MIZAN CONSULT FZE

Reed Bed Treatment System

GENERAL INFORAMTION & FAQ

04th June 2012

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1 General

1.1 Summary of Reed Bed Technology

The reed bed technology - a 'constructed wetland' - is a worldwide approved system to treat and recycle water in a sustainable way. Within the last years several reed bed systems in the Middle East have proven the efficiency of this technology in arid regions. The biological processes are enhanced in this region when compared to Europe due to local climate conditions.

The reed bed technology is not only limited to the treatment of sewage but can also be used for the treatment of storm water, grey water, drinking water, irrigation water, pool water, pond water, lakes, lagoons, sewage sludge, tertiary treatment for sewage treatment plants (STP's) enhancement of existing STP's and can even be used to stabilise river and lagoon banks, remediate soils and produce biomass for production of energy or local construction products, (e.g. light eco concrete blocks, insulation material and construction panels).

Limitations of this technology are most importantly the required area to locate the constructed wetland. Where sufficient land is available this technology gives better performance over decades of activity at considerable short and long-term savings, as well as providing significant additional environmental benefits.

While the obvious features of constructed wetlands are the reed plants the system utilises natural microbial processes in the root zone to transform the sewage pollution into gases, minerals and humus. The area required for an effective wetland is effectively converting the space into a natural habitat wildlife including birds and larger insects and has a positive CO_2 sequestration effect compared to technical system. While the space required is often considered as the main limitation for the Reed Bed, when compared to conventional sewage treatment plants, the other benefits the system has to offer far out way this limitation, as the wetland can be landscaped into its surrounds.

Benefits of using the Reed Bed technology are the following:

- Environmental enhancement
- Management and conservation of biodiversity
- Reduction or elimination of sewage and sludge disposal
- Low to zero electrical power consumption for the process (in average 0.12 kWh/m³)
- Fast construction, no long term delivery periods for technical components (all components are available from the local market)
- Treatment and storage of storm water
- According to design, water storage inside the wetland filter (for irrigation, fire fighting, etc.)
- Mesoclimate enhancement
- Visual enhancement, with wind and dust protection
- Reduction of fresh water demand for irrigation by substitution of soft landscape area with reed bed basins
- Provision of a “green* recreation area
- Feeling of an eco-friendly, environmentally enhanced facility
- Teaching sustainability through practice
- Production of biomass from the project
- Enhancement of environmental credentials of the organisation developing the project

Natural Wetland in Azraq (Jordan), artificial supplied with water to preserve the last hectares of a former famous hunting and wildlife region, which dried out due to lowering of the ground water.

This wetland is an important feeding and resting place for migrating birds and has become an eco-tourist destination.

The Reed Bed technology will also help in the implementation of the following Green Building Regulations:

- Provide habitat and promote biodiversity
- Reduce or eliminate pollution from storm water runoff
- Limit disruption and pollution of natural water flows by managing storm water runoff.
- Limit or eliminate use of potable water or subsurface water resources for irrigation.
- Reduce generation of waste water and potable water demand and increase the local aquifer recharge.
- Increase demand for materials and products that are extracted and manufactured within the region.

Reed Bed in Dubai, created to treat waste water from an office complex. Distance between Reed Bed and nearest accommodation: 5 m

Outflow Parameter [mg/l]:

