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PRIORITIES IN WASTE
STABILIZATION POND RESEARCH

A discussion paper

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PRIORITIES
IN
WASTE STABILIZATION POND
RESEARCH

A discussion paper
by
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1. Despite a great increase in research on waste stabilization ponds during the past twenty five years, there is still a considerable degree of uncertainty about pond performance. Further research is needed and, since research is expensive, it must be well focussed. In this short discussion paper I set out what I believe to be the current research priorities for the treatment of domestic wastewater in ponds.

CURRENT RESEARCH PRIORITIES

Anaerobic ponds

2. Design procedures are very conservative as there is a great lack of reliable field data. The main research priority is to determine the variation of BOD removal with BOD loading and temperature, so that realistic design recommendations can be made.

3. Further work is needed on sulphur transformations in anaerobic ponds. Important research areas include the determination of:

- the maximum sulphur (organic S and $\text{SO}_4^{2-}$) loading rate that does not cause odour release [according to Gloyna (1971), sulphate concentrations in the raw wastewater of less than 500 mg $\text{SO}_4^{2-}$ $l^{-1}$ are unproblematic];
the role of photosynthetic sulphide-oxidising bacteria in preventing odour release, and how their growth may be encouraged;

- the maximum sulphide concentration that does not inhibit methanogenesis [Kunst (1985) found that 38 mg L\(^{-1}\) was inhibitory in anaerobic digesters];

Facultative ponds

4. There is a need to determine the performance of deep facultative ponds. Current research at EXTRABES is investigating 2.25 m deep primary facultative ponds, but information on 3 m deep ponds is required. Sulphide and ammonia toxicity to the pond algae, position of the oxicanae, thermal stratification are all likely to be more important in deep ponds, and this emphasises the need for in-pond research.

5. Performance differences between primary and secondary facultative ponds need to be more fully understood, so that the latter can be designed with greater confidence.

Maturation ponds

6. More information is needed on BOD removal in maturation ponds to permit the development of a realistic design procedure. The model proposed by Uhlmann and others (1983) is unsatisfactory due to flaws in their kinetic analysis.

Pathogen removal

7. Recent research has not produced a rational method for predicting faecal coliform (FC) removal in waste stabilization ponds. The current, rather confused state of the art can be briefly summarised as follows:

(a) Anaerobic ponds: Marais (1974) reports that FC die-off is negligible in anaerobic ponds, yet data from EXTRABES (Silva, 1982; Mara, Pearson and Silva, 1983; Mara, 1986) shows that this is not the case: a one log\(_{10}\) unit reduction is obtained at a one day retention time, equivalent to a \(k_{1(CM)}\) value of 9 day\(^{-1}\) (which is higher than that often found in facultative ponds).

(b) Facultative and maturation ponds: several equations currently exist. For example:

(i) Marais (1974): \(k_{T(CM)} = 2.6(1.19)^{T-20}\)
(ii) Yanez (1982): \( k_{TC} = 0.84(1.07)^{T-20} \)

(iii) Polprasert, Dissanayake and Thanh (1983):

\[
\exp(k_{1(DF)}) = 0.716(1.0281)^T(1.0016)^{C_a(0.994)}^{\lambda_{COD}}
\]

where \( k_1 \) is the first order rate constant for FC removal (d\(^{-1}\)); \( k_T \), the value of \( k_1 \) at a temperature \( T(°C) \); CM refers to the assumption of complete mixing in the pond, and DF to dispersed flow conditions and the use of the Wehner-Wilhelm equation (Thirumurthi, 1969); \( C_a \) is the concentration of algae in the pond (mg l\(^{-1}\)); and \( \lambda_{COD} \) is the COD loading (kg ha\(^{-1}\) d\(^{-1}\)).

There is no corresponding equation from EXTRABES as there was no annual temperature variation in the ponds, but the data do indicate a relationship between \( k_{1(CM)} \) and organic load (Silva, 1982; Mora, 1986).

The equation of Polprasert and others (1983) is unsatisfactory as \( C_a \) is a function of \( \lambda_{COD} \). An equation which relates \( k_{1(DF)} \) only to temperature and \( \lambda_{BOD} \) (or \( \lambda_{COD} \)) is required.

**Nutrient removal**

8. More information is needed on the nature and kinetics of nitrogen and phosphorous transformations in ponds. The approach of Roed (1985), who applied a plug flow model to data on the influent and final effluent quality of several pond series, is clearly inappropriate. Detailed information on N and P transformations in each type of pond is required.

9. The kinetics of N and P removal from final maturation ponds by floating macrophytes require evaluation. Several macrophytes should be evaluated, not just water hyacinth (which, if not already introduced locally, should be disregarded).

**Hydraulic flow regime**

10. Ponds are neither completely mixed reactors, nor plug flow ones. As pointed out by Thirumurthi (1969), they are dispersed flow reactors with dispersion numbers (δ) between zero and infinity, and in which BOD and FC removal is described by the Wilhelm-Wehner equation. This is a good approach for research, but not so useful for design engineers who do not know what value of δ their ponds will have. Recently, using data from pilot ponds, Polprasert and Bhattacharya (1985) produced a predictive
equation for $\delta$ based on the kinematic viscosity of the pond water (which is a function of temperature) and the pond dimensions; but Marecos do Monte (1985) found that it was a poor predictor of the dispersion number in full-scale ponds in Portugal. Clearly a better equation is required, or otherwise designers will have to continue to assume complete mixing or plug flow, which requires engineering judgement to decide for which length to breadth ratios these assumed hydraulic regimes are most appropriate.

High altitude

11. No information is available in the literature on pond performance at high altitudes (> 2000 m above m.s.l.). At least a minimum evaluation of their performance (Pearson, Mara and Bartone, 1986) is required, with special attention being paid to the effects of large diurnal temperature changes and prolonged periods of low temperature.

Algal BOD

12. A significant proportion of the raw wastewater BOD is converted in ponds to algal biomass. Clearly this algal BOD is not remotely similar to the BOD of conventional effluents; and this poses a problem in assessing pond performance, since pond efficiency is properly expressed as:

\[
\frac{[\text{raw wastewater BOD}] - [(\text{pond effluent BOD}) - (\text{effluent algal BOD})]}{[\text{raw wastewater BOD}]}
\]

Frequently the effluent BOD is determined on filtered samples, but filtering removes non-algal solids-associated BOD as well. Research is needed to determine how much BOD is exerted during the 5-day BOD test by different species of pond algae, and thus how a chlorophyll correction factor may be applied to the BOD of pond effluents.

REFERENCES


