Guidelines of FSTP (Waste stabilization Pond)

Introduction

Waste stabilization ponds (WSPs) are usually the most appropriate method of domestic and municipal wastewater treatment in developing countries, where the climate is most favorable for their operation WSPs are low-cost (usually least-cost), low-maintenance, highly efficient, entirely natural and highly sustainable. The only energy they use is direct solar energy, so they do not need any electromechanical equipment, saving expenditure on electricity and more skilled operation. They do require much more land than conventional electromechanical treatment processes such as activated sludge – but land is an asset which increases in value with time, whereas money spent on electricity for the operation of electromechanical systems is gone forever).

WSP systems comprise one or more series of different types of ponds. Usually the first pond in the series is an anaerobic pond, and the second is a facultative pond. These may need to be followed by maturation ponds, but this depends on the required final effluent quality – which in turn depends on what is to be done with the effluent: used for restricted or unrestricted irrigation; used for fish or aquatic vegetable culture; or discharged into surface water or groundwater.

Wastewater treatment in WSPs

WSPs are one of the main natural wastewater treatment methods. They are man-made earthen basins, comprising at any one location one or more series of anaerobic, facultative and, depending on the effluent quality required, maturation ponds. WSPs are particularly suited to tropical and subtropical countries since sunlight and ambient temperature are key factors in their process performance.

Prior to treatment in the WSPs, the wastewater is first subjected to preliminary treatment − screening and grit removal − to remove large and heavy solids.

The wastewater treatment processes that occur in anaerobic, facultative and maturation ponds. Basically, primary treatment is carried out in anaerobic ponds, secondary treatment in facultative ponds, and tertiary treatment in maturation ponds. Anaerobic and facultative ponds are for the removal of organic matter (normally expressed as "biochemical oxygen demand" or BOD), Vibrio choleras and helminth eggs; and maturation ponds for the removal of fecal viruses, fecal bacteria and nutrients (nitrogen and phosphorus).

Due to their high removal of excreted pathogens, WSPs produce effluents that are very suitable for reuse in agriculture and aquaculture. The reuse of WSP effluents is discussed in Section Reuse of WSP effluents.

Advantages:

Simplicity

- simple to construct
- simple to operate and maintain
- only unskilled labor is needed

1. Drying Bed:

Drying bed is for recycling in human excreta. It reports on the use of drying beds in separating solid and liquid fractions of fecal sludge (FS) so that the solids can be co-composted and the organic matter and part of the nutrients captured for urban agriculture.

- There Three Drying Bed.
- Each Bed Dimension (3.04m X 1.21m X 1.06m).
- The sludge is applied once bi-weekly intervals in each bed.
- Sludge drying takes 10 to 20 days.
- Both the incoming and dried sludge are pathogenic; therefore, workers should be equipped with proper protection (boots, gloves, and clothing). Also beds should be installed in a certain distance to settlements, as odor occur, especially when sludge has been recently applied. The dried sludge and effluent are not sanitized and may require further treatment or storage, depending on the desired end-use. Sludge can be composted before reuse to enhance pathogen removal.

  The drying bed may cause a nuisance for nearby residents due to bad odors and the presence of flies. Thus, it should be located sufficiently away from residential areas.

2. Anaerobic pond:

Anaerobic ponds operate in the absence of oxygen. Anaerobic ponds main purpose is to provide pre-treatment as they remove organic loads and settled solids. Anaerobic ponds are normally characterized by:

