ANNEXURE 6

ECO-FRIENDLY AND NON ENERGY INTENSIVE TECHNOLOGIES FOR WASTE WATER TREATMENT

Eco-housing Assessment Criteria - Version II

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1. INTRODUCTION

Household wastewater comprises of two types of wastewater as classified below –

Black water- Wastewater from the toilet, containing faecal matter and urine is called black water. It is also referred to as sewage.

Grey water –Grey water is wastewater generated from the kitchen sink, clothes wash area, bathroom and other taps.

Both grey and black water can be suitably treated and reused for non potable applications.

1.1 Recycling and reuse of waste water

Approximately 70% of domestic water supplied is released as wastewater. In today's context of fresh water shortage, wastewater needs to be seen as a resource rather than as a waste. Wastewater can be recycled and reused for various applications such as for flushing and gardening.

Grey water comprises 50-80 % of domestic waste water and it is easier to treat and recycle than black water as the contamination levels in grey water are comparatively low.

In any application, care needs to be taken to meet IS standards for water quality for the particular application.

1.2 Precautions to be taken in recycling and reuse of waste water

- Contact of grey water with humans is not recommended due to public health concerns.
- It is recommended that grey water should not to be stored for long periods of time because it can create breeding grounds for bacteria and pathogens and create foul odors.
- If water from kitchen sinks is used, it may be necessary to include grease traps in the recycling system, and the filter selected must be able to separate out food particles.

2. ECO FRIENDLY TECHNOLOGIES FOR WASTEWATER TREATMENT

Besides the conventional treatment systems such as sewage treatment plants and septic tanks, there are other alternative technologies which can be implemented at the level of a neighborhood or housing complexes which recycle black and/or grey water for reuse purposes such as for flushing and gardening. Some of the technologies for treatment and recycling of wastewater are listed below and described in brief.

1. Constructed Wetland /Root Zone Systems
2. Aerobic treatment system
3. Anaerobic treatment system
4. Package treatment system
5. Membrane Bio-Reactors

Sub-sections in this Annexure describe the above technologies. More detailed description and application of these technologies can be found in the Web Links mentioned in **Section 3**

2.1 Constructed Wetland/Root Zone Treatment Systems

These systems are suitable for the treatment of wastewater from various sources containing biodegradable compounds. Dr Reinhold Kickuth of Germany developed the process in 1970. The system is most suited to decentralized wastewater treatment in small housing colonies, neighbourhoods etc. It is based on the principle of attached growth biological reactors similar to conventional trickling filters with a combination of aerobic and anaerobic zones created around plant roots. The contaminants present in the wastewater are treated as they seep through the root-zone of the plants by a combination of plants, soil, and bacteria and hydraulic flow systems resulting in physical, chemical, and microbiological processes. Oxygen present in the zones closer to the roots facilitates the degradation of wastewater. A wide variety of microorganisms present in the root-zone of the plants results in efficient degradation of organics. Percolation of sewage through the bed material also results in efficient reduction of pathogens.

As these systems require relatively larger land areas, in an urban context, they are more suitable for grey water treatment or tertiary treatment of black water.

The general design and application of the Root Zone Treatment Systems is described below-

A.) Design of zones

- The optimum filter depth should be 50-100 cm for horizontal filters and 60-120 cm for vertical filters.
- The surface of both the zones should be even and flat for uniform flooding.
- Sealing or lining with impermeable material is needed for preventing the percolation of wastewater into groundwater. Concrete or plastic tank can be used to achieve the desired requirement of avoiding percolation
- Plastic liner of polyethylene, which is UV/sun resistant, or geo-textiles is preferable. The thickness of the lining should be > or = 1 mm
- A clay sealing with a thickness of > or = 30 cm has to be provided
- To improve the quality of the soil, mixture of bentonite and fine clay can be compacted

