Waste Stabilization Pond for Rural Area

Rohit P. Deshmukh[1] Dr. Arif Khan[2]
[1]Student [2]Principal
[1,2]NCET, Nagpur, India

Abstract— In this research, we study the suitability of Waste Stabilization Ponds for treating waste water in rural areas. Waste generated in rural areas is commonly discharged into environment without any prior treatment. For treating waste water WWTP have two methods which are mechanical and natural. All the WWTP units taken as mechanical method of treating wastes, but the natural methods has proved to be more effective & less expansive. Waste stabilization ponds taken as natural methods which are we effectively used in rural areas to reduce environmental pollution. A good design and construction of waste stabilization ponds are needed to grow application of waste water purification & environmental regulations. In that study, we see types, application, design parameters, advantages and disadvantages of WSP.

Keywords: Environmental Regulations, WWTP, Mechanical Methods of Treating Wastes, WSP

I. INTRODUCTION

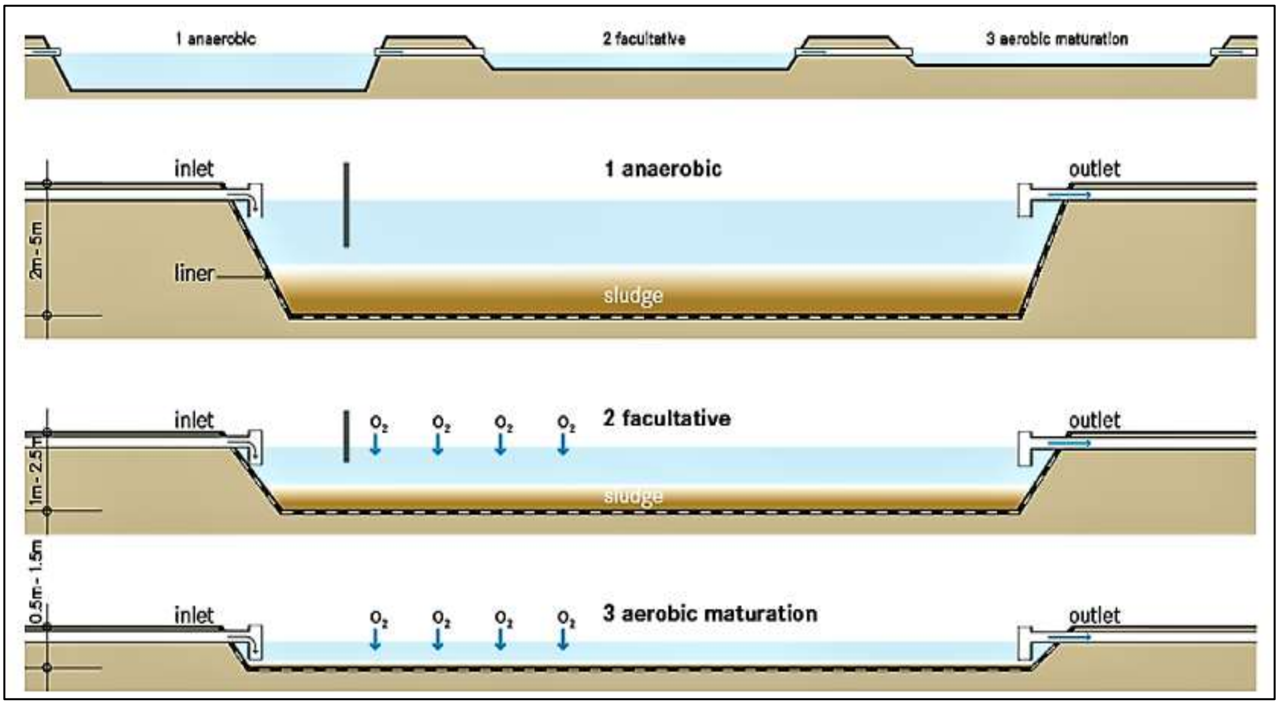
Several techniques are used for treating domestic waste water. These can be classified into two groups Mechanical and Natural methods. The mechanical methods includes Aeration, Trickling filter, activated sludge system, primary and secondary clarifiers. It has high cost & energy requirement. Waste stabilization ponds (WSP) which are natural method increasingly applied for domestic waste water treatment as they can offer completely natural purifying processes. WSP are large, shallow basins in which raw sewage is treated entirely by natural processes involving both algae and bacteria. They are used for sewage treatment in temperate and tropical climates, and represent one of the most cost-effective, reliable and easily-operated methods for treating domestic and industrial waste water.

