AN ACTIVATED SLUDGE BASED SYSTEM FOR THE TREATMENT OF A LEACHATE CONTAINING CHLOROPHENOLS AND PHENOXYACETATE HERBICIDES.

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ABSTRACT

A study was made on the biological treatment of a landfill leachate containing high concentrations of the phenoxy herbicides 2,4-dichlorophenoxyacetic acid (2,4-D), 2-methyl-4-chlorophenoxyacetic acid (MCPA) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), along with significant quantities of *para*-chloro-*ortho*-cresol (PCOC), methanol, butan-1-ol and butan-2-ol.

A mixed, natural microbial population (consisting of Pseudomonas species) was developed from a soil inoculum. The culture was found to be capable of mineralising 2,4-D and reducing the toxicity of the leachate by 92 %. The culture was found to be stable in continuous culture (residence time = 14.5 h) for 872 days.

The optimum concentrations for degradation were found to be 5-10% leachate (217-435 mg/l phenoxies, 33-66 mg/l PCOC, 40-80 mg/l alcohols and 0.6-1.2 g/l ash) for batch work and 10-15 % leachate (435-708 mg/l phenoxies, 66-107 mg/l PCOC, 80-120 mg/l alcohols and 1.2-1.9 g/l ash) for CSTR work. Batch studies showed sequential utilisation of the substrates: alcohols, followed by PCOC followed by phenoxies.

Studies were carried out to determine the kinetics of degradation for each group of substrates. The results showed that alcohols were the most rapidly degraded (μ_{MAX} = 0.3 h^{-1}), although growth was inhibited by PCOC and phenoxies.

PCOC was inhibitory to its own degradation, with inhibition directly proportional to PCOC concentration up to 290 mg/l, above which no degradation occurred. Both alcohol and PCOC degradation were described well by a linear inhibition model.

A comparison was made between the batch determination of PCOC degradation kinetics and a relatively new method, the Modified Infinite Dilution Test (MIDT). The MIDT results showed rates 50 % higher than the batch methods, indicating there was a change in the nature of the biomass in batch studies.

The kinetics of phenoxy degradation indicated that there was no inhibition in the concentration range of interest for MCPA and 2,4-D. However, 2,4,5-T was apparently degraded by cometabolism, with PCOC the best stimulator of degradation.

An interactive three substrate model was used to describe degradation and was found to fit measured data for CSTR systems. The model was robust and could predict the single substrate (ie pure compound kinetics) on simplification, indicating the wide range of application of the model.

The model showed that the presence of the alcohols in leachate considerably accelerated the degradation of PCOC and phenoxies. Critical points for washout were significantly shifted and reversed

from those of pure compounds, indicating interactions between the substrates could not be ignored. The model provides a method for quantifying the effect of a secondary substrate on the target compounds.

Results from laboratory activated sludge experiments showed that this process was capable of degrading the alcohols, PCOC and phenoxies present in both 10 and 15 % leachate. Loading rates (1.9-3.0 kgsubstrate/m^3.d) were high in comparison to the typical loadings quoted in the literature. The three substrate model, in association with the critical point method predicted three regions of plant operation, total substrate removal, stable operation with residual substrate and no degradation, compared with the two regions of the critical point method.

The results also showed that the system could be treated as non-inhibitory for design purposes, as the Monod model gave a closer prediction of behaviour than the critical point method. However, as the composition of the leachate is expected to change, the three substrate model is required to predict the effect of these changes on an AS plant.

The sludge produced by the AS plant had low concentrations of residual organic and inorganic ions, indicating it could be treated as a non-hazardous byproduct. While AS reduced the toxicity by 71 %, the effluent toxicity could be reduced further by the use of activated carbon treatment. This produced a final effluent with an EC_{50} (48h) of 46 %.

Preliminary economic analysis showed that AS followed by activated carbon treatment was capable of treating the leachate for 42c/l, lower than the alternatives of activated carbon alone and incineration. The cost was most sensitive to leaching rate, with lower rates resulting in smaller and cheaper processes.

To conclude, it was shown that a biologically based process is capable of producing non-hazardous byproducts and is economically viable as compared to alternative treatment processes.

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TABLE OF CONTENTS

Disks containing Appendices 1,7,9,11,15 and 18 can be found inside the back of this thesis. The data were stored on a write protected 5 1/4 inch, 360 K disk using the spreadsheet VP-PLANNER. The data can be read into the public domain spreadsheet ASEASYAS, along with VP-PLANNER, LOTUS 1-2-3 and QUATTRO. The remaining Appendices can be found (on microfiche) in the same envelope.

LIST OF FIGURES

LIST OF TABLES

THESIS PRESENTATION

The reader will note that many of the chapters are broken into discrete Results and Discussion sections. This was done to emphasise the logical progression of the work, rather than adhere to the conventional thesis structure.