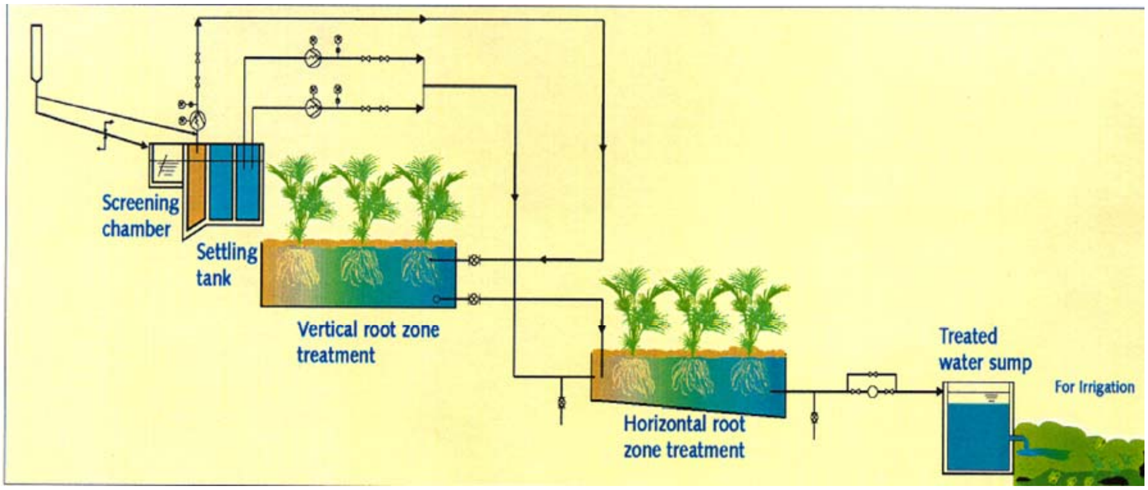

Figure 1. *Root-zone treatment system*

Source: www.borda.net

B) Design criteria for sizing:

- For the vertical zone, the organic load is 20-40 g BOD/m^2/day
- For the horizontal zone, the load is 10-30 g BOD/m^2/day
- Based on hydraulic load*:* The criteria for flow in horizontal zone are 40-100 l/m^2/day and that in the vertical zone is 50-130 l/m^2/day.

C) Construction material required for Root Zone treatment:

- Use of locally available filter material.
- The filter material should be sand/gravel, mix of soil with rounded grains with uniform size. It should be neither too coarse nor too fine to facilitate the proper flow of water. Ideal material would be river sand or sieved materials
- Typical parameters for ideal filter bed material:
- Permeability: 10-4 to 10-3 m/s
- Uniformity co-efficient: d60/d10 < or = 5 (ratio of grain sizes which contain 60% and 10% of the total weight)
- Effective grain size d10: > or + 0.2 mm
- Content of silt or bonded admixtures: < or = 5%

D) Applications of root zone system:

- Domestic and industrial wastewater containing biodegradable matter
- Not easily biodegradable substances requiring increased retention time but with lesser volumetric loading
- 250 g BOD per day to 50 kg BOD per day
- On-site treatment of domestic sewage
- Dispersed settlements, where no connection to the sewerage lines exist
- Main treatment or polishing stage

E) Advantages:

- Low capital costs
- Low operating and maintenance costs
- No chemicals required for the treatment process
- Absence of by-products requiring treatment
- Technical expertise for the operation not required
- Effective treatment resulting in near-tertiary standards

There are various patented systems available today which use the constructed wetland / root zone treatment system technology. DEWATS and the Hybrid Wetland Living Machine System also are similar to the root-zone systems, are patented and are described below.

2.1.1 DEWATS

DEWATS stands for “Decentralized Wastewater Treatment Systems”. DEWATS applications are based on the principle of low-maintenance since most important parts of the system work without external energy inputs and cannot be switched off intentionally.

DEWATS system consists of four basic technical treatment modules, namely,

- Primary treatment: sedimentation and floatation
- Secondary anaerobic treatment in fixed-bed reactors: baffled upstream reactors or anaerobic filters
- Tertiary aerobic treatment in sub-surface flow filters
- Tertiary aerobic treatment in polishing ponds

