Monitoring and Evaluation of Waste Stabilization Ponds

By

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Introduction

Once a WSP system has been commissioned, a routine monitoring programmer should be established so that the actual quality of its effluent can be determined. This permits a regular assessment to be made of whether the effluent is complying with local discharge or re-use standards. Moreover, should a pond system suddenly fail or its effluent start to deteriorate, the results of such a monitoring programmer often give some insight into the cause of the problem and so indicate what remedial action is required.

The evaluation of pond performance and behavior, although a much more complex procedure than the routine monitoring of effluent quality, is nonetheless extremely useful as it provides information on how under loaded or overloaded the system is, and thus by how much, if any, the loading on the system can be safely increased as the community it serves expands, or whether further ponds in parallel and/or in series are required.

It also indicates how the design of future pond installations in the region can be improved to take account of local conditions.

Effluent Quality Monitoring

Effluent quality monitoring programs should be simple and the minimum required to provide reliable data. Two levels of effluent monitoring are recommended:

- 1 *Level 1*: representative samples of the final effluent should be taken regularly (at least monthly) and analyzed for those parameters for which effluent discharge or re-use requirements exist.
- 2 *Level 2*: when Level 1 monitoring shows that a pond effluent is failing to meet its discharge or re-use quality, a more detailed study is necessary.

Table 1 gives a list of the parameters whose values are required, together with recommendations for the types of samples that should be taken.

Since pond effluent quality shows a significant diurnal variation (although this is less pronounced in anaerobic and maturation ponds than in facultative ponds), 24-hour flow-weighted composite samples are preferable for most parameters, although grab samples are necessary for some (pH, temperature and *E coli*). Composite samples should be collected in one of the following ways:

1. in an automatic sampler which takes grab samples every 1–2 hours, with subsequent manual flow-weighting if this is not done automatically by the sampler;
2. by taking grab samples every 1–3 hours with subsequent manual flow weighting; or
3. by taking a column sample near the outlet of the final pond; this can be done at any time of day and gives a good approximation (± ~20 per cent) to the mean daily effluent quality **[1]** .

Flow-weighting is used in order to determine more accurate estimates of mean daily parameter values such as BOD and suspended solids. Grab samples are taken every 1–3 hours for 24 hours, and the volume of each grab sample used to make the 24-hour

composite sample depends on the wastewater flow at the time it was taken, for example, if at any time the flow were 10,000 m3/day, then 100 ml of the grab sample taken at that time would be used to make the 24-hour composite; 150 ml would be used for a flow of 15,000 m3/day, and 230 ml for a flow of 23,000 m3/day, and so on. Thus the greater the flow, the more 'weight' is given to the sample – hence the term 'flow-weighting'.

Table 1 ***Parameters to be determined for Level 2 Pond Effluent Quality Monitoring***

Parameter	***Sample type*** [a]	***Remarks***
Flow	-	Measure both raw wastewater and final effluent flows
BOD	C	Unfiltered samples [b]
COD	C	Unfiltered samples [b]
Suspended solids	C	
pH		
Temperature	G	Take two samples, one at 08.00 – 10.00 h and the other at 14.00 – 16.00 h
E. coli	G	Take sample between 08.00 and 10.00 h
Total nitrogen	C	
Total phosphorus	C	
Chloride	C	
Electrical conductivity	C	Only when effluent being used (or being assessed for use) for crop irrigation. Ca Mg and Na are required to calculate the sodium absorption ratio
Ca, Mg, Na	C	
Boron	C	
Helminthes eggs	C	

Notes:
a C = 24-hour flow-weighted composite sample; G = grab sample
b Also on filtered samples if the discharge requirements are so expressed

Evaluation of the performance of a WSP

A full evaluation of the performance of a WSP system is a time-consuming and expensive process, and it requires experienced personnel to obtain and interpret the data. However, it is the only means by which pond designs can be optimized for local conditions. It is often, therefore, a highly cost-effective exercise. The recommendations given below constitute a Level 3 monitoring programs, and they are based on the guidelines for the minimum evaluation of pond performance given by Pearson et al (1987e**) [2].**

It is not intended that all pond installations be studied in this way, but only one or two representative systems in each major climatic region. This level of investigation is most likely to be beyond the capabilities of local organizations, and it would need to be carried out by a state or national body, or by a university under contract to such a body. This type of study is also necessary when it is required to know how much additional loading a particular system can receive before it is necessary to extend it.

Samples should be taken and analyzed on seven days over a seven-week period at both the hottest and coldest times of the year. Samples are required of the raw wastewater and of the effluent of each pond in the series and, so as to take into account the weekly variation in influent and effluent quality, samples should be collected on Monday in the first week, Tuesday in the second week and so on. **Table 2** lists the parameters whose values are required. Generally the analytical techniques described in the latest edition of *Standard Methods* (American Public Health Association, currently 1998) are recommended, although the modified Bailenger technique should be used for counting the number of nematode eggs and *E coli* is best counted using modern selective media (such as chromogenic media, **[3,4]**.

