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A comparison of the biodegradation of phenol and o-chlorophenol using a municipal mixed liquor and three commercial microbial preparations

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ABSTRACT

Title of Thesis: A Comparison of the Biodegradation of Phenol, and O-Chlorophenol Using a Municipal Mixed Liquor and Three Commercial Microbial Preparations

Nigel P. McMullen, Master of Science, 1985

Thesis directed by: Dr. Gordon A. Lewandowski
Associate Professor of Chemical Engineering

The biodegradation of phenol and O-chlorophenol was studied in six-liter batch reactors, using a municipal mixed liquor (from the Livingston, NJ treatment plant) that had not previously been exposed to either of the substrates. In addition, three commercial microbial preparations: BI-CHEM (Sybron), Hydrobac (Polybac), and LLMO (General Environmental Science), were tested alone and in combination with the municipal mixed liquor.

It was found that the municipal mixed liquor performed significantly better than any of the commercial preparations by themselves. When the commercial preparations were mixed with the municipal mixed liquor in a ratio of 1:10 it was found that the rate of degradation of each substrate increased over the rate of the municipal mixed liquor by itself. However, the increase in rate would not be great enough to justify the cost of using the commercial preparations.

A Comparison of the Biodegradation of Phenol and O-Chlorophenol Using a Municipal Mixed Liquor and Three Commercial Microbial Preparations.

by

Nigel P. McMullen

Thesis submitted to the faculty of the Graduate School of the New Jersey Institute of Technology in partial fulfillment of the requirements for the degree of Master of Science in Chemical Engineering
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APPROVAL SHEET

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I. INTRODUCTION

Presently the most common method of handling hazardous chemical waste is storage in a landfill. Whether the storage location contains contaminated soil or 55 gallon drums, an impervious clay cap is needed to minimize leaching of toxic chemicals to drinking water supplies. This is only at best a temporary solution. The waste has not been destroyed, and remains a threat to the environment. Worse yet are situations where chemical drums have been stored above ground. This was demonstrated by an explosion of chemical waste at a site in Elizabeth, New Jersey, on April 23, 1980 [1].

The alternative to storage is to destroy the waste. This is most commonly carried out by thermal oxidation in an incinerator. However, due to the high cost of energy, this process has become very expensive to operate, particularly where the toxic chemicals are diluted in an aqueous medium. In addition, there have been charges that the incinerators do not work satisfactorily, as carcinogenic compounds such as dioxin have been released into the atmosphere [2].

However, instead of high temperature thermal oxidation, low temperature catalytic oxidation can be used, in the form of microbial degradation. Microbial populations have been

exposed to naturally occurring organic waste for hundreds of millions of years, and so have adapted their enzymes (i.e. catalysts) to utilize natural carbon sources as nutrients.

In 1976 the EPA published the Consent Decree List [3], of 114 organic priorty pollutants, "...to ascertain the extent of microbial degradation and to determine the acclimation periods," [4]. Many of the 114 compounds are "man-made" and do not occur naturally in the environment. As a result, naturally occuring microorganisms have only been exposed to these compounds for a relatively short period of time, and so do not produce the correct enzymes to degrade these chemicals efficiently.

Martin Alexander [5] reported that, "...many compounds are acted on biologically in soils and water but no microorganism able to use the (synthetic) compounds as sources of nutrients or energy could be isolated." This was determined by C14 labelling of synthetic compounds, and the absence of C14 in the biomass of the microorganisms. It has been hypothesized that many of the enzymes present do not act solely on one compound, but rather can act with a related group of compounds. It is thus possible to partially degrade some of the synthetic compounds with only minor modifications in the enzyme's structure. However, in order to utilize these compounds as sources of nutrient or energy, the microorganisms would require futher adaption, and the

production of appropriate enzymes.

In recent years several companies have produced products that they claim are pre-acclimated to toxic compounds, and also contain the bacteria that are known to be dominant in biologically degrading these chemicals in the secondary stage of wastewater treatment plants. However, it has yet to be substantiated by experimentation whether such commercial preparations can provide a more cost-effective method for treating contaminated aqueous wastes.

II. BACKGROUND

A. LiteratureSearch

An extensive literature search was undertaken in order to obtain the published results of other investigators who have also used commercially available mutant bacteria. The abstracts of biology, chemistry, and microbiology were searched for the period 1977-1983 using the following keywords: bacteria, biodegradation, commercial culture, culture. A similar search was performed of the annual indices of Applied Environmental Microbiology, Biotechnology and Bioengineering, Bulletin of Environmental Toxicology, and Environmental Science and Technology. Both searches produced large numbers of references, none of which on close inspection were relevant to the use of commercial preparations.

The computer data base containing the publications of the American Chemical Society (ACS), and the Pollution Abstracts (published by Cambridge Scientific Abstracts), was also searched for the years 1974-1984. In order to reduce the number of references that would eventually have to be examined for relevancy, the following specific keywords were used: Bactisolv, BI-CHEM, Hydrobac, Polybac, Sybron. The ACS search produced no results, but in the Pollution Abstracts 11 references were found, 3 of which had relevant subject

matter. All these references were found using the keywords Polybac (producer of Hydrobac) and Sybron (producer of BI-CHEM DC-1006/7).

By using the affiliation index and the author index for the institutions and authors known to be active in this area, the Selected Water Resources Abstracts (published by the National Technical Information Service) and the abstracts of the Engineering Index for the years 1979-1983 were searched. These were the sources in which most of the articles were found.

Once a complete copy of a relevant article was obtained, the references cited within it were also consulted. An additional computer search was conducted using these authors and affiliations as keywords. The Pollution Abstracts and the Selected Water Resources Abstracts for the years 1974-1984 were searched. A total of 37 authors and 8 affiliations were used. At this point the literature search was stopped since only a few of the articles produced were useful, while a majority had previously been found.

B. LiteratureReview

In the following articles it should be pointed out that Zitrides is President of Polybac Corporation and Thibault was formerly an employee of Polybac. Futhermore, Davis, Blair,

Spraker, and Telepchak were all employees of Sybron Corp., so that only three articles are by disinterested parties.

