Effects of vegetation on pond retention time

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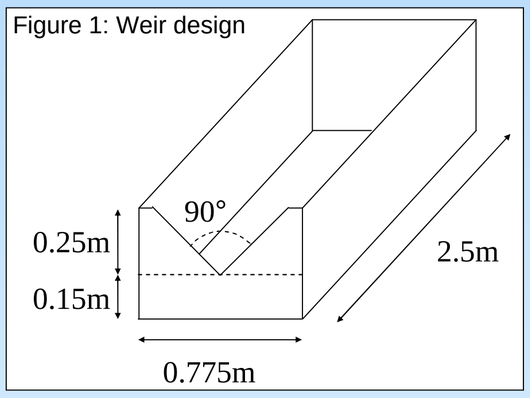
1. Introduction

This research is a preliminary study to quantify the effects of vegetation on pond retention times. The hydraulic retention time (HRT) is defined as the mean time that a molecule or particle is retained within a system. This is of primary importance in pond design, as adequate time must be allowed for the chemical, biological, and physical processes to take place. It is known that vegetation has an effect on HRT, but there is no easy method currently available to account for it within design. The research is split into two phases. Modifying the full size ponds in Sweden to enable them to be used for research, and investigating vegetation effects using a scale model within the University. Due to time constraints it was not possible to investigate vegetation effects in Sweden.

Figure 1: Weir design



3. Weir design

British Standard, BS 3680-A4:1981, for ‘V’ notch weirs was the principle design guide, however the design was heavily influenced by the narrow location and by the materials available. Both the height and the length of the weir were ultimately dictated by the marine ply boards used in their construction.

The design was optimised using a spreadsheet, and the final design is shown in figure 1. Two weirs were constructed, the first positioned in the outlet of the second pond and the second weir positioned between the sedimentation pond and the first pond (figure 2)

Figure 3: Trace setup

4. Calibration

Because the weirs were not a standard design they had to be calibrated. Once calibrated, a measurement of the water level 1m from the ‘V’ notch can be used to calculate the discharge.

Two methods of measuring the discharge were used. The first was using a bucket to catch the flow and measure the volume of water collected within a certain time. The other involved injecting known quantity of a fluorescent dye, rhodamine, into the water a known distance upstream. A portable fluorometer was used to record the concentration and a time-concentration distribution was created. Then a mass balance was conducted to obtain the discharge. The setup is shown in figure 3.

5. Conclusion

During the fortnight there was a variety of weather conditions, enabling a wide range of discharges to be sampled. Figure 4 shows the weir calibration of head (h) against discharge. Although there was not sufficient time to conduct a trace during the visit, the ponds are in a condition that meaningful trace data can be obtained.

The trip was a success with all the objectives met. It was a lot of hard work, with most of the rock and soil moved by hand, but very rewarding and a good insight into the challenges of working in the field as opposed to working in laboratories.

Sweden

2. Aims and weir specification

Aim:

•To install monitoring equipment to enable meaningful trace data to be gathered.

Specification:

- The area should look natural after the work
- The weir must be removable
- The design must stay within the parameters set in BS 3680-4A:1981
- All the water must flow over the weir
- The weir must take a maximum discharge of 40l/s without overtopping.

Figure 2: Pond layout

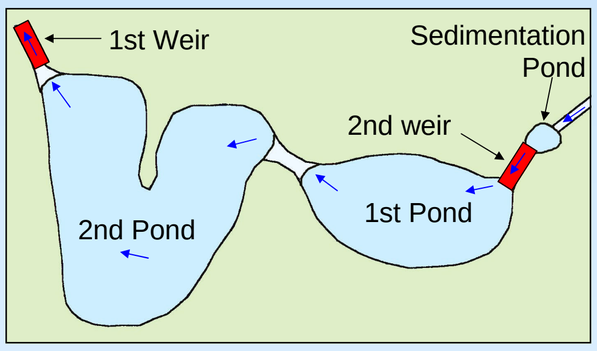
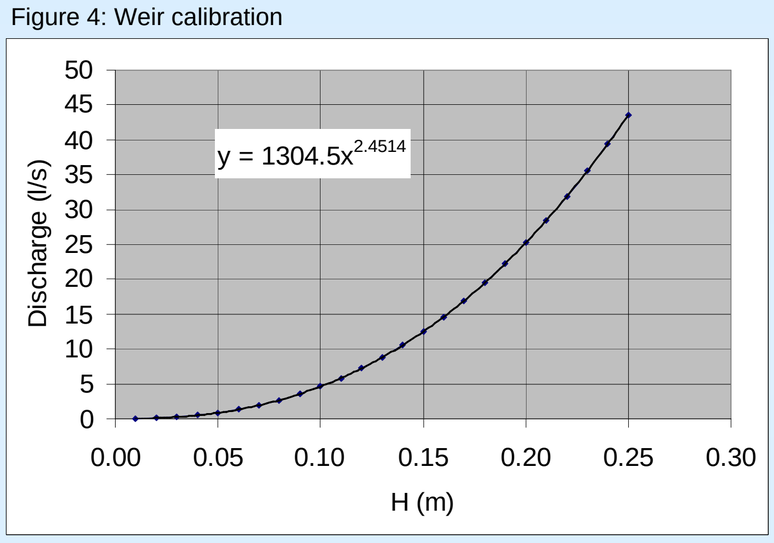


Figure 4: Weir calibration



University

1. Aims and objectives

Aim:

•To generate preliminary data on the effects of edge vegetation on the HRT of the pond.