This study was conducted to establish proper design guidelines for installation of WSP in rural area to provide a solution for the problem of the waste water generated from villages and small towns in the province. WSP are shallow basins enclosed by earthen embankment in which raw sewage is treated by natural process. Waste stabilization ponds are biological treatment systems, which processes and operations are highly dependent on the environmental conditions such as temperature, wind speeds and light intensity which highly variable and any given combination of these environmental parameters is usually unique to a given location. WSP system generally consists of a series of ponds involving anaerobic, facultative and maturation ponds. Anaerobic and facultative ponds are respectively used for primary treatment and secondary treatment. They are both for the removal of biochemical oxygen demand (BOD), Vibrio cholerae and helminth eggs. The maturation ponds are used for tertiary treatment of waste water effluents and responsible for the removal of fecal viruses.

Waste stabilization ponds (WSPs) are large, shallow basins of varying depth. where raw sewage is treated entirely by natural processes using both bacteria and algae. They are one of the most cost-effective, reliable and easily-operated methods for treating domestic and industrial wastewater in temperate and tropical climates (Abdullahi et al; 2014). Solar energy is the only requirement for its working. The temperature and duration of sunlight in tropical countries provides an excellent opportunity for high efficiency and performance for this type of water cleaning system. Further, it requires minimum supervision for daily operation, simply by cleaning the outlets and inlet works. Waste stabilization ponds are very effective in the removal of faecal coliform. They are well-suited for low-income tropical countries where conventional wastewater treatment cannot be achieved due to the lack of a reliable energy source. Many African countries in tropical climates use WSPs for wastewater treatment e.g., Botswana, Kenya, Malawi, Tanzania, Uganda, Zambia, and Zimbabwe (UNEPIETC, 2014). In four successive summers of polar regions of Canadian Arctic WSPs were found to reduce more than 80% of total suspended solids (TSS) and carbonaceous biochemical oxygen demand (CBOD5) (Ragush et al; 2015). In America the most common types of pond used are facultative pond having different names like oxidation pond, sewage lagoon and photosynthetic pond (Reed et al; 1995). Further, the advantage of these systems in terms of removal of pathogens is one of the most important reasons for its use. WSP are often thought of as being suitable in developing countries because of their simplicity, low cost and maintenance, low energy utilization, strength, and sustainability (Mara, 2003). The efficiencies of combined anaerobic, facultative and maturation ponds in treating municipal wastewater to reduce BOD, COD, TSS was found to be 50.65%, 48.95% and 44.3%, respectively (Ghazy et al; 2008).

Regarding the design, WSP systems consist of single or several series (in parallel) of anaerobic, facultative and maturation ponds. The anaerobic pond is deprived of oxygen and function like a open septic tank where the anaerobic digestion occur at the bottom converting organic load to CH_4 and CO_2 and releases some soluble products in water column. The anaerobic treatment is more suited to waste water with high BOD (UNEPIETC, 2002). The chemical reactions occurring in anaerobic pond can be illustrated through following equation (Crites et al; 2006):-

$$5(CH_2O)_x \; (CH_2O)_x + 2CH_3COOH + Energy$$
$$2CH_3COOH + 2NH_4HC \; 2CH_3COONH_4 + 2H_2O + 2CO_2$$
$$2CH_3COONH_4 + 2H_2O \; 2CH_2 + 2NH_4HCO_3$$



A. Anaerobic Pond:

Anaerobic ponds are commonly 2 – 5 m deep and receive wastewater with high organic loads (i.e., usually greater than 100 g BOD/m 3 .day, equivalent to more than 3000 kg/ha.day for a depth of 3 m). They normally do not contain dissolved oxygen or algae. In anaerobic ponds, BOD removal is achieved by sedimentation of solids, and subsequent anaerobic digestion in the resulting sludge. The process of anaerobic digestion is more intense at temperatures above 15 o C. The anaerobic bacteria are usually sensitive to pH. Thus, acidic wastewater must be neutralized prior to its treatment in anaerobic ponds. A properly-designed anaerobic pond will achieve about a 40% removal of BOD at 10 o C, and more than 60% at 20 o C. A shorter retention time of 1.0 - 1.5 days is commonly used.