Zitrides [6] reported using mutant bacteria to control an overabundance of filamentous organisms in an oxygenated secondary treatment plant. A pulp and paper mill was the source of the wastewater. The system was seeded with LIGNOBAC produced by the Polybac Corporation. The product contains organisms "specifically selected for their ability to digest lignocellulose wastes". The addition of LIGNOBAC reduced the amounts of lignin and tannin in the effluent by about 42%. The filamentous bacteria were brought under control and a healthy biomass was produced. Also, the sludge settled better than it had prior to the onset of filamentous growth.

Zitrides [7] added PHENOBAC, made by the Polybac Corporation, to the biotower of a facility treating wastewater containing emulsified petroleum waxes, polyacrylic and polyvinyl acetate polymers. These compounds inhibit the growth of the naturally occurring organisms present in the biotower. The bacteria in PHENOBAC can degrade "long- chain hydrocarbons, phenols, cyanides, detergents, and herbicides". Within 30 days after inoculation with PHENOBAC, COD was reduced by 57% compared to 47% prior to seeding. When operating conditions were changed to accomodate a COD load 3 times larger than the design value, a 90% reduction was

regularly obtained.

Spraker and Telepchak [8] used BI-CHEM 1004TX to control foaming and degrade nonionic detergents in a wastewater containing ethoxylated nonyl phenols (ENP's) and surfactants. The organisms in BI-CHEM 1004TX are specially adapted to degrade ENP's and reduce foaming. The waste treatment system consisted of a biotower and four lagoons. Occasionally, up to 50% of the biomass was displaced from the biotower due to foaming. After adding a large dose of BI-CHEM 1004TX, foaming problems subsided and the biotower achieved a 20% reduction of COD and an 85% reduction in phenol. To reduce the load on the biotower each lagoon was also seeded. Data were collected for one year in order to evaluate how BI-CHEM 1004TX affected the performance of the system. Over that period, the average overall reduction of COD was 62.6%. For phenols, the overall reduction was 99.1%.

Blair, et. al., [9] used BI-CHEM DC-1008SF to augment the bacterial cultures in the clarification and activated sludge systems of a plant treating waste from a pulp and paper mill. The mill had been out of compliance on discharge levels of total suspended solids (TSS) and biochemical oxygen demand (BOD) due to wide variations of mixed liquor suspended solids (MLSS) in the system. Addition of BI-CHEM DC-1008SF stabilized the level of MLSS, resulting in a 50% or more reduction in TSS, thus bringing the plant back into

compliance.

Davis and Blair [10] isolated and tested a mixture of bacteria capable of reducing the color intensity of Kraft process black liquor waste. A slime layer of the isolated culture was built up on the packing of a bench scale biotower with a volume of 3.25 liters. The biotower was run continuously on Kraft black liquor wastewater from two separate paper mills. The first wastewater experienced a 30 percent drop in color intensity in the first 4 to 17 hours of operation with an additional drop of 16 to 24 percent with recycling. The second wastewater was reduced in color intensity by 54 percent in 25 hours with no further reduction by recycling. While admitting some part of the color loss was due to adsorption, the authors pointed out that the ability to continuously reduce color suggested that enzymatic degradation "was a principal mechanism" for removal.

Thibault and Tracey [11] discussed the addition of mutant bacteria as a way of improving the stability and performance of activated sludge units. They cite examples in which bacterial additives reduced effluent total organic carbon (TOC) by 32%, generally reduced influent and effluent BOD, and improved overall operating stability.

Thibault and Tracey [12] solved several operating problems of an oxygen activated sludge system treating

wastewater generated by the production of alcohols, olefins, organic acids and synthetic rubbers. To deal with unacceptably high levels of BOD, total oxygen demand (TOD) and total suspended solids (TSS), the system was periodically inoculated with PHENOBAC Mutant Bacterial Hydrocarbon Degrader. Each microbial species in this preparation is capable of degrading a specific class of compounds. Data on TOD, BOD (total and soluble), TSS, and tertiary butanol (TBOH) were taken 50 days prior to the addition of PHENOBAC and 50 days following the begining of regular inoculation. The presence of PHENOBAC typically reduced effluent TOD from 280 mg/l to 150 mg/l. The values of other effluent parameters were also reduced: BOD from 47 mg/l to 12.5 mg/l (73%), soluble BOD from 9.5 mg/l to 3.9 mg/l (59%), average TSS from 37 mg/l to 23 mg/l (38%). Finally, no measurable amount of TBOH was found in the effluent during the two-month period following PHENOBAC addition. This is due to the stabilizing effect that PHENOBAC had on the active biomass of the system.

Tracey and Zitrides [13] used two parallel treatment systems to demonstrate the effectiveness of PHENOBAC Mutant Bacterial Hydrocarbon Degrader on refinery wastewater. One activated sludge system was seeded with the additive while the other served as a control. The levels of total organic carbon (TOC) were used as an indicator of effectiveness. After 12 days, during which the mutant organisms reproduced

and adapted to their environment, the performance of the treated unit improved steadily in comparison to the control. Average effluent TOC values were 32% lower in the treated system. When an upset in effluent quality caused deterioration and, finally, shutdown of the control unit, the treated unit was able to handle all the plant flow for two days while maintaining a 71% reduction in TOC.

Hirt, et. al.,[14] reported that changes made in the flow pattern of a paper mill waste treatment plant effectively overcame the sludge bulking problems caused by filamentous growth. The authors first tested a variety of chemical additives for their ability to reduce filamentous growth and improve sludge settling time. Although no details of these tests were given, they concluded that chemicals such as lime, polymers, chlorine and peroxide treated only the symptoms of an operational problem. More importantly, the use of commercial preparations of microorganisms was evaluated in both bench- scale and pilot-scale biological reactors. Unfortunately, no details of the experiments were provided, nor were any of the preparations mentioned by name. The authors stated that "no improvement was noted" from the use of commercial preparations in controlling the persistence of filamentous bacteria. Finally, after a review of the literature concerning the control of filamentous bulking, and yet another set of undescribed tests, an effort was made to improve the levels of dissolved oxygen (DO) and food to mass

ratios (F/M) in the four aeration tanks comprising the system. This was achieved by adjusting the flow pattern from tank to tank in such a way as to evenly distribute these measures of organic loading stress. Within 2 weeks, BOD and suspended solids removal were above 96 and 94%, respectively. In the final month of a three-month trial period there was a 95% reduction in filament number with the average filament length decreasing from greater than 400 um to less than 100 um.