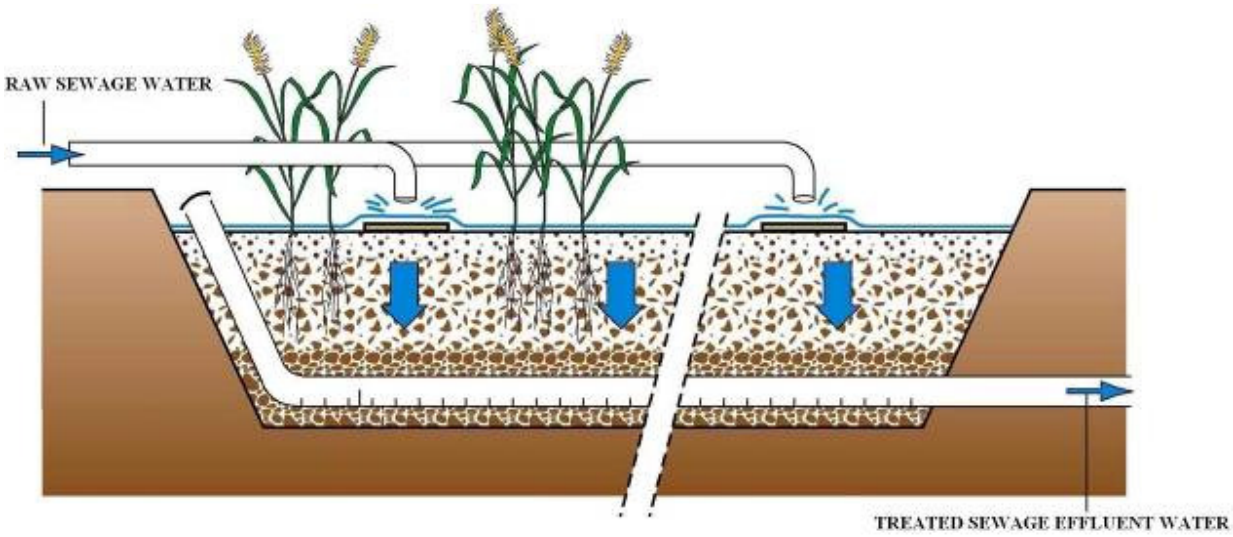
TSS:	0
TDS:	550
COD:	8
BOD:	2
NH_4-N:	1

The treated water is directly used to top up a fish pond and for subsurface drip irrigation

1.2 Processes in a reed bed

Raw sewage treatment:

If raw sewage is distributed on the reed beds mostly a double stage system is used. The first step (Stage A reed basins) is used to filter the suspended solids from the water which will accumulate on the surface of the planted filter layer.



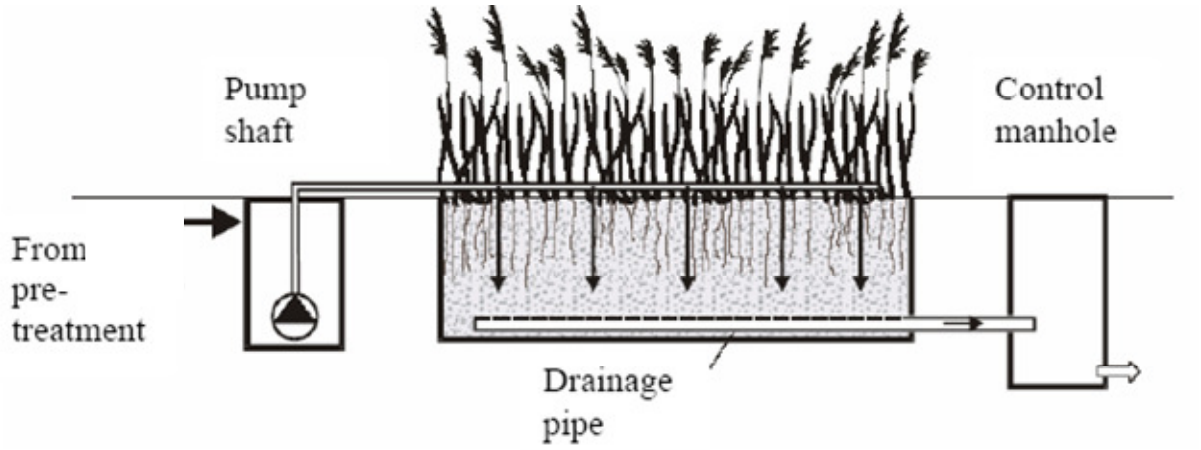
Raw sewage (Stage A) reed bed

The reed plants grow through the overlying organic solids of the waste water and develop numerous roots and shoots in the substrate. This leads to a forced dewatering, drying and mineralisation of the organic solids. The organic solid's volume declines to about 10 % of the initial volume. The filter bed and accumulated solids are kept aerated and open by the continuous growth of rhizomes (underground stems) and roots from the above-ground plants, as well as the microbial and fungal activity, which also increases the permeability of the deeper solid layers. This sedimentation stage will work for a period between 25 to 40 years without needing removal of the solids. During this period the solid layer increases slowly to a thickness of up to 0.5m. The resulting product of the sedimentation, dewatering and mineralisation is an earthy organic material (like peat). This solid humus can be used for further composting, for fertilisation, for thermal recycling, for recultivation, gardening and landscaping.

The outflow of the raw sewage stage is then further biological treated in a second stage reed bed (Stage B reed beds). This stage can also be used separate to biological treat the outflow of a technical pre-treatment stage like a septic tank, fine filter, SBR or UASB.