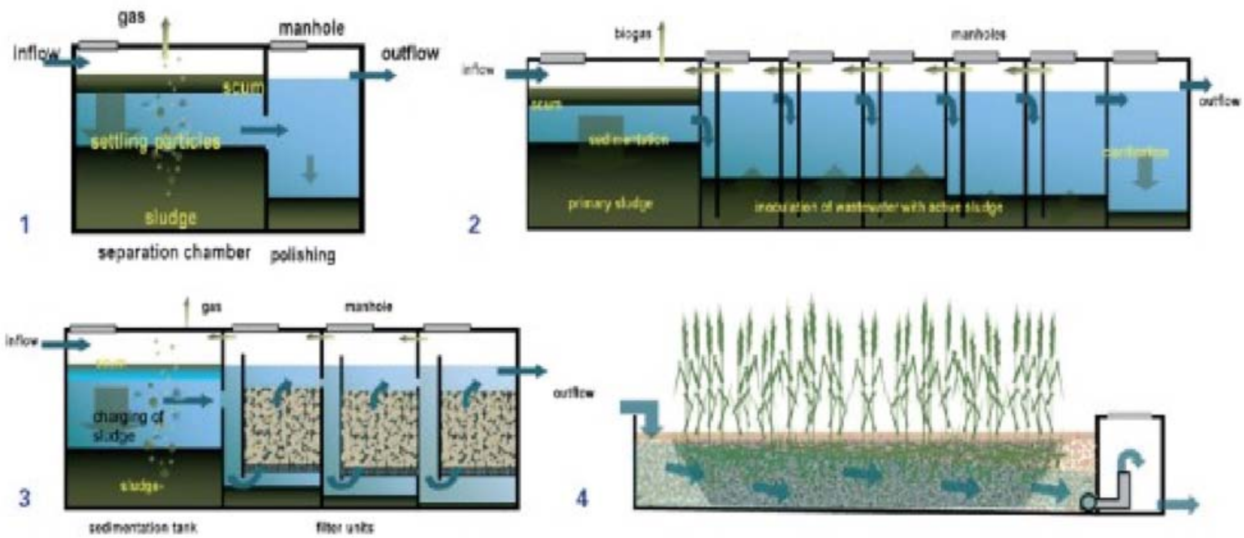

Figure 2. *Modules of DEWATS system.*

1. Settler 2. Anaerobic Baffled Reactor 3. Anaerobic Filter. 4. Planted Gravel Filter,

Source: BORDA-net.org

As can be seen in the figure above, in DEWATS, root zone treatment is applied in the tertiary treatment stage.

2.1.2 The Hybrid Wetland Living Machine System

As in case of DEWATS, Living Machine systems provide tertiary treatment, allowing the water to be reused for numerous applications including gardening and toilet flushing.

The Hybrid Wetland Living Machine system combines horizontal and tidal flow wetlands. Horizontal subsurface flow wetlands are well established, simple, low energy systems capable of moderate to good treatment. Tidal Flow Wetlands utilize a fill-and-drain wetland technology with special media to increase treatment efficiency and final effluent quality of the combined wetland system. The overall treatment system consists of the horizontal flow wetland cell(s), coupled to a set of tidal flow wetland cells with a hydraulic control/pump structure and a control system.