Qasim and Stinehelfer [15] tested the effectiveness of a "bacterial culture product" in an aerated, continous-flow activated sludge process. Two identical bench-scale systems were operated under similar conditions. Both reactors had a volume of 10.9 liters and were initially filled with a municipal wastewater having a MLSS concentration of 2250 mg/l. A feed rate of 35 l/day was maintained through both units. Each day some sludge was wasted by removing a baffle and mechanically mixing the contents of the reactors. The waste volume was made-up with distilled water. After the reactors reached steady-state (6 to 8 days of constant sludge growth and percent COD removal), dosing of one reactor began while the other was used as a control. Then, on a daily basis the following parameters were measured: total flow, influent soluble COD and BOD, effluent soluble COD and BOD, effluent suspended solids (SS), volatile suspended solids (VSS), mixed liquor suspended solids (MLSS) and mixed liquor

volatile suspended solids (MLVSS). The data obtained from both systems were used to determine values of kinetic constants that reflect the ability of a microbial media to maintain biological growth and utilize substrates. The comparitive values of these constants indicated that the "bacterial culture product" had some positive effect on sludge growth but no effect on substrate utilization. The authors concluded that the product would have little effect "on the overall performance of a well-designed and well-operated activated sludge plant". They also claimed that their experimental procedure "provides a systematic and rational approach" for evaluating bacterial culture products.

Grubbs and Zitrides [16] questioned the data interpretation and conclusions in the article by Qasim and Stinehelfer. They claimed that the data were presented inadequately and that the "scale effects" of biological systems were ignored. The use of only "4-days' data" and the unclear notion of "steady-state" were challenged. Sludge residence time (SRT) is seen as being a more appropriate measure. The conclusions, however, drew the sharpest criticism. Contending that the experiments were not performed in a "well-designed and well-operated activated sludge plant", the conclusion that the product would have "little effect" on such a plant is considered to be erroneous. Also, since the authors of the original article did not compare their experimental procedure with those used

by other investigators, their claim that they provide a "systematic and rational approach" for evaluating bacterial products is argued to be totally incorrect.

Qasim and Stinehelfer [17] responded to the comments of Grubbs and Zitrides in defense of their original article, stating that while most mutant bacteria product manufacturers talk about their successes, "little has been published about testing methodology". Hence the intent of the paper "was to present a methodology for evaluating such products". The "4-days' data" were only presented so as to reduce the length of the article. The use of all the collected data would produce no difference in the results. Finally, the procedure presented in the original paper is commonly used in "developing design parameters for industrial.... wastewater treatment facilities".

III. OBJECTIVE

The objective of this study was to determine the substrate degradation rates of phenol, and ortho-chlorophenol, in different microbial media. A municipal mixed liquor, and three comercial microbial preparations were used. The commercial preparations were: Hydrobac from the Polybac Corporation, Bi-Chem 1006/7 from the Sybron/Biochemical Corporation of America, and Liquid Live Micro Organisms (LLMO) from General Enviromental Sciences.

In addition the chemical oxygen demand (COD) was monitored (in order to determine if any organic byproducts are produced), as well as pH, ammonia, chloride, and MLSS levels

IV. EXPERIMENTAL APPARATUS

The biodegradation of phenol, and o-chlorophenol was studied in six-liter batch reactors, constructed of six-inch diameter clear Lucite tubing. An over-flow drain was placed at the two liter mark. The base was bonded to the tube using Du Pont epoxy resin. In all, five reactors were constructed, and labelled so that mixing of the different commercial preparations would not occur. In order to reduce contamination between the reactors a box was constructed with partitions to separate the reactors. In addition, each reactor was capped with a removable lid

Each reactor (Figure 1) had a separate air supply, manifolded from the laboratory supply. Prior to the manifold, the air was filtered through cotton wool, and activated carbon in order to remove oil droplets. At the manifold each air line had a separate on/off valve. The volume of air supplied to each reactor was regulated by a needle valve at the base of a rotameter, so that the flow rate was 1.0 scfh (500 cc/min). In order to increase the efficiency of air/liquid contact, an aquarium diffuser stone was placed on the end of the air line at the bottom of the reactor. The liquid was sufficiently well mixed by the air flow so that mechanical stirring of the reactor was not deemed necessary.

V. ANALYTICAL EQUIPMENT

The following analytical equipment was used in the experimental procedures in this study:

(1) mv meter: Orion Research Model 701A/Digital IONALYZER
pH electrode: Orion Reseasch Model 91-04
ammonia gas electrode: Orion Research Model 95-10
chloride electrode: Orion research Model 94-17

(2) gas chromatograph: Tracor Model 560
operating temperature: oven (i) phenol 120 C.
(ii) o-chlorophenol 125 C.
FID 250 C.
injection port 250 C.
gas flow rates: N2 45 cc/min at STP
H2 30 cc/min at STP
Air 0.9 scfh at STP

(3) gas chromatograph: Tracor Model 565
Tracor Model 770 Auto Sampler
Varion Aerograph Auto Injector
operating temperature: oven (i) phenol 120 C.
(ii) o-chlorophenol 125 C.
FID 300 C.
injection port 300 C.

gas flow rates: N2 45 cc/min at STP

H2 30 cc/min at STP

Air 0.9 scfh at STP

(4) GC columns: Supelco - 5' x 1/8" SS

5% SP 2100 on 100/120 Supelcoport

(5) Electronic intergrator: Hewlett Packard 3390A

(6) Centrifuge: DAMON/IEC Model IEC HN-SII

(7) COD Reactor: Hach Model 16500-10

PROCEDURE

The present study has used and refined some of the techniques developed previously in the laboratory by J.C. Colish [18]. The results of air stripping, sample preservation, ultra violet degradation, and the impact of sample pH on the GC results were taken directly from that source.

A. MEDIA PREPERATION

i) Mixed Liquor

The activated sludge mixed liquor was obtained from the municipal wastewater treatment plant in Livingston, New Jersey. This plant treats about 2.5 million gallons of sewage a day, with a residence time of six to eight hours in the secondary treatment aeration tanks. This source of mixed liquor was chosen because it primarily treats domestic sewage, and as such has not been exposed to significant concentrations of industrial organic compounds.

A sample of the activated sludge was obtained by taking approximately eight liters of mixed liquor from the six open aeration tanks, in order to obtain a broad cross-section of the microbial population. This sample was then split into

two six liter cylindrical tanks, similar to the reactors to be used, with a continuous air supply of about 2 scfh (1 l/min).