The Reed Bed as a biological treatment (Stage B):

The reed bed treatment system as biological treatment step after technical pre-treatment or after a Stage A reed bed combines aerobic and anaerobic biological decomposition processes in a substratum layer. The polyethylene lined and refilled basins are planted with reeds (*Phragmites australis*). The wastewater percolates the filter substrate vertically or horizontally to the bottom drains. Besides the microbial and fungal decomposition of organic matter and pollutants in the rooted substrate matrix, chemical and physical precipitation, adsorption and filter processes occur. Some of the wastewater nitrogen is released out of the artificial ecosystem as N_2O (dentrification).



Vertical flow (Stage B) reed bed, after pre-treatment (Stage A reed bed, septic tank, holding tank, fine screen)

Through changing the water load on the reed beds an associated change of oxygen regime is achieved. After water saturation by feeding with the distribution system a drainage network at the base collects the purified water. The pore space of the substrate is refilled with air thus enabling aerobic decomposition processes. Another part of oxygen transfer into the rhizosphere happens through a special spongy tissue in the plant stems and roots (aerenchyma).

Sewage water reed bed for a labour camp in Dubai, 200 PE

Outflow Parameter [mg/l]:

TSS: 0
TDS: 550
COD: 8
BOD: 2
NH_4-N: 1

Clogging of the filter substrates is prevented by the continuous growth and decay of roots and rhizomes of the reeds and soil macropores are created by this decay. Thus, long-term water transport into the soil matrix is affected and no additional filtration is required.

1.3 Frequently Asked Questions

What about smell?

The treatment process in the upper layers is an ***aerobic*** process. Oxygen is supplied by the Reeds through the spong aerenchyma tissue. Noisesome smells are only created by ***anaerobic*** processes, ***so*** smell is absent at the reed beds.

What about mosquitoes?

Mosquito have a larval stage, which lives in water. As, in comparison to waste water lagoons, reed beds do not have constant open water areas, mosquitoes are unable to breed. Other insects (e.g. flies) are reduced by the high biodiversity of the system.

What about rats?

Rats do not find any food in the pre-treated or totally shredded sewage which is fed into the reed beds (depending on the design) therefore they are not attracted to the wetland for food.

As any other plantation reed beds can give shelter, if not food, for birds and small mammals, including rats. But, because the filter bed is temporary charged with water from time to time, and there is always water level close to the surface rats, mice or rabbits can not burrow in the reed bed sub-soil. Any infestations for small mammals can be controlled in the usual way for plantation areas in urban landscaping.

Is a pre-treatment of sewage required?

That depends on the design; there are reed bed systems which require a pre-treatment in form of a screen, septic tank or even an aerobic biological process (SBR, trickling filter, fixed bed). But there are also systems which can be charged with raw sewage. These systems have a special reed bed filtration stage (Stage A) which removes and converts the suspended solids prior to a second biological reed bed treatment stage (Stage B). Which reed bed technology will be chosen depends on the project and client.

What about the sewage sludge?

If a reed bed system with a pre-treatment in the form of sedimentation tank is chosen, the accumulated sludge in the sedimentation stage can either be discharged by tankers or converted into humus in a special sludge composting reed bed.
The produced volume of sewage sludge, if any, depending on the chosen reed bed system, is always less than in any other STP system as the sewage treatment do not rely on activated floating sludge but on the microbiological processes in a rooted substrate layer which does not produce any surplus activated sludge.
In a raw sewage reed bed the mineralised sludge in the first filtration stage (Stage A) should be removed after 30 – 50 years depending on the design.

Must the reed plants be harvested?

According to the extreme growth rate of the reed plants under the local climate conditions, the reed plants should be harvested at least every 2nd to 3rd year. If required the plants *can* frequently be harvested (up to 2 times per year) and used as biomass for firewood, biogas production or eco-friendly construction materials without any negative effects on the treatment process.

Can other plants be used?

Because of its physiology, *Phragmites australis* is the best marsh plant for reed beds. But there are several other native wetland plants which can be used in the reed bed, including species of *Typha* and *Cyperus*. These other species are effective in processing the waste water, but less effective than *Phragmites* in removing heavy metals, organic pollutants and higher levels of phosphates. We would propose to use these other native plants as well in the system (Stage B) to deliver a bio diverse system and helping to conserve stocks of these species, being reduced in the wild due to drying of the oasis', wadis and wetlands.

Must the plants be replanted?