Composite samples are necessary for most parameters, but grab samples are required for temperature, pH and *E coli*, and samples of the entire pond water column should be taken for algological analyses (chlorophyll *a* and algal genera determination), using the pond column sampler.

Pond column samples should be taken from a boat or from a simple sampling platform that extends beyond the embankment base (or from the outlet structure if this extends sufficiently far into the pond). Data on at least daily maximum and minimum air temperatures, rainfall and evaporation should be obtained from the nearest meteorological station.

On each day that samples are taken, the mean mid-depth temperature of each pond, which closely approximates the mean daily pond temperature, should be determined by suspending a maximum-and-minimum thermometer at the mid-depth of the pond at 8–9 am and reading it 24 hours later.

On one day during each sampling period, the depth of sludge in the anaerobic and facultative ponds should be determined by the 'white towel' test (figure1).

Table 1 Parameters to be Determined for the Minimum Evaluation of WSP Performance

Parameter	***To be determined for*** [a]	***Sample type*** [b]	***Remarks***
Flow	RW, FE	-	
BOD	RW, all pond effluents	C	Unfiltered and filtered samples
COD	RW, all pond effluents	C	Unfiltered and filtered samples
Suspended solids	RW, all pond effluents	C	
E. coli	RW, all pond effluents	G	
Chlorophyll *a*	All F and M pond contents		p
Algal genera	All F and M pond contents		p
Ammonia	RW, all pond effluents	C	
Nitrate	RW, FE	C	
Total phosphorus	RW, FE	C	
Sulphide	RW, A pond effluent, F pond contents or depth profile	G, P	Only if odor nuisance present or facultative pond effluent quality poor A depth profile is preferable
pH	RW, all pond effluents	G	
Temperature (mean daily)		-	Use maximum–minimum thermometers suspended in RW flow and at mid-depth in ponds
Dissolved oxygen [c]	Depth profile in all F and M ponds	-	Measure at 08.00, 12.00 and 16.00 h on at least three occasions
Sludge depth	A and F ponds	-	Use 'white towel' test

Electrical conductivity	FE	C	Only when effluent being used or to be used for crop irrigation. Ca Mg and Na are required to calculate the sodium absorption ratio
Chloride	RW, FE	C	
Ca, Mg, Na	FE	C	
Boron	FE	C	
Helminthes eggs	RW, all pond effluents	C	

Notes:

a RW, raw wastewater; FE, final effluent of pond series; A, anaerobic; F, facultative; M, maturation.

b C, 24 hour flow-weighted composite sample; G, grab sample taken when pond contents most homogeneous; P, pond column sample.

c Measure depth profiles of pH and temperature at same times, if possible

The sludge depth should be measured at various points throughout the pond, away from the embankment base, and the mean depth calculated.

It is also useful to measure on at least one occasion during each sampling season the diurnal variation in the vertical distribution of pH, dissolved oxygen and temperature. Profiles should be obtained at 08.00, 12.00 and 16.00 h. If submersible electrodes are not available, samples should be taken manually every 15–20 cm.

Figure 1 Sludge Depth Measurement by the 'White Towel' Test

DATA STORAGE AND ANALYSIS

It is advisable to store all data in a PC using a spreadsheet such as Excel, so that simple data manipulations can be performed. From the data collected in each sampling season (or month if sampling is done throughout the year), mean values should be calculated for each parameter. Values, based on these means, can then be calculated for:

1. 1 the mean hydraulic retention time (= volume/flow) in each pond;
2. 2 the volumetric BOD and COD loadings on anaerobic ponds;
3. 3 the surface BOD and COD loadings on facultative ponds; and
4. 4 the percentage removals of BOD, COD, suspended solids, nitrogen, phosphorus, *E coli* and nematode eggs in each pond and in each series of ponds.

A simple first-order kinetic analysis may be undertaken if desired. The responsible local or central governmental agency should record and store all the information on, and all the data collected from, each pond complex, together with an adequate description of precisely how they were obtained, in such a way that design engineers and research workers can have ready and meaningful access to them.

References

[1] Pearson, H W, Mara, D D, Konig, A, de Olivera, R, Silva, S A, Mills, S and Smallman, D J (1987d) 'Water Column Sampling as a Rapid and Efficient Method of Determining Effluent Quality and the Performance of Waste Stabilization Ponds,*Water Science and Technology*, vol 19, no 12, pp109–113.

[2] Pearson, H W, Mara, D D and Bartone, C R (1987e) 'Guidelines for the Minimum Evaluation of the Performance of Full-scale Waste Stabilization Ponds', *Water Research*, vol 21, no 9, pp1067–1075.

[3] Ayres, R M and Mara, D D (1996) *Analysis of Wastewater for Use in Agriculture: A Laboratory Manual of Parasitological and Bacteriological Techniques*, World Health Organization, Geneva; available at http://www.leeds.ac.uk/civil/ceri/water/tphe/ publicat/reuse/parasitanal.pdf.

[4] Chromagar (2002) *CHROMagar E Coli*, available at http://www.chromagar.com/ products/ecoli.html