- Pond Dimension (2.74m X 1.21m X 4.57m)
- The color of the wastewater contained within the pond is normally dark brown to black.
- Normally contain no significant algal population. Scum layer could be found on top of the pond.
- Receive high organic loading (100 to 350 g BOD/m3 d) – contain no dissolved oxygen and no algae.
- The influent received. Anaerobic ponds were mostly used for systems receiving Night soil. Now that buckets have been eradicated, the influent received is mainly domestic.
- Sedimentation pond.
- High waste water loading – depletes all O2.
- Solids settle at bottom of the two pond.
- Anaerobic digestion of sludge occurs at the bottom of the pond**.**
- Primary function is BOD removal.
- BOD removals > 90%.
- Expected efficiency to reduce DBO due to average air temperature in the coldest month
- Anaerobic ponds work extremely well in warm climates: for example, a properly designed pond will achieve around 60 percent BOD5 removal at 20°C and over 70 percent at 25°C and above. Organic matter removal in anaerobic ponds is governed by the same mechanisms that occur in all other anaerobic reactor. A retention time of one day is sufficient for wastewaters with a BOD5 ≤300 mg/l at temperatures above 20°C.
- A Retention times less than one day should not be used for anaerobic; if it occurs. However, a retention time one day should be used. And the volume of the pond should be recalculated.

  The hydraulic retention time is than calculated, as follows.

  (HRT)=V/Q

  =15.15 cum/day

  =3.03 days.

3. Facultative ponds:

Facultative treatment pond are the simplest WSPs and consist of aerobic zone close to the surface and a deeper. Anaerobic zone they are designed for BOD removal and can treat water in the BOD range of 100-400 kg/ha/day corresponding to 10-40 g/m2/day at temperature above 20°.
These ponds are of two types:

1. Primary Facultative Pond
   – receive raw wastewater.
2. Secondary Facultative Pond
   – receive settled wastewater
   (e.g. effluent from anaerobic pond)

Facultative ponds operate with both aerobic and anaerobic zone. Aerobic conditions are generally maintained in the upper layers while anaerobic conditions exist towards the bottom.
Facultative ponds are normally characterized by:

- There are two Facultative pond.
- Each Pond Dimension (1.83m Dia X 1.98m height)
- The primary function is the removal of BOD
- To have clear water, light penetration and photosynthetic production of oxygen to decompose organic material take place easier
- Part of the solids present in the wastewater settle and are biodegradable in an anaerobic process
- the color of the wastewater contained within the pond is normally that of the influent received. Sometimes the color is bluish to green
- Retention time are short (e.g. 1 day).

3 zone exist:

- A surface zone where aerobic bacteria and algae exist in a symbiotic relationship. The algae provide the bacteria with oxygen and the bacteria provide the algae with carbon dioxide.
- An anaerobic bottom zone in which accumulated solids are decomposed by anaerobic bacteria.
- An intermediate zone that is partly aerobic and partly anaerobic in which the decomposition of organic wastes is carried out by facultative bacteria.

4. Maturation ponds:

Maturation ponds receive the effluent from the facultative ponds and their size and number depends on the required bacteriological quality of the final effluent. They are shallower than facultative ponds with a depth in the range 1−1.5 m, with 1 m being optimal. Because of the lower organic loadings received by maturation ponds, they are well oxygenated throughout their depth. The algal populations are much more diverse than that in facultative ponds; algal diversity increases from pond to pond along the series.
Maturation ponds only achieve a small additional removal of BOD5, but they make a significant contribution to nitrogen and phosphorus removal. Total nitrogen removal in a whole WSP system is often above 80 percent and ammonia removal is generally more than 90 percent (these figures depend on the number of maturation ponds included in the WSP system). Phosphorus removal in WSPs is lower (usually about 50 percent).

Aerobic ponds operate in the presence of oxygen. Oxygen supply is totally dependent on

natural conditions, principally the wind and due to algal photosynthesis. An example of an aerobic pond is called a maturation pond. Maturation ponds are used for polishing the effluent quality. The primary function of maturation ponds is to remove pathogens. Aerobic ponds are similar in appearance to facultative but only differ in organic load. Maturation ponds are characterized by:

- There are two Maturation Pond.
- Each Pond Dimension (5.59m X 1.06m X 1.52m)
- normally follows a series of facultative ponds. Maturation ponds are the last ponds of the waste stabilization ponds system.
- the color of the wastewater contained within ponds is clear. Sometimes dark green in due to algae but appears red or pink when slightly overloaded. Final effluent (if applicable) can be used for irrigation (if meets standards for irrigation) or recycled to the receiving pond.
- Receive the effluent from a facultative pond.
- The main objective of maturation ponds is to remove pathogenic microorganisms present in the wastewater, which occur mainly due to sunlight in the water column.
- (HRT)=V/Q
  =9.08 cum/day
  =1.82 days.