B. Facultative Pond:

Facultative ponds (1-2 m deep) are of two types: Primary facultative ponds that receive raw wastewater, and secondary facultative ponds that receive particle-free wastewater (usually from anaerobic ponds, septic tanks, primary facultative ponds, and shallow sewerage systems). The process of oxidation of organic matter by aerobic bacteria is usually dominant in primary facultative ponds or secondary facultative ponds.

The processes in anaerobic and secondary facultative ponds occur simultaneously in primary facultative ponds, as shown in Figure 2.1. It is estimated that about 30% of the influent BOD leaves the primary facultative pond in the form of methane (Marais 1970). A high proportion of the BOD that does not leave the pond as methane ends up in algae. This process requires more time, more land area, and possibly 2 -3 weeks water retention time, rather than 2 -3 days in the anaerobic pond. In the secondary facultative pond (and the upper layers of primary facultative ponds), sewage BOD is converted into “Algal BOD,” and has implications for effluent quality requirements. About 70 – 90% of the BOD of the final effluent from a series of well-designed WSPs is related to the algae they contain. In secondary facultative ponds that receive particle-free sewage (anaerobic effluent), the remaining non-settleable BOD is oxidized by heterotrophic bacteria (Pseudomonas, Flavobacterium, Arthrobacter and Alcaligenes spp). The oxygen required for oxidation of BOD is obtained from photosynthetic activity of the micro-algae that grow naturally and profusely in facultative ponds.

Facultative ponds are designed for BOD removal on the basis of a relatively low surface loading (100 – 400 kg BOD/ha.day), in order to allow for the development of a healthy algal population, since the oxygen for BOD removal by the pond bacteria is generated primarily via algal photosynthesis. The facultative pond relies on naturally-growing algae. The facultative ponds are usually dark-green in color because of the algae they contain. Motile algae (Chlamydomonas and Euglena) tend to predominate the turbid water in facultative ponds, compared to none-motile algae (Chlorella).

C. Maturation Pond:

The maturation ponds, usually 1-1.5 m deep, receive the effluent from the facultative ponds. Their primary function is to remove excreted pathogens. Although maturation ponds achieve only a small degree of BOD removal, their contribution to nutrient removal also can be significant. Maturation ponds usually show less vertical biological and physicochemical stratification, and are well-oxygenated throughout the day. The algal population in maturation ponds is much more diverse than that of the facultative ponds, with non-motile genera tending to be more common. The algal diversity generally increases from pond to pond along the series (Mara, 1989). Although fecal bacteria are partially removed in the facultative ponds, the size and numbers of the maturation ponds especially determine the numbers of fecal bacteria in the final effluent. There is some removal of solids-associated bacteria in anaerobic ponds, principally by sedimentation. The principal mechanisms for fecal bacterial removal in facultative and maturation ponds are now known to be:

1) Time and temperature;
2) High pH (> 9); and
3) High light intensity, combined with high dissolved oxygen concentration.

II. Design Parameters

Design of anaerobic ponds: The anaerobic ponds are designed on the basis of volumetric loading (λv, g/m3 /d), which is given by:

$$\lambda v = Li\ Q\ Va$$

Where Li is influent BOD (mg/l), Q is flow rate (m3 /day), and Va is anaerobic pond volume (m3). Meiring et al., 1998 recommended that the loading should be between 100 – 400 g/m3 .day, in order to maintain anaerobic conditions. A retention time less than one day should not be used for anaerobic ponds; if it occurs, however, a retention time of one day should be used, and the volume of the pond should be recalculated.