Objectives:

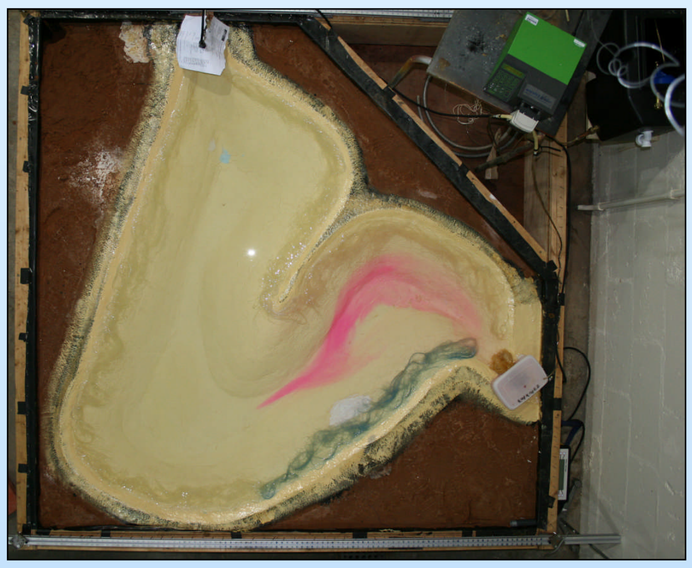
- Refurbish and check the existing 1:15 scale model
- Find an appropriate scale approximation of vegetation
- Conduct traces with and without vegetation

2. Scale model

The scale model needed some considerable refurbishment, and this was mainly carried out by Mr. V. Tiev, a PhD student working in the same area. The sand model was re-sealed and re-painted. The inflow was also modified, to take out the pulsing effects of the peristaltic pump used to regulate the discharge.

After looking at a number of options for vegetation, sisal proved to be small enough to work in the pond and buoyant enough not to sink to the bottom. Although the end result does not look like reeds and other plants, the matted fibres of the sisal have the same effects on the flow. Due to time constraints a high discharge was modelled, because that gave a shorter HRT, enabling more traces to be conducted. Figure 5 shows the pond with the vegetation around the edge. It also shows the preliminary stages of a trace (the pink dye near the inlet).

Figure 5: Scale pond setup



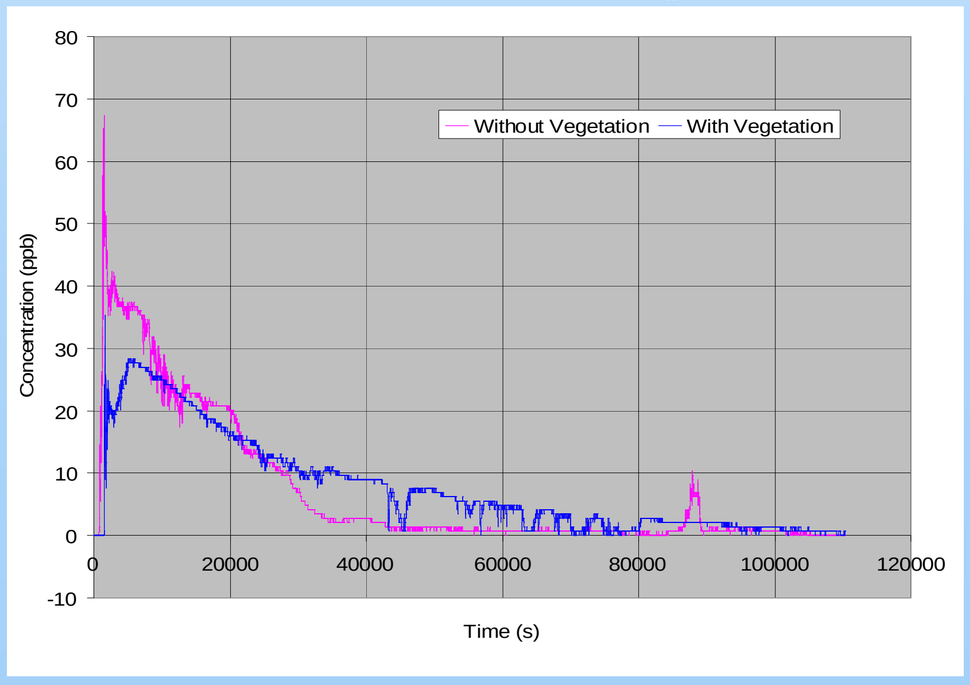
4. Results

Figure 6 shows two traces, one with vegetation, and one without. The mean HRT without vegetation is 12722 s and with vegetation is 21346 s. The peak concentration is lower with vegetation and occurs later. The tail is also longer with the vegetation.

5. Conclusion

Vegetation around a pond increases the HRT and increases the mixing within the pond, causing the flatter shape to the trace, shown in figure 6. However more research is needed in order to quantify the effects fully. In conjunction with further scale model work, traces can now be conducted on the full size pond to verify the scale data.

Figure 6: Time-concentration distribution with and without vegetation



3. Method

- Set up the required inlet discharge
- Check the calibration of the fluorometer (Cyclops)
- Start recording the background concentration
- Check the outlet discharge
- Inject dye
- Import the data into Excel and convert voltage to concentration. Then construct a time-concentration distribution and find the mean HRT (centre of mass)

Acknowledgements

Dr. J. O. Lacoursière for housing us in Sweden, and letting us destroy his ponds, Mr. V. Tiev for all his help during the project and Prof. I. Guymer for making me aware of this opportunity and for being my supervisor.

References

British standard: BS 3680-A4:1981