BOD Removal

- in anaerobic ponds BOD removal is achieved by sedimentation of settleable solids
- in secondary facultative ponds that receive settled water (anaerobic pond effluent), the remaining non-settle able BOD is oxidized by heterotrophic bacteria
- in primary facultative ponds (receive raw wastewater), the above functions of anaerobic and secondary facultative ponds are combined
- in maturation ponds only a small amount of BOD removal occurs

Pathogen Removal

Bacteria

- Fecal bacteria are mainly removed in facultative and especially maturation ponds
- The principal mechanism for fecal bacteria removal are:

1- Time and temperature
  - fecal bacteria die-off in ponds increase with both time and temperature

2- High pH
  - fecal bacteria (except Vibrio Cholera) die very quickly (within minutes) at pH>9

3- High light intensity
  - Light of wavelength 425 – 700 nm can damage fecal bacteria

5. Polishing Pond:

These ponds, also known as finishing ponds, receive water flowing from the oxidation pond or from some other secondary treatment systems. Here, additional BOD5, solids, fecal coliform, and some nutrients are removed from the water.
In addition, polishing ponds are typically deeper than the other types of ponds, usually operating at a depth of 5 to 10 feet.

OPERATION AND MAINTENANCE OF WSP

The facultative ponds and maturation ponds are commissioned before the anaerobic ponds so as to avoid odor release when the anaerobic pond effluent discharges into empty facultative ponds. The facultative ponds and maturation ponds should ideally be filled initially with fresh surface water or groundwater to permit the development of the required algal and heterotrophic bacterial populations. If freshwater is not available, then the facultative pond can be filled with raw wastewater and allowed to rest in batch mode for 3−4 weeks to allow the microbial populations to develop. Some odour release may be expected during this period.
Once the facultative ponds and maturation ponds have been commissioned, the anaerobic ponds are filled with raw wastewater and, if possible, inoculated with active biomass (sludge seed) from another anaerobic bioreactor. The anaerobic ponds are then loaded gradually up to their design load over a period of 2−4 weeks (the time depends on whether the anaerobic pond was inoculated with an active sludge seed or not). The pH of the anaerobic pond has to be maintained at around 7−7.5 during the start-up to allow for the methanogenic archaeal populations to develop. If the pH falls below 7 during this period, lime should be added to correct it.

Operation and maintenance of a waste stabilization pond system is relatively simple. Nevertheless, basic operations and maintenance needs to be performed to ensure proper functioning and a long system life. This includes consideration of:

- Pump station maintenance
- Security
- Health & Safety (Operator facilities)
- Proper operation & Maintenance of the system
- Leak detection
- Maintaining WSP facility

Pump stations maintenance

Influent to the waste stabilization ponds system could either be pumped or gravity fed. Raw wastewater entering the wastewater treatment system normally carries materials such as rags, plastics, etc. which can damage pumps if not removed. Such damage and blockages need to be

avoided by installing screens at the pump station. It is necessary to always have a back-up pump in case of emergencies. Routine maintenance such as greasing, servicing, etc. should be carried out as indicated on the pump manual provided by the manufacturer. The figure below shows a pump station.

Security

- The ponds sites should be fenced and the gate kept closed. A 2m high razer mesh type of
- fence is recommended as vandalism may occur. Anecdotal accounts indicate that other
- types of fencing are often stolen or vandalized.
- Animals and unauthorized people should be kept out of the ponds site. A visitor's record
- sheet may be provided for any person entering the site.
- No animals should be deliberately kept on-site for grazing and drinking.
- Put up "No entry" signs on the fence or gate.
- Children are especially at risk as they may be tempted to swim in the ponds.