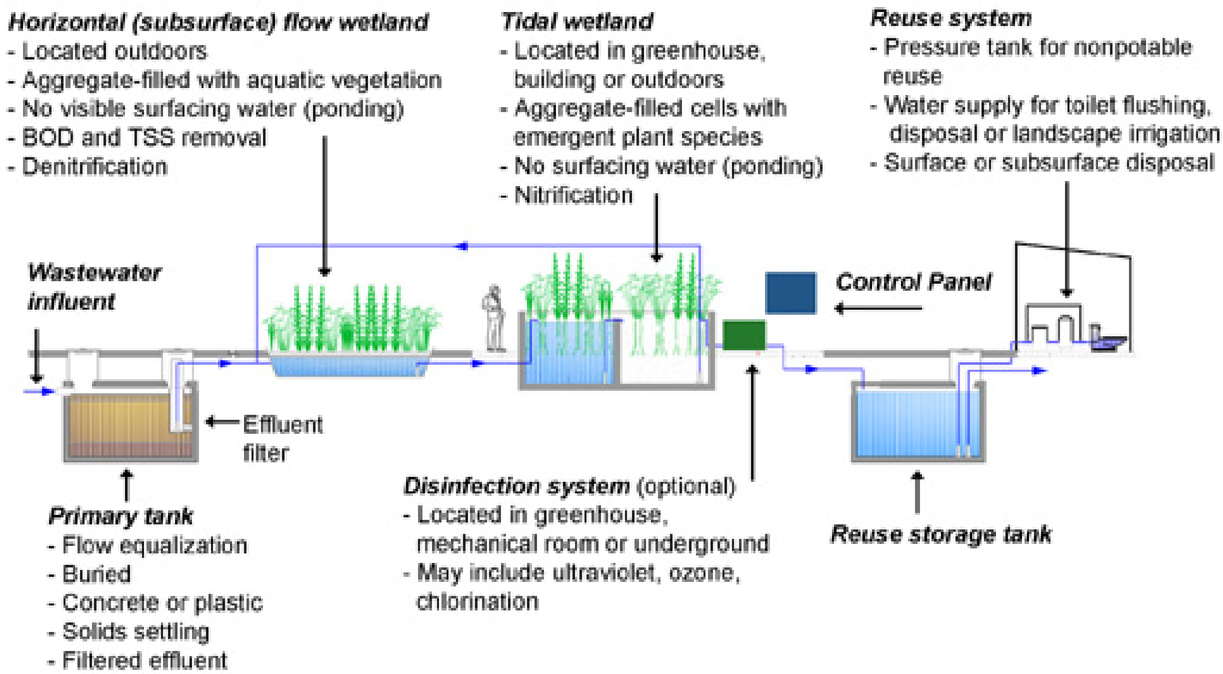

Figure 3. *Working of Hybrid wetland system,* Source: www.livingmachines.com

The horizontal flow wetland receives wastewater influent and provides initial treatment and flow equalization. Water is recycled through the Tidal Wetland Cells to “turbocharge” the horizontal wetland and enhance the nitrogen removal. (*Refer* ***Fig.3***)

2.2 Aerobic treatment system

Aerobic treatment systems: These processes are based on the biological conversion of organic contaminants in the wastewater in the presence of oxygen; carbon dioxide is given off and sludge is produced, leaving the water relatively clean. The wastewater is generally pre-treated by passing it through a settling chamber before aeration; the system could be based on either suspended growth or attached growth. *(Refer* ***Fig. 4****)*

Advantages

- Complete treatment of the wastewater.
- Used as the final polishing step before discharge of wastewater.

Disadvantages

- High land requirement.
- High energy required for operation of the treatment plant.

Figure 4. *Aerobic treatment system, Source: Eco-housing training module.*

2.3 Anaerobic treatment system

These systems are also based on the degradation of pollutants in the wastewater by microorganisms, but reactions occur in the absence of oxygen. Conventional digesters such as sludge and anaerobic CSTR (continuous stirred tank reactors) have been used in India for many decades in sewage treatment plants for stabilizing activated sludge and sewage solids. Presently, high rate biomethanation systems based on the concept of sludge immobilization techniques (UASB, fixed films, etc.) is also being considered. In the case of up-flow anaerobic sludge blanket (UASB) reactors, the treatment efficiencies are high even for a very short retention time. This is being used for treatment of domestic wastewater for small towns. An advantage with this type of reactor is the generation of useful by products – high calorific value fuel biogas and digested sludge that can be used as manure.

Advantages:

- Lower energy requirement combined with the production of biogas
- Low nutrient requirement
- High degree of waste stabilization
- Handling high organic loading rates
- Lower production of excess sludge, which in addition, is well-stabilized and therefore easier to dispose.
- Easier preservation of well-adapted sludge, which can be kept, unfed for a period of more than one year without any deterioration.

Disadvantages:

- Requires skilled operation
- Capital cost is high

2.4 Packaged wastewater treatment plants

Typical Packaged Plants include screening, flow equalization, aeration, clarification, sludge digestion, and effluent disinfection. Construction is based on fabrication steel tanks properly coated for long term exposure to wastewater. These systems come in different capacities ranging from 10 m^3/day to 1000 m^3/day. An example is the Akar Dynamic Bio-Reactor System (ADBR) shown in the figure below

Figure 5. *Package treatment plant, Source: Eco-housing training manual*

Advantages:

- No time is needed in erecting and commissioning the system and this system is ready to use.
- These systems are mounted on skids therefore easily transportable and are compact. Hence it requires no excavation, no major concrete work, no major onsite fabrication and pipe / fittings. (*Refer **Fig. 5***)
- Suitable for both black and grey water treatment

2.5 Membrane Bio Reactors (MBR)

The Membrane bioreactor (MBR) consists of a suspended growth biological reactor integrated with a micro filtration membrane system. The micro filtration membrane system replaces the solids separation function of secondary clarifiers and sand filters in a conventional activated sludge system. Usually the suspended solids are held back completely by the membranes with pore sizes of about 0.1 to 0.4 µm.

These systems occupy lesser space as compared to conventional Activated Sludge Blanket Systems, and are thus more suited to urban areas where plant area footprint is a prime concern. They can be used for both black and grey water treatment and the effluent can be directly reused for non potable uses such as flushing and gardening.

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