In order to acclimate the microbial population to phenol, and to stimulate growth the tank was shock loaded with a solution of phenol, ammonium carbonate, and ammonium phosphate in distilled water, so that the phenol concentration of each tank was 100 ppm. This provided a supply of carbon, nitrogen, and phophorous that was initially in a ratio of 50:14:3 [19]. When only phenol was added degradation of the substrate was found to be significantly slower than when the nutrient solution (Table 1) was added.

The pH of the tank was continously monitored with a submerged electrode [20]. Although rarely necessary the pH could be adjusted by the addition of sodium bicarbonate or dilute sulphuric acid.

The phenol content of the tanks was also monitored on a daily basis during the acclimation period. This was done by direct aqueous injection of the supernatant liquid of a centrifuged sample from each of the tanks, into a gas chromatograph. When the phenol content of the tank fell below the detection limit of the GC (about 2 ppm), the nutrient solution was added to the tank so that its phenol concentration was again 100 ppm. This acclimation procedure

was repeated for two to five days prior to rate tests, so that it could be assured that a viable microbial population was present.

ii) Commercial Preparations

The three commercial products under study are available in two different forms. The BI-CHEM and Hydrobac are both supplied in a dry form, in which the bacteria are suspended on dried bran flakes. The third remaining product (LLMO) was supplied in a liquid form (aqueous), which was saturated in hydrogen sulphide so as to supress biological activity until it was required. Consequently these products were treated differently during testing.

a) Dried Preparations

The methodology used in preparing this type of product was based on a procedure supplied by the Polybac Corp. (the supplier of Hydrobac). No applicable laboratory procedure was supplied for the preparation of the product BI-CHEM by its manufacturer. However due to the similarity of the two products the same methodology was incorporated in the preparation of both products.

Before any degradation rate data were taken several months of testing was undertaken, in order to ascertin

whether or not a viable microbial population could be bred and maintained in the laboratory for a period ranging from several days to several months, with repeatable degradation rates based on daily monitoring, as described above.

Throughout this period several changes were made in the preparation procedure of the media, which resulted in a better survival rate of the preparation in the critical first twenty-four hours of growth.

Approximately twenty-four hours prior to growing one of the preparations, the tank in which the prepration was to be grown was washed with soap and water, rinsed out, and then rinsed with 3% hydrogen peroxide to sterilize the tank. It was then rinsed with distilled water and dried. The tank was then filled with about one liter of distilled water that was aerated at about 2 scfh (1 l/min).

The following day 12.5 grams of the bran flakes was weighed out and placed in a 2000 ml beaker containing 1000 ml of room temperature distilled water. Using a magnetic stirring rod this mixture was mixed for two hours. The motor on the magnetic stirer caused some warming of the mixture, which was beneficial to bacterial motility. After two hours the stirer was switched off, and the mixture was allowed to settle for five minutes. Then, 600 ml of the supernatant liquid was decanted into the assigned vessel, to which 400 ml

of aerated water was added, and the mixture aerated at 1.0 scfh (500 ml/min). The vessel was then loaded with the nutrient solution so that the phenol concentration of the tank was 50 ppm.

The following day the phenol concentration was checked. If phenol was still present in the vessel, the contents were discarded and the procedure was started again. If, however, the phenol concentration was below the detection limit of the GC (about 1 to 2 ppm), the previously described method of preparing the preparation was repeated, and the volume of the media in the tank was brought up to two liters by adding an additional 600 ml of decanted preparation and the appropriate volume of aerated distilled water. Nutrient solution was then added to bring the phenol concentration to 100 ppm.

The following day the phenol concentration was again checked, and (as on the previous day) if there was still phenol present, the mixture was discarded and the entire procedure started at the beginning. If, however, no phenol could be detected then the contents were again loaded with nutrient solution so that the phenol concentration was initially 100 ppm. Normally if the procedure reached this stage the media would continue to consume 100 ppm of phenol a day for several weeks without any problems.

b) Liquid Preparation

No applicable laboratory methodology was provided by the supplier of the LLMO for its acclimation. As a result many months were spent in devising a methodology by trial and error, so that a viable population could be established and acclimated to phenol. Although some of the methods tried were initially successful, they proved to be non-reproducible in the laboratory, and so were discarded.

Initially, 500 ml of LLMO were added to 500 ml of distilled water and aerated. Nutrient solution was then added to give a phenol concentration of 100 ppm. After several days of monitoring the phenol concentration, some disappearence was observed. However in comparison to the results observed in the acclimation of the mixed liquor with other commercial products, this rate was insignificant, and clearly another method had to be found.

Presumably as the hydrogen sulphide was stripped out and the bacteria became active, the initial phenol concentration of 100 ppm was too toxic to the relatively small numbers of bacteria present at this stage. As a result the survival rate of the bacteria was too small to produce a viable population.

The next method tried was to add 500 ml of LLMO to 500

ml of distilled water, and aerate overnight before loading the tank with 100 ppm of phenol in the nutrient solution. This proved to be slightly more successful than the method above. However, it still proved to be difficult to degrade the phenol initially.

Several more attempts were made to grow the LLMO by using the same procedure described above, by lowering the initial phenol concentration first to 50 ppm, then to 25 ppm, and finally to 5 ppm.

Using an initial load of 5 ppm phenol, the LLMO was usually able to degrade the phenol within twenty-four hours. The mixed liquor was then loaded to 10 ppm, and if the phenol was again degraded, the concentration was increased by 5 ppm daily, until the media was able to degrade 100 ppm phenol in less than twenty-four hours. Although this was successful in growing and acclimating the LLMO to phenol it took about three weeks.

When the distilled water was aerated for twenty-four hours prior to use, it allowed the acclimation process to begin at 20 ppm rather than 5 ppm, with daily increases of 20 ppm. This reduced the acclimation period from three weeks to about one week. The reason for the improvement is unknown.

As a result, the following procedure was settled on:

A volume of 250 ml of LLMO was added to a clean vessel and the volume brought up to 1000 ml by adding distilled water that had been aerated for twenty-four hours. The vessel was then futher aerated for an additional eighteen to twenty-four hours to strip out the hydrogen sulphide before the addition of the phenol and nutrient solution. The phenol concentration was initially started at 20 ppm, and then on consecutive days the concentration was increased by 20 ppm per day, until the concentration reached 100 ppm. At this stage the media was considered ready for substrate testing. This procedure took about five days, and after this the media was maintained by loading the tank with 100 ppm of phenol plus nutrients each day, until kinetic rates could be determined.