Health & Safety (Operator facilities)

The facilities to be provided for pond operators depend partly on their number but should normally include the following:

- First aid kit.
- Eye Protection
- Dress Appropriately for the Job
- Footwear
- Personnel on-site should be provided with gloves, rain suit, gum boots and masks.
- A room for shelter and to eat should be provided.
- A toilet, toilet paper, soap and clean towels should be provided.
- Drinking water tap should be provided
- A spade, rake and wheelbarrow are necessary
- Strategically placed lifebuoys.
- Washbasin and toilet.
- Storage space for protective clothing, grass-cutting and scum-removal equipment, screen rake and other tools, sampling boat (if provided) and life jackets.

Proper operation & Maintenance of the system

Once the ponds have started functioning in steady-state, routine maintenance is minimal but essential for good operation. The main routine maintenance activities are:

- Removal of screenings and grit from the preliminary treatment units
- Operator should make the pipe connections using quick couplers between the pump and the hosepipe
- Operator waits for the signal it is okay to start pumping.
- Monitor the filling process. Be prepared to shut it down in case of a broken pipe or separated coupling.

- Workers must be responsible for wearing eye protection (goggles) and other PPE, especially when mixing lime to form the slurry.
- Periodically cutting the grass on the pond embankments
- Removal of scum and floating microphysics from the surface of facultative ponds and maturation ponds. This is done to maximize the light energy reaching the pond algae, increase surface re-aeration, and prevent fly and mosquito breeding
- If flies are breeding in large numbers on the scum on anaerobic ponds, the scum should be broken up and sunk with a water jet
- Removal of any material blocking the pond inlets and outlets
- Repair of any damage to the embankments caused by rodents
- Repair of any damage to fences and gates.
- Application of sludge, desludging, control of drainage system and of the secondary treatment for percolate or dried sludge. Desludging everyone to several weeks.
- Trained staff for *operation and maintenance* (application of sludge, desludging, control of drainage system and the control of the secondary treatments for percolate or dried sludge) is required to ensure proper functioning.

The operators must be given precise instructions on the frequency at which these tasks should be done, and their work must be regularly inspected. Operators may also be required to take samples and carry out some routine measurements. Solids in raw wastewater, as well as biomass produced, settle out in first-stage anaerobic ponds and they require desludging when half full of sludge

As a rough guide one full-time operator is required at WSPs receiving wastewater flows up to about 5 m3/d, one operator for wastewaters flows up to about 5 m3/d. A foreman/supervisor is required at sites treating more than 5 m3/d and should also keep a record of all maintenance activities, measure and record the wastewater flow and carry out routine effluent sampling. All WSP operators should receive adequate training so that they understand what they have to do and how to do it correctly. If, for example, the pond operators have not been told to remove scum from facultative ponds and maturation ponds, they will not know that it should be removed. As a result, scum can cover a substantial part of the pond, algal photosynthesis becomes impossible, and the pond turns anoxic

Anaerobic ponds need to be dislodged when they are around one-third full of sludge. This occurs every 2−5 years, but it is operationally better to remove some sludge every year (as a task to be done, for example, has a better chance of being done on time than one which has to be done every few years). The sludge removed from anaerobic ponds can be dewatered on sludge drying beds). Facultative ponds store any sludge for their design life, which is a significant operational advantage.

<u>Leak detection</u>

Possible leaks could be detected by observing if there are any:

- Cracks through the cement embankment or peeling of synthetic lining.
- Signs of moist soil around the waste stabilization ponds.
- Water pools at the inlet or anywhere on site and the source are not known.

Maintaining WSP facility

All wastewater facilities require ongoing maintenance and Waste Stabilization Pond systems are no different. Operators should keep a maintenance log book and record all activities. The following are recommendations for your maintenance program:

1. Identify the equipment and other parts of your system that will require, periodic maintenance
2. Develop a regular inspection program to visually inspect each of these critical locations throughout your facility at least once a month. Make sure to document the inspection.
3. Conduct regular training activities so everyone knows their role.
4. Keep a file of all manufacturer's product literature and maintenance requirements and follow the procedures exactly.
5. Determine what spare parts will be needed, buy them in advance and keep them in a locked storage area
6. Develop a schedule for preventative and regular maintenance and follow it.

Proper maintenance will help to ensure the sustainability of your facility and minimize down time due to broken equipment.

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