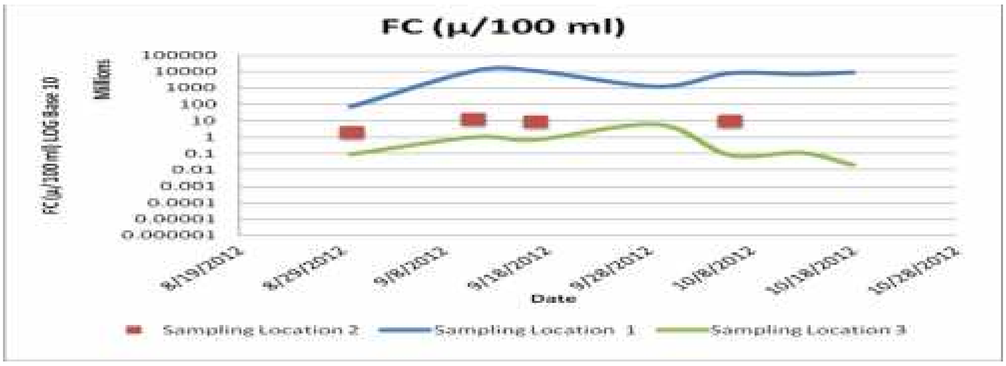


**Figure 6. FC level in the three sampling location in the monitoring period**

**Figure** 7 present the suspended solid (SS) in the three location in the monitoring period. The level of the SS in effluent (location 3) decreased and the performance improved as SS decreased from around 350 mg/l to 100mg/l after about one month of operation.

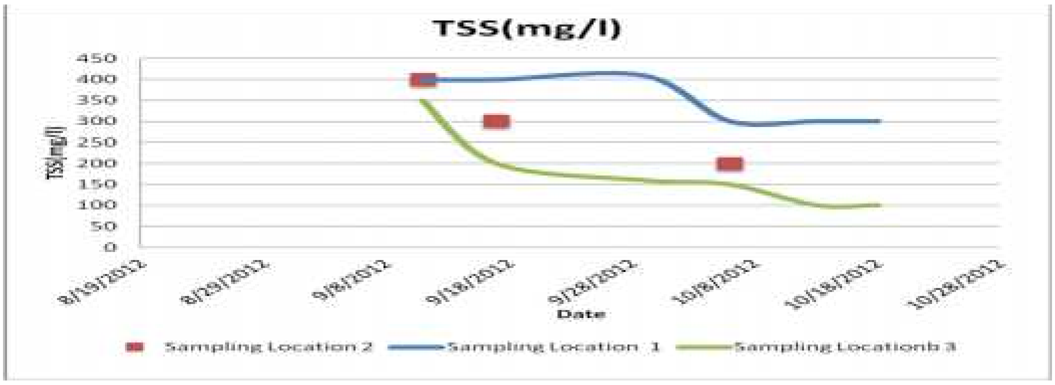


**Figure 8. TSS Level in the Three Sampling Location in Monitoring Period**

The field survey with the beneficiaries which was conducted after the system operation showed that the monthly cost of sewage disposal reduced from around $US 20 to less than $US 4. In addition, the negative impacts that result from previous system are totally disappeared. Moreover, most of the beneficiaries reused the effluent in olive plant irrigation.

## Conclusions

The main objective of the study is to provide urban semi/urban community with wastewater treatment and reuse system in areas with unavailable sewage systems in the Gaza Strip. Through the project the following point can be conclude:

- Reed bed system is a appropriate practice for small communities or single households in remote areas which lacking of communal sewerage system and it is often a good complement to a septic tank, which removes about 80% of BOD.
- The applied system is a cost - effective system for disposal and treatment of wastewater in urban semi/ urban community and give opportunity for effluent reuse.
- Participation of beneficiaries in design is a guarantee for sustainability of the constructed system, as the beneficiaries showed further interests and enthusiasm in operation and maintenance of the system. Overall 5 Reed Bed and Septic Tank units have been constructed and benefitting about 134 people.
- The complexity of microbial life forms and the reactions within the root zone of the reed bed result in a powerful water cleaning capability which is often much less constrained than in many chemical or physical treatment systems.


### Acknowledgements

The authors would like to extend thanks to NGO, Palestinian Environmental Friends for their successful implementation and completion of this work. We also take this opportunity to express a deep sense of gratitude to Oxfam GB WASH advisory and Oxfam GB Gaza Team Office of the valuable information, consultation and day-to-day technical support and funding.


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