No, once the marsh plants are established they will self generate until the system is no longer required.

The footprint of the system?

2 to 8 m² per person, but this area can be implemented into the landscaping and can have any shape.

Do reed plants match with the local flora and fauna?

Yes, *Phragmites australis* is a wide-spread native species in the region. Wherever brackish or freshwater moisturises the soil or is appearing at the surface (wadis, oasis, sewage and irrigation water spills), reeds will grow naturally. Reed plants could also be used to link fresh water wetlands with salt water wetlands including sabkhas, mangroves and salt marshes.

What effect has the local temperature on the system?

The higher the better, in contrast to technical sewage treatment plants the reed bed technology has its optimum performance in hot climate as the physiology of Phragmites is tuned to photosynthesis operating at these temperatures and the activity of the biological processes in the rooted filter layers are at an optimum under the local climate conditions.

Is water"lost" by the reed plants?

Water is not lost, as it is used to create greenery with the reed plants. If the reed bed is integrated into the landscaping its footprint substitutes area of the normal soft landscaping which would otherwise consume water for irrigation. Water is removed from the system by transpiration, a process by which the plant loses water through its stomata (breathing pores) but like all plants in arid climates these pores are closed in high temperatures and strong sunlight. Consequently, although a much more dramatic system in terms of height, reed beds do not consume more water per m^2 than spray irrigated turf and it can be less.

Do the system needs a constant inflow of sewage (low season)?

No, only during establishment is it important to have a constant inflow to prevent the young plants from dying (the first half year). Once the reed plants are established and have developed their Rootzone it is impossible to kill the complete stock. A longer period without sewage inflow (3 – 4 month) will lead a hibernation of the reeds; the above ground biomass will dry off, but the below ground stems (Rhizomes) will immediate sprout new shoots when water becomes available again. The dried biomass can be harvested before new sewage is filled into the system. A start up period (like with a technical treatment plant) is not required.

Will the reed plants invade other landscaping areas?

There is no danger of seeds from reed plants establishing in nearby areas, unless there is regular inundation by water. Precautions can be taken against the spread of the Root system of the established reed stock in a reed bed, but this is already done by the PVC or HDPE liner which divides the root system from the surrounding soils. Only horizontal off-shoots of the stalks can invade surrounding areas; and again, will survive only if regular inundation. As these horizontal off-shoots grow roots very slowly a monthly removal of these shoots is sufficient to prevent invading of the reed stock into adjacent areas and is considered as normal landscaping or gardening maintenance.

What is the life time of the system?

As the reed stock is a self generating system and all sewage solids will be totally broken down by associated micro organisms into minerals, there is no wear in the system, only an increase of mineralised solids on the surface of the system, which has no impact on the performance. The only mechanical part of the system is a lift station, which is assumed to have a life span of 7 years.

What operation and maintenance is required?

Depending on the size of the system a weekly visual check and a monthly trimming of the reed shoots is enough.

Time between design and functional system?

As there are no delivery times for foreign materials and equipments a reed bed treatment system for a single household can be built within a few days after the design and approval period. The installation time of larger system depend mainly on the civil works needed.

References in the Middle East?

Several systems have been set up in the Middle East in the last few years (Dubai, Ajman, Abu Dhabi, Oman, Qatar, Jordan, Iran).

Who can design a reed bed for the Middle East?

There are many small specialized reed bed consultants all over the world. The U.K., US, Denmark, France, Austria, Netherlands and Germany have design guidelines for reed bed systems. These design guidelines are not sufficient to design reed beds in the Middle East, as treated water quality regulations for irrigation in the Middle East exceed the required treated water discharge quality of the systems in countries with reed bed guidelines where the treated water will be discharged to the ground water or other water bodies and not used for irrigation. Therefore only few reed bed consultants are available who can design a reed bed in the Middle East.

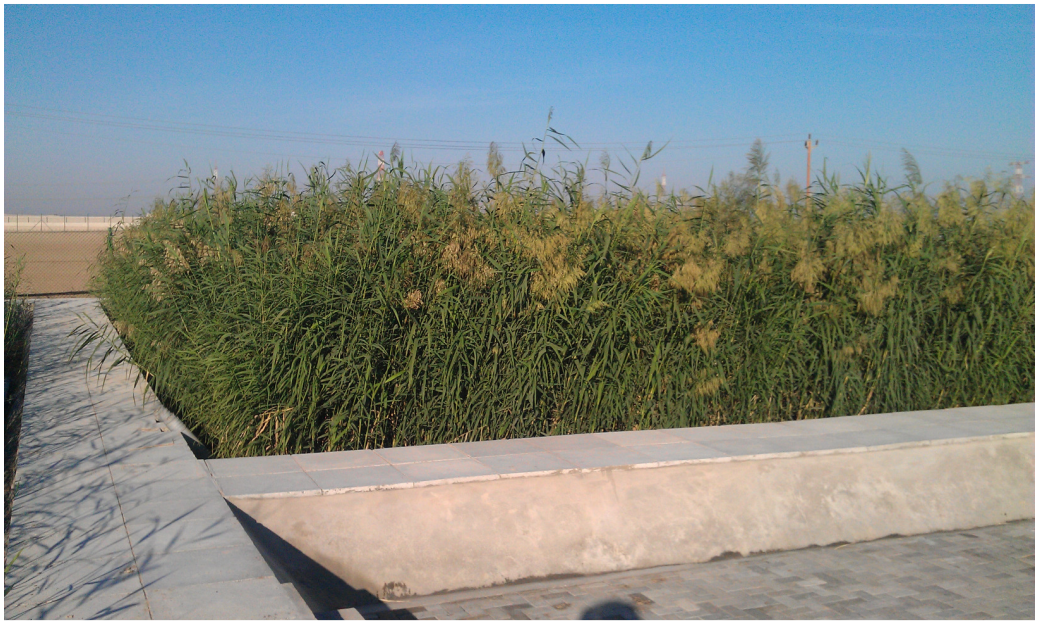
Are specialized contractors required?

Once the reed bed system is designed in details by a reed bed expert the system can be build by any contractor who is familiar with earth works, sewer networks, pressure pipes and pump stations. Only the liner system (PVC or HDPE) has to be installed by a specialised sub-contractor for liner installation, available in all Middle East countries.

There are only few steps during the installation and operation which should be supervised by an experienced reed bed engineer:

1. Installation of the drainage system
2. Test and installation of the filter material
3. Nursing and planting of the reed plants
4. Start-up of the system, setting start and stop levels of pumps and training of operator with operation instructions and logbook
5. Adjustment of the system during operation

2 References



Mirfa Reed Bed

Al Sifah Reed Bed

Six Senses Resort, Zighy Bay

Sila Reed Bed

Sir Bani Yas Island, Anantara Hotel

3 Performance

Parameters	RSB P1	ADSSC	Dubai, Drip	Dubai, Spray	Sharjah Restricted Irrigation	Sharjah Unrestricted Irrigation	Oman Restricted Irrigation	Oman Unrestricted Irrigation	Reed Bed Sir Bani Yas	Reed Bed ME General
TDS mg/l		2000	1500	1000*	2000	1500	2000	1500	**1290**	≤ 1500
DO mg/l	≥ 1	≥ 3	2	2					**6**	≥ 5
pH	6 – 8	6 - 8	6 – 8	6 – 8	6 -9	6- 9	6 - 9	6 - 9	**7.6**	7 - 8
Turbidity NTU	≤ 5	2							**0.9**	≤ 1.5
COD mg/l	100		100	50	150	200	200	150	**45.9**	≤ 50
BOD mg/l	10	10	20	10	20	15	20	15	**5.5**	≤ 8
TSS mg/l	10	10	50	10	30	15	30	15	**1**	≤ 5
NH4-N mg/l	10	2	5	1	10	5	10	5	**0.8**	≤ 1
NO3-N mg/l TN=Total Nitrogen	50		TN 50	TN 30	TN 50	TN 50	50	50	**42.9**	≤ 50
Phosphorus mg/l	30	2	20	20	30	30	30	30	**0.3**	≤ 5
E.Coli cfu/100ml		100								≤ 100
Faecal Coliform cfu/100ml	100		500	20	1000	100	1000	200	**13**	≤ 20
Intestinal Enterococci cfu/100ml	40								**11**	≤ 5
Helminth Ova Number/l	< 1				< 1	NIL	< 1	< 1	**NIL**	NIL
Perceivable Odour in 5 m distance of the reed basins									**NIL**	NIL

*As some of the water gets evaporated by the reed plants and the filter material adds some minerals to the TSE the TDS increases in the hot summer month above the limit of Dubai spray irrigation, without any negative effect on human beings or the irrigated plants, the only negative effect is some scaling on the irrigation sprayers.