Temperature (o C)	Volumetric loading (g/m3 .day)	BOD removal (%)
< 10	100	40
10-20	20T-100	2T+20
20-25	10T+100	2T+20
>25	350	70

Design of facultative ponds: Facultative ponds can be designed on the basis of kinetic or empirical models. The rate at which the organic matter is oxidized by bacteria is a fundamental parameter in the rational design of biological wastewater treatment systems. It has been found that BOD removal often approximates first-order kinetics; that is, the rate of BOD removal (rate of oxidation of organic matter) at any time is proportional to the quantity of BOD (organic matter) present in the system at that time. This is expressed mathematically

$$dL\ dt = -k1L$$

Where L is the quantity of BOD remaining (= organic matter to be oxidized) at time "t", and k1 is first-order rate constant for BOD removal (day-1).

Design of maturation ponds: The method of Marais (1974) is generally used to design a pond series for faecal coliform removal. This assumes that faecal coliform removal can be reasonably well represented by a first-order kinetic model in a completely-mixed reactor. The resulting equation for a single pond is given by:

III. Objectifies

1) To provide WSP, builders and operators with appropriate information to develop, implement and operate WSP for a range of applications and design objectives.
2) To provide standard systems approach that can be adopted universally, and which can accommodate a development technology, with changes in information concepts and ideas with time.
3) To Provide theoretical background on the biological, chemical and physical processes of WSPs, the current state of the technology and technical knowledge on how to design, operate and maintain the systems.
4) To Provide theoretical knowledge on how the models can be used in the best manner to describe the systems.

IV. Conclusion

After examining the existing condition of village pond and surroundings of different villages. it was observed that people in villages do not have proper sewerage facility available, these villages had water supply systems. Due to the provision of water supply in these villages, the water use has increased and consequently the wastewater generation has also been increased. This results in increased amount of wastewater reaching the pond which exceeds the self-purifying capacity of the ponds. Due to improper knowledge and awareness cow dung mixture is put by the nearby dairy workers in the open drains which further jammed or choked the open drains due to this wastewater flow stops flowing and the waste flow get collected on the side roads. This research will definitely help to proper management of waste water in rural areas to minimize the environmental pollution.

References

[1] Eriksson, E., et al. (2002). "greywater wastewater characteristics". Urban Water, 4, pp.85–104.
[2] Constructed wetlands & Waste stabilization ponds design manual by S. Kayambo, N. Ladegaard.
[3] Treatment of wastewater through subsurface flow constructed wetlands. A Technology Assessment EPA 832-R-93-008 July 1993.
[4] Design of modern WSPs in Warm Climates: Comparison with Traditional Design Methods by Gawasiri pg.9
[5] Whitworth.K & Baldwin, D. S (2009) Current conditions & blackwater potential events in the Wakool River. Technical Report MDFRC 1/2009. MDFRC
[6] Ecological Sanitation Toilets in Tanzania on Integrated Environmental Management in Southern Africa, Johannesburg, August 2002
[7] E. Muelegger & G. Lanergraber- Environment International Journal 31 (2005) 433–444 4.3.bLu¨beck-FlintenbreiteQ, Germany pg. 440
[8] E. Muelegger & G. Lanergraber- Environment International Journal 31 (2005) 433–444 4.3.bLu¨beck-FlintenbreiteQ, Germany pg. 440
[9] Peter Ridderstolpe, WRS Uppsala AB (2004). "Introduction to Greywater Management".pp 1-3.
[10] Mara, D. 2003. Design manual for waste stablization ponds in UK, Leeds University, UK.
[11] Abdullahi, I., Naguri, I., Saminu, A., Sagir, L., Charity, E., 2014. Design of waste stabilization pond for sewage at Nigerian defense academy staff quarter, permanent site Mando Kaduna. International Journal of Engineering and Applied Sciences.1(2), 9-15.
[12] Ghazy, M.M.E.D., El-Senousy, W.M., Abdel-Aatty, A.M., Kamel, M., 2008. Performance evaluation of a waste stabilization pond in a rural area in Egypt. American Journal of Environmental Sciences., 4(4), 316-325.

[13] Mara, D., Pearson, H., 1998. Design manual for waste stabilization ponds in Mediterranean Countries, Lagoon Technology International, Leeds, England.
[14] Mara, D., Pearson, H., Oragui, J., Arridge, H., Silva, S. A., 2001. Development of a new approach to waste stabilization pond design, TPHE Research Monograph No. 5 School of Civil Engineering, University of Leeds, Leeds, England.

