Study of the parameters for optimisation of the design and performance of waste stabilisation ponds in extreme continental climates

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Experimental work
Four experimental waste stabilisation ponds located in Almaty, Kazakhstan were run over a 2-year period. The ponds went through a typical cycle from warm weather to cold weather conditions, with ice formation, and a spring/summer warm up period to a point where summer steady state conditions were established. In winter samples were taken from beneath the ice in each of the ponds. An accurate solids determination was made just before ice formation and immediately after ice melt in order to determine the loss of accumulated bio-solids over the winter period. During spring and summer the ponds were monitored on a daily basis to assess the growth of phytoplankton, the level of chlorophyll, the suspended solids, COD, BOD, ammonia and phosphate. The results showed a rapid rise in algal growth with increasing water temperature but a long period of acclimatisation was required before a stable effluent quality was reached. There was an increase in soluble nutrients when the water cooled in the autumn. Stabilisation of wastewater beneath ice cover was found to be minimal and there is evidence of release of nutrients from the bottom sediments on warming.
**Modelling data**
A model was developed to determine the oxygen balance in the pond during the critical spring period when there is a transition between ice cover and free water. At this time BOD load on the pond is a maximum, due to the accumulation of wastewater under the ice during the winter period. A number of elements are included within the model, both physical and biological, some of which can be considered separately but others other only synergistically. Data for model calibration was obtained from the experimental ponds and also from laboratory studies, more specifically light-dark experiments to determine rates of oxygen production and utilisation by mixed algal/bacterial cultures of pond origin. Algal growth experiments in batch culture were used to determine the temperature dependence of growth. A model to predict temperature changes at different depths was also developed to show the diurnal fluctuation in temperature and the time lapse as the depth of the pond increased.

![](image1.png)

- COD from 3 trial ponds in different feeding regimes

**Model characteristics**
In the model both algal and bacterial growth are simulated by a Monod kinetic model in which growth rate is described by the term $\mu$, corrected for temperature using a temperature activity coefficient. Oxygen utilisation is calculated from the substrate removed and the oxygen production potential of the algae is considered in terms of its primary metabolite yield. Algal growth rates in relation to temperature were determined in the laboratory using cultures of algae typically found in waste stabilisation ponds. The model uses a mass balance approach to determine the level of dissolved oxygen in the pond at any time.

![](image2.png)

- Pond simulation output
Results and conclusions
The results show the potential for using waste stabilisation ponds in an extreme continental climate. They produce a high quality effluent in the summer period with very low levels of soluble nutrients (ammonia, phosphate and nitrate). This factor would limit the impact that the effluent has on the receiving environment, providing that the biomass could be removed. The results have increased our knowledge of how extreme cyclic temperature changes affect waste stabilisation pond operation. The work has resulted in a computer simulation model that provides the foundation upon which a design tool can be built.

Collaborators
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Publications