SUBSTRATE TESTING

When a viable population had been determined to be acclimated to phenol, the media was ready for substrate testing. Two substrates were to be tested: phenol, and o-chlorophenol. Each substrate was tested in two ways. The first consisted of periodical sampling in a reactor containing 2000 ml of only the municipal mixed liquor or only one of the commercial products. While in the second, 200 ml of one of the commercial products were added to 2000 ml of the municipal mixed liquor. This resulted in the testing of the two substrates in seven different media. Each substrate

was tested in each media in triplicate, for a total of at least 42 runs. In some cases, as many as six replicate runs were made.

The experimental procedure and sample analysis was generally the same in all cases. Prior to loading the reactor with the substrate to be tested, the ambient air temperature in the laboratory was recorded, the pH electrode calibrated using a pH 7 phosphate buffer. Several 24 ml capped vials were prepared for sampling by adding to the vial 0.5 ml of 10,000 ppm copper sulphate (as a biocide) and 0.5 ml of thymol (as internal standard).

Initially the media was loaded with phenol to a nominal concentration of 100 ppm, using a 10,000 ppm stock solution without any other nutrients. After three successive runs were completed with phenol, the reactor was loaded with O-chlorophenol for three more runs (i.e. the O-chlorophenol runs were made with phenol acclimated organisms). The nominal concentration of 20 ppm was obtained by adding 2,000 ppm o-chlorophenol in distilled water without any nutrients. Because of the different rates of reaction, samples were taken every 15 minutes in the phenol runs, and every 30 minutes with the O-chlorophenol runs.

After initially loading the reactor with a substrate to the appropriate nominal concentration, the reactor was

briefly swirled (manually), and the air supply regulated to 500 ml/min (1.0 scfh). After one minute a 15 ml sample was withdrawn using a serological pipet with a pipet filling bulb. The sample was then centrifuged at 2500 RPM for four minutes to remove the bulk of the suspended solids. Using a 10 ml pipet, 10 ml of the liquid was transferred to a vial containig the biocide and the internal standard. At this point the biodegradation reaction was quenched, the time noted since substrate addition, and the sample labelled before being placed in a refrigerator for storage until required for analysis.

Periodically, the reaction was qualitatively checked by manual injection of 3 ul samples in a GC. This gave an indication if the sampling rate was reasonable, and when the reaction might be expected to be completed.

SAMPLE ANALYSIS

1. Substrate Analysis

The substrate concentration was determined using direct aqueous injection of the sample onto a column of SP-2100 on 100/120 Supelcoport in a Tracor 565 GC, using a Varian auto injector. For phenol, the oven temperature was operated at 120 C, at which the retention time of phenol was about 0.55 minutes, and for thymol 2.95 minutes. For o-chlorophenol the

oven temperature was 125 C, and the retention time was about 0.65 minutes (with 2.65 minutes for thymol).

The intergrator (HP3300A) has a feature that is capable of storing a number of calibrations made from standard solutions. These solutions were made up for calibration with the same ratio of thymol and copper sulphate as in the sample vials. Approximately 1 ml of the sample (or standard) was placed in an injection vial. Up to 60 vials could be placed in the auto injector at one time. The auto injector injects each vial 3 times, with 3 ul of sample each time. For each reactor sample, two vials were loaded so that each reactor sample was injected six times. A sample output from the intergrator for each substrate is shown in Figures 2 and 3. The area under each curve was determined electronically, and a concentration determined automatically using calibration tables programmed into the intergrator. The average of the six injections was taken to arrive at a concentration of the substrate in the sample. Occasionally, the standard deviation of the six injections was considered large and some of the injections were discarded from the calculation.

2. Chemical Oxygen Demand (COD)

Chemical oxygen demand represents the amount of oxygen required in the oxidation of organic and oxidizable inorganic matter in a sample. The theoretical COD can be calculated

from a balanced equation for the complete oxidation of a compound to carbon dioxide and water. This method therefore provides a way of determining whether partial or total oxidation of the substrate is taking place. COD analysis was performed on about five samples from most of the phenol and O-chlorophenol degradation runs.

As an example of how the theoretical COD of a substrate was determined, consider the following balanced equation for the complete oxidation of Phenol:

From which:

Table 2 lists the theoretical COD for the compounds of interest and their respective internal standards.

The experimental COD was determined by a slight modification of the Standard Methods procedure, as described in the Federal Register [21]. All reducing agents present in a sample were completely oxidized with a solution of potassium dichromate, silver sulfate, mercuric sulfate, and sulfuric acid. This digestion solution was made by adding 7.5 gm potassium dichromate, 10.0 gm silver sulfate, and 5.0 gm mercuric sulfate to a 2.5 liter bottle of concentrated sulfuric acid. The bottle was placed on a magnetic stirrer/hot plate, then agitated and heated overnight to

dissolve the potassium dichromate and silver sulfate. When both compounds had dissolved, the acid bottle was removed from the hot plate and cooled to room temperature. Five ml of the cooled digestion solution was pipetted into a 16 mm x 100 mm screw-top vial, 2.0-5.0 ml of the filtered sample (through 0.2 micron filter) was added, and the cap was screwed on tightly. Several blanks containing 2.0-5.0 ml deionized water were included with each batch of samples. The vials were placed in a Hach COD reactor and heated at 150 C for 2 hours. After heating, the vials were removed and cooled to room temperature. The contents of the vial were then transferred to a 250 ml Erlenmeyer flask that contains approximately 50 ml water (rinsing the inside of the vial several times with water, and adding the rinsings to the flask). Also added to each flask were: 0.03 gm mercuric sulfate to reduce chloride ion interference and 5 drops of Ferrion indicator. This solution was then titrated to a bright orange endpoint with a 0.0125N ferrous ammonium sulfate (FAS) solution. The 0.0125N FAS solution was made by adding 9.8 gm ferrous ammonium sulfate to approximately 1000 ml deionized water, adding 20 ml concentrated sulfuric acid, cooling the solution to room temperature and finally, diluting to 2 liters with deionized water. The blanks were titrated in a similar manner.

The experimental COD of a sample was calculated from the following expression:

Where:

A = volume of FAS used to titrate blank (ml)

B = volume of FAS used to titrate sample (ml)

N = normality of FAS solution (equiv/liter)

C = volume of sample (ml)

Because of the limited amount of sample volume available for each test, the COD analysis was performed in the presence of the internal standard (thymol), and the biocide (copper sulphate). Therefore, a general equation for converting experimental COD to an equivalent concentration of the substrate had to accouint for the theoretical COD of the internal standard, as well as dilution of the sample with copper sulphate. The relation obtained was:

$$\text{EQUIV COD (ppm)} = [\text{EXP COD} - (\text{CODI} \times \text{CIS})/\text{CODS}] \times [\text{SDF}]$$

Where:

EXP COD = experimental COD of the sample, mg/l

CODI = theoretical COD of internal standard, mgCOD/mgIS

CIS = concentration of internal standard, ppm

CODS = theoretical COD of substrate, mgCOD/mg subst.

SDF = sample dilution factor

For both Phenol and O-Chlorophenol:

SDF=11/10

CIS=45.545

In this method, the experimental error associated with

titrating the sample and the need to subtract the COD of the internal standard caused a residual error of about +20 ppm.

3. Mixed Liquor Suspended Solids (MLSS)

For MLSS determination, a sample was taken approximately three to five times during each run. Using a serological pipet, 10 ml of the reactor contents were withdrawn and placed in a preweighed aluminum dish. The dish was then dried in an oven at 95 C for at least 24 hours, before reweighing to determine the MLSS.

4. pH

The pH of the reactor was checked by continous monitoring with a submerged electrode [22]. Although rarely necessary the pH was adjusted by the addition of sodium bicarbonate or dilute sulphuric acid.

5. Ammonia Concentration

The concentration of ammonia was determined using an ammonia gas electrode.

A direct measurement method was used, as suggested by the electrode manufacturer [22]. A 0.1M ammonium chloride standard solution was made by adding 0.535 gm reagent grade ammonium chloride to 50 ml distilled water in a 100 ml

volumetric flask, stirring to dissolve, then diluting to volume with distilled water. Additional standards, having concentrations of 0.01M, 0.001M, and 0.0001M, were prepared by serial dilution of the 0.1M solution.

The electrode was placed in 100 ml of the 0.001M standard and 1 ml of 10M sodium hydroxide was added while the solution was agitated with a magnetic stirrer. The meter reading on the relative millivolt scale was then set to 000.0 by adjusting the calibration control.

The electrode was rinsed and placed in 100 ml of continuously stirred 0.0001M standard with 1 ml of 10M sodium hydroxide. The meter reading was recorded. The same procedure was repeated using the 0.01M standard. A calibration curve was made by plotting the millivolt readings (linear axis) versus their corresponding concentrations (log axis) on 4-cycle semilogarithmic paper.

Since only a limited amount of sample volume was available and the ammonia electrode is relatively large, it was necessary to dilute a portion of each sample with distilled water. A sample of 1 ml was pipetted into a sample vial containing 10 ml distilled water, and 3 drops of 10M sodium hydroxide. The vial was placed on a magnetic stirrer and, while being agitated, the ammonia electrode was submerged. A reading was taken after about 2 minutes, when

the meter displayed a constant value. The experimental values of ammonia concentration were obtained from the calibration curve and, after accounting for sample dilution, converted to a ppm basis (17 ppm [=] 0.001M).

At regular intervals, the electrode was rinsed with distilled water and placed in one or two of the standard ammonium chloride solutions as an accuracy check on the millivolt readings. Although there was always some drift, it was never great enough to warrant recalibrating the meter.

The error in ammonia concentration measurement was estimated to be +5 ppm.

6. Chloride Ion

The concentration of inorganic chloride was measured in samples from the O-chlorophenol degradation runs with a chloride ion electrode. The electrode [23] required no sample agitation and

An ionic strength adjustor (ISA) was added to all standards and samples so that the background ionic strength was constant relative to the variable concentrations of chloride. For all halide electrodes, sodium nitrate was used as the ISA. A 5M solution was made by dissolving 42.5 gm in 100 ml distilled water.

A 1000 ppm stock solution of sodium chloride was prepared by placing 1.65 gm in a 1 liter volumetric flask, dissolving with about 500 ml distilled water, and diluting to 1 liter. Two additional standards, having concentrations of 100 ppm and 10 ppm, were prepared by serial dilution of the 1000 ppm stock solution. The ISA was added to each solution using a ratio of 2 ml of ISA per 100 ml of standard.

The electrode was placed in the 100 ppm standard. By turning the calibration control, the meter reading on the relative millivolt scale was set to zero. Very often the meter could not be set to exactly 000.0, in which case the millivolt reading was recorded.

The electrode was rinsed, placed in the 1000 ppm standard, and the meter reading was recorded. The same procedure was repeated using the 10 ppm standard. A calibration curve was prepared by plotting the millivolt readings (linear axis) versus their corresponding concentrations (log axis) on 4-cycle semilogarithmic paper.

The electrode was then placed in 1 ml of sample with 1 drop of ISA. The millivolt reading was recorded and the chloride ion concentration determined directly from the calibration curve. After about 2 hours of use, the meter was recalibrated by placing the electrode in the midrange standard and setting the millivolt reading to its original

value.

Partly because of background chloride, the error in chloride ion concentration was estimated to be about +20 ppm.

VII. RESULTS

In addition to biodegradation of the substrate by microorganisms, two additional phenomena also result in the reduction of the substrate concentration in the reactor. These are air stripping, and adsorption of the substrate onto the bacterial flocs.

A. AirStripping

Using the same system of reactors, Colish [18] studied the effects of air stripping on the substrate concentration for both phenol and O-chlorophenol in distilled water. Table 3 presents a comparison of the experimental air stripping rate and the theoretical air stripping rate from vapor-liquid equilibrium calculations. This shows that over the period of one experimental run (as much as 8 hours), the change in substrate concentration for either substrate is negligable due to air stripping.

B. Adsorption

The adsorbtion of the substrate onto the surface of the bacterial flocs is a relatively fast rate in comparison to biodegradation. However this surface phenomena does not act as a significant mechanism for the removal of the substrate when the active surface of the flocs becomes saturated with

substrate. The bacterial flocs were exposed to phenol for several days prior to the taking of concentration/time data; and so the active surfaces were saturated with phenol. However, when the dried commercial preparations were exposed to O-Chlorophenol for the first time (with only prior exposure to phenol), the removal of the substrate in the liquid samples was very rapid. This was followed by a second exposure where the removal rate was significantly slower, (see Figures 22 and 45-47). The assumption that this phenomenon was due to adsorbtion of the substrate onto the flocs was supported by the COD data (Tables 4, 8, 16, and 22).

C. COD

COD analysis was not performed on all samples. However, data obtained from about five samples for most of the runs are shown in Tables 4-45 (concentrations shown are equivalent to ppm of the substrate being tested). For the phenol runs, COD generally followed the decline in substrate concentration, but levelled off at about 20 ppm (the limit of accuracy). This generally indicates that complete oxidation to carbon dioxide was taking place. This observation has previously been noted by Davis et al. [24] for the decomposition of phenol. In contrast, COD results for O-chlorophenol were inconclusive. In some cases (Table 30) the COD was seen to drop. However, in most of the runs the change in COD levels was small. In all cases the COD

concentration was significantly higher than the substrate concentration. This could be observed throughout a run. This may be due to the low initial concentration of O-chlorophenol, and the magnitude of the error in the procedure for COD analysis. GC/MS analysis must be performed in the future to determine if any organic compounds are being formed on decomposition of O-chlorophenol.

D. Ammonia&ChlorideIon

In some of the earlier runs, the nutrient solution (Table 1) was added to the reactor whenever phenol or O-chlorophenol was added. This resulted in the initial concentration of nitrogen in the reactors ranging from 200 to 600 ppm. Testing of the Livingston mixed liquor prior to acclimation showed that a concentration of approximately 30 ppm would be sufficient to maintain a viable population. As a result, the nutrient solution was only added at the first two loadings of the reactors during acclimation. The resulting ammonia concentration at the start of testing was about 100 ppm. The data are shown in Tables 4 to 45. These show that generally the level of ammonia falls about 5 to 15 ppm during a reaction.

Due to the high background level of chloride ion from the original microbial mixtures, determination of chloride concentration during the O-chlorophenol runs provided no

useful infomation. (It had been hoped that it would indicate the degree of mineralization.

E. SubstrateDegradation

Figures 46-47 summarize the results of substrate degradation after successive shock loadings to the reactors. Detailed plots and raw data are shown in Figures 4-45 and Tables 4-45 respectively. Each concentration represents the average of six injections on the GC. The resulting average substrate concentration usually had a standard deviation of less than 0.5 ppm for substrate concentrations above 2 ppm.

From a qualitative point of view, it can be seen that the Livingston mixed liquor degrades either substrate significantly faster than any of the commercial preparations by theselves (Figure 46-47). The effect of mixing the commercial preparations with the Livingston mixed liquor did have a positive effect, by increasing the degradation rate of the substrate. However, it should be pointed out that the increase in degradation rate was the result of the addition of the commercial preparation to the Livingston sludge in a volume ratio of 1:10. The distributors of these products recommend that a ratio of 1:1,000,000 be used, at which there would be no perceptible difference from the Livingston mixed liquor. Even at a ratio of 1:10 the increase in degradation rate relative to the Livingston mixed liquor by itself is not very large. At a cost of approximately $25 per pound for the

commercial preparations, a volume ratio of 1:10 corresponds to an operating cost of $10,000/million gallons of waste.

F. Kinetics

In order to ascertain a quantitative picture of the rate of substrate degradation, the concentration data was regressed using three mathematical models. These are i). a zero-order model, ii). Monod's model [25], and iii). Haldane's model [26].

The zero-order kinetic model assumes that the rate of substrate disappearance, -dS/dt, is constant and independent of the substrate concentration at all times. In differential form, it is given by:

$$-dS/dt = k \qquad (1)$$

and the intergrated form by:

$$So-S = kt \qquad (2)$$

where:

S = substrate concentration at time t (mg/l)

So = initial substrate concentration (mg/l)

k = zero-order kinetic rate constant (mg/l hr)

t = time (hr)

In order to find the "best" value of k, a computer

program FIT (see APPENDIX 1) was used to perform a least squares regression of the experimental concentration versus time data. The degree of fit of each set of data was evaluated by the correlation coefficient. In addition, the average absolute residual between the experimental and the calculated values were determined.

Using the Monod equation, assuming a constant biomass concentration, the rate of substrate utilization is:

$$\frac{-dS}{dt} = \frac{k_1 S}{k_2 + S} \qquad (3)$$

which, in integrated form becomes:

$$\frac{k_2}{k_1} LN \frac{S_o}{S} + \frac{1}{k_1}(S_o - S) = t \qquad (4)$$

where:

S = substrate concentration at time t (mg/l)

So = initial substrate concentration (mg/l)

k1 = rate constant (1/hr)

k2 = substrate utilization constant (mg/l)

t = time (hr)

A linear regression was used to solve for the rate constants (the computer program is also listed in APPENDIX 1) using Gaussian elimination. Equation (4) is in the wrong form to obtain a corresponding expression for the correlation coefficient, so the degree of fit was evaluated by determining the residual at each data point, and the average

absolute residual for each set of data.

The Haldane model for substrate inhibition kinetics, (again assumuing constant biomass) is given by:

$$\frac{-dS}{dt} = \frac{k_1 S}{k_2 + S + S^2/k_3} \qquad (5)$$

which, in integrated form becomes:

$$\frac{k_2}{k_1} LN\frac{S_o}{S} + \frac{1}{k_1}(S_o - S) + \frac{S_o^2}{2k_1 k_3} - S^2 = t \qquad (6)$$

where:

S = substrate concentration at time t (mg/l)

So = initial substrate concentration (mg/l)

k1 = kinetic rate constant (1/hr)

k2 = substrate saturation constant (mg/l)

k3 = inhibition constant (mg/l)

t = time (hr)

The constants in equation (6) were evaluated by again making use of the Gaussian elimination routine, and the degree of fit of the data was indicated by the absolute average residual.

The constants for the three models are listed in Tables 46 through 171, and are summarized in groups by model and media in Tables 172 through 183. Table 184 shows the typical results obtained in this study for the zero order model, and compares them to results that have been previously reported.

Generally the zero-order model best represents the experimental data for phenol, with consistently high correlation coefficients of greater than 0.97 (see Tables 172 ,175) The absolute average residual for all phenol runs falls in the range of 0.5 to 5.0 ppm, with the most common values between 1 and 2 ppm. Similarly for O-chlorophenol the range is 0.1 to 1.0 ppm, with the most common value being about 0.2 ppm. The results for the fit of O-chlorophenol would be expected to be superior to those of phenol from a statistical point of view, because the initial concentration is 20% that of Phenol with approximately the same number of data points for both substrates. The magnitude of the absolute average residual is primarily related to the degree of the fit at the start and end of each run. However, at the end of each run there were insufficient data to accurately model this portion of the curve where the substrate concentration tails off to approach zero. There is a similar problem at the start of each run, where the rate accelerates, and the data are often insufficient.

The major draw-back in using the zero-order model for correlating the data is that there is no theoretical basis for using this type of model. In addition the model predicts a negative substrate concentration when extrapolated. For these reasons the data were also regressed to two additional models, the Monod model, and the Haldane model, both of which are derived on a theoretical basis dealing with the

biological activity of microoganisms on exposure to toxic materials. Both models have an asympote at zero substrate concentration.

The intergrated form of the Monod model (eqn. 4) was solved for the two constants using Gaussian elimination. The residuals were then calculated by trial and error using a bounded secant method. The fit of the data was generally poorer than when fitted to the zero-order model, but the O-chlorophenol data was fitted reasonablly well (in terms of residuals). For phenol, the residuals ranged from 0.5 to 13 ppm with the common value being about 5 ppm. Similarly for O-chlorophenol, the residuals ranged from 0.1 to 1.4 ppm with the common value being about 0.3 ppm. However, one or more of the constants are usually found to be negative, and as such have no physical meaning. In addition, the Monod model failed to yield constants of consistent magnitude for sets of data that showed similar concentration/time plots.

The intergrated form of the Haldane model (eqn. 6) was solved for it's constants and residuals in the same way as the Monod model, by using Gaussian elimination and a bounded secant. Of the three models tested, the Haldane model yeilded the poorest fit of the data, with average absolute residuals ranging from 2.5 to 8 ppm (and a common value of about 3 ppm) for phenol. For O-chlorophenol, the absolute average residuals ranged from 0.4 to 2.0 ppm with the common

value being about 1.2 ppm. Again as with the Monod model, one or two of the calculated constants were frequently negative.

The zero-order constants are summarized in Tables 172, 175, 178, and 181. These show a phenol degradation rate for Livingston mixed liquor in the range of 72.7-85.7 mg/l.hr, which is greater than that of the commercial preparations by themselves (where the degradation rates range from 50.0-59.1 mg/l.hr for BI-CHEM; 20.7-28.6 mg/l.hr for Hydrobac; and 7.2-11.0 mg/l/hr for LLMO).

Prior to this research, typical degradation rates for phenol were reported by Pitter [27] to be 3.36 ppm/l.hr, and by Holladay, et al. [28]to range from 9 to 111 ppm/l.hr in a CSTR. A study by Desai [29] showed the phenol degradation rate to range from 188.1-206.9 in batch studies where the Livingston mixed liquor was maintained by feeding continuously at 500 ppm/day. In another study Colish [18] observed degradation rates of 31.6 to 61.7 ppm/l-hr in Livingston mixed liquor that was maintained in a similar fashion to the present study. However, organisms had been acclimated for 800 to 2100 hours, compared to 50 to 120 hours in the present study.

As with phenol, prior to this series of studies much lower degradation rates had been reported for the

diappearence of O-chlorophenol. Haller [30] reported the complete degradtion of 16 ppm O-chlorophenol in 19 days. More in line with the results of this study were the observations reported by Pitter [27], of 1.49 ppm/l-hr. Colish [18] observed rates in the range of 2.90 to 7.21 ppm/l-hr in a similar study to this one, but as with his results with phenol, the sludge age was much older than that used in this study.

G. MLSS

Generally the MLSS was observed to be approximately constant during the course of a run. This was partlydue to the presence of detritusand dead organisms in the samples, and also due to the the large tare-weight of the aluminum weighing dishes. For these reasons, it was not possible to use MLSS as a measure of biological activity, as it is not sensitive enough to detect changes in the microorganism population.

VIII. CONCLUSIONS

1. The Livingston Mixed Liquor degraded both phenol and O-chlorophenol at rates significantly faster than those exhibited by any of the three commercial preparations tested by themselves.

2. In order to obtain a significant increase in the degradation rate of the substrates, a ratio of the mixed liquor to commercial preparation of 10:1 was required, in contrast to the manufacturer's recommendation of 1,000,000:1.

3. When the Livingston Mixed Liquor was added to each of the commercial preparations in a ratio of 10:1, the degradation rate increased to a rate aproximately equal to the sum of the rates when the preparations and the mixed liquor were tested by themselves.

4. A zero-order kinetic model was successfully used to represent all the data obtained for both the substrates tested.

5. Contary to previous investigations [27] the Monod, or Haldane models were not capable of fitting the data well, and often resulted in negative rate constants.

6. The use of a research grade GC with an auto-injector

greatly improved the quantity and the quality of data obtained, in comparison to data obtained previously in the same laboratory. In a period of about nine months approximately 15,000 injections were performed, with the reproducability of one sample often within 0.5 ppm.

7. The limit of accuracy of the COD method used was about 20 ppm, which made it ineffective in predicting the degree of mineralization of O-chlorophenol. In future work GC/MS analysis should be performed to determine if any organic compounds are being formed in the degradation of O-chlorophenol.

8. The original microbial mixed liquor had a high background level of chloride. As a result chloride ion measurement was not effective in determining the degree of mineralization of the O-chlorophenol.

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Table 1

Nutrient Solution Contents (per liter)

Phenol	10.000 gms
Ammonium Carbonate	6.640 gms
Ammonium Phosphate	1.805 gms
Water (distilled)	1000 mls

Table 2

Theoretical Chemical OxygenDemand (COD) of the Substrates and Internal Standard

Substrate	Theoretical COD
compound)	
Phenol	2.38
O-Chlorophenol	1.68
Thymol *	2.77

* Internal Standard

Table 3

Vapor-Liquid Equilibria Data for the Substrates

Substrate	gamma data	gamma calc	gamma expt	vapour pressure
Reference	(32)	(33)	(18)	(31)
Phenol	44-67	45	60	0.32 mm Hg
O-Chlorophenol	--