# Recommendations for performance evaluation of maturation ponds

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### Summary of key findings

Maturation ponds are a critical step in a wastewater treatment system, offering pathogenic inactivation and final water quality polishing. The performance of a maturation pond is vitally important for the safe reuse and recycle of wastewater. It is of the interest of water authorities, regulators and local communities that the information required for evaluating a maturation pond performance is documented, as well as the measures and steps to be undertaken for the evaluation process. This study presents a summary of research outcomes addressing the said issue, offering recommendations for the performance evaluation of maturation ponds.

### Background and relevance

A correctly designed and operated maturation pond system is a shallow water basin (up to 1.5m depth) (Power and Water Corporation (2011), or series of basins used at the final stage of a wastewater treatment system to remove excreted human pathogens. It normally has a retention period and water quality conditions to result in: (1) reductions of 4-6 log units of faecal coliforms; (2) reductions of 2-4 log units of faecal viruses; and (3) 100% removal of parasites (Mara et al, 1992). An accurate evaluation of maturation pond performance is of vital importance to ensure a safe and economical wastewater reuse and recycle. This study aims to formulate/propose recommendations to water authorities, regulators and communities, listing the suite of information to be collected, the measurements or steps to be undertaken for the validation of maturation pond performance.

The recommendations proposed in this study resulted from two major activities: numerical modelling and field study.

(1) Numerical modelling
The modelling activity used the software package MIKE 3 developed by the Danish Hydraulic Institute (DHI). It is a comprehensive modelling system to model three-dimensional free surface flows and associated sediment and water quality processes. It applies a non-hydrostatic engine to simulate unsteady three-dimensional flows; takes into account density variation, bathymetry and external forces such as meteorology, tidal events and currents; enables the incorporation of hydrodynamic, transport and ecological sub-modules to account for the physical, chemical and biological processes in a maturation pond. The mathematical formulation of the flow in the pond addresses the conservation laws in mass, momentum and energy: (DHI, 2012). The pathogen inactivation mechanism in the pond is presented by the transport equation incorporated with the die-off process.

(2)Field study
Field data collection and sampling activities are organised in alignment with the needs of modelling input and validation. To evaluate the pond treatment performance for a certain time period (referred to as the 'evaluation period' thereafter), a range of factors (e.g., water quality and operational parameters) prior to this period (referred to as the 'pre-evaluation period') are influential. This is largely due to the fact that there is a retention period of wastewater in the pond. According to the experienced gained throughout the study, the date types and their associated data collection frequency are as follows:

a) Pond structural information: geographical location; orientation; length; width; bathymetry; inlet and outlet layout including locations, depths and directions; baffling information including length, depth, number and location. They are considered invariant over the period of the evaluation, and hence is a one-off measurement.
b) Meteorological data: air temperature, relative humidity; wind speed, wind direction; precipitation; solar radiation. They need to be collected both for the pre-evaluation period as well as the evaluation period. The frequency is suggested to be hourly to capture any daily variation.
c) For influent information: inflow rate; influent velocity, direction and temperature are preferably measured on an hourly basis to incorporate diurnal variation in pond loading. The concentration of indicators and/or pathogens is suggested to be measured every 6 hours to adequately reflect typical daily variation. This sampling frequency can be extended to every 24 hours, if relatively long term (e.g., seasonal) performance of a maturation pond is of interest.
d) Temperature profiles of the pond water can be measured with a frequency of an hour for modelling validation purposes. They only need to be covered for the evaluation period.
e) The snap-shot sampling, dye study and the chamber study are to be conducted in the evaluation period. Dye study can be conducted multiple times (multiple dye injections) under a range of environmental conditions. It is suggested that chamber study sampling, water physic-chemical parameter measurements and microbiological snap-shot sampling synchronise with microbiological time-series sampling. The data collection interval is suggested to be every 6 hours, covering the coldest time prior to sunrise, the hottest time in the early afternoon, the time at sunsets, and midnight (night sampling is possible with auto-sampler).

Apart from the temporal sampling scheme, a reasonable and logistically feasible spatial sampling and data collection plan is essential to the performance evaluation success.

## Results

A baffled maturation pond, M1, located in Queensland, Australia was employed herein as a case study. The bathymetry survey conducted in 2013 showed the water depth in M1 to be approximately 1 m. At the same time, information was collected in terms of pond location (ie, the latitude and the longitude), geometry (length and width), structural layout including the location and orientation of the inlet and the outlet, and additional structures (number and length of baffles and their relative locations in the pond).

Temperature chains were constructed and deployed into the pond to collect water temperature profile data for model validation purposes. The chains were made using HOBO sensors spaced at 20 cm intervals, capturing temperature data at pond surface, 0.4-0.6 m below water surface and close to pond bottom. The temperature chains were placed in the pond on January 9, 2014, and the first data retrieve was conducted on March 20, 2014. Figure 1 provides a comparison of measured and simulated temperature data at the water surface level. The comparison shows a good correlation between the modelled and the measured data, with a RMSE (Root Mean Square Error) = 1.01℃, resulting in an average 3.74% difference between the two data set, and a R2 (R-Squared) = 0.87.

E. coli inactivation within the pond was simulated and the results were compared with measured data. In the simulation, a die-off rate coefficient K(t) = 0.5/day was used, as recommended by the field sampling and the subsequent microbiological analysis. As shown in Figure 2 (a), E. coli concentration was examined at six locations, represented in Figure 2 (b) by the time it took the wastewater to travel from the inlet to each specific location. Scattered triangles denote E. coli concentration from field measurement, and lines represent simulated results, both showing a 3-log unit removal in E. coli concentration in pond water.

## Discussion

In conclusion, information required to undertake a performance evaluation of a maturation pond can be summarised as:

- Pond structural information;
- Meteorological data;
- Influent information;
- Indicators and/or pathogen die-off process in the pond: die-off rate coefficient;
- Temperature data and dye concentration data;
- Water sampling and the associated microbiological analysis for indicators and/or pathogen concentration at various locations in the pond including the outlet.

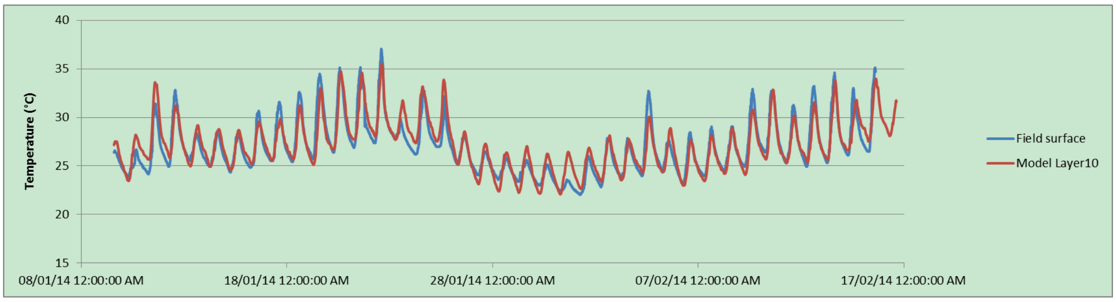
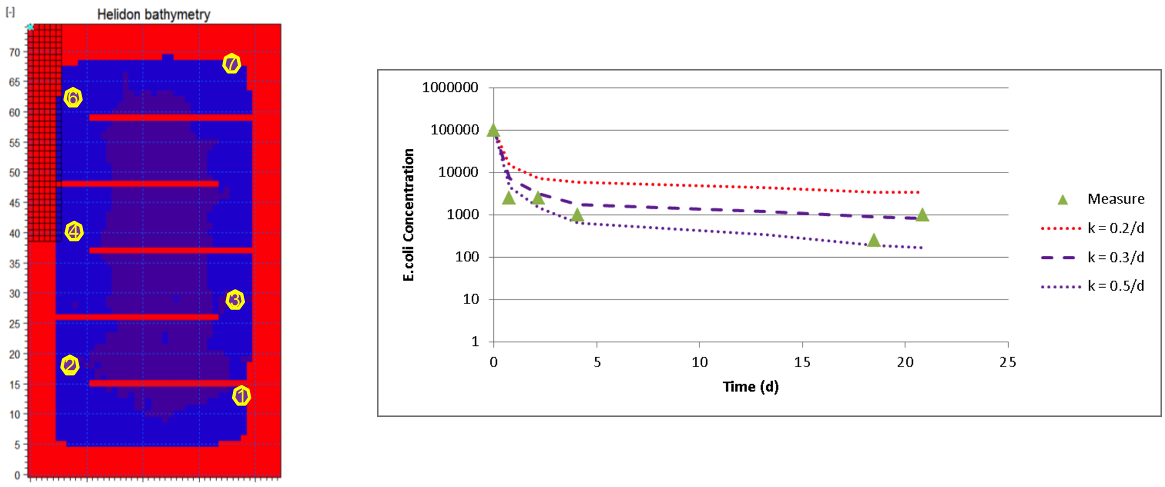



**Figure 1.1 A comparison of measured and simulated temperature data at the water surface level**




(a) (b)

**Figure 1.2 *E.coli* removal efficiency in a baffled maturation pond: (a) sampling locations in the pond; and (b) *E.coli* counts vs time, the time axis corresponds to the locations specified in the left figure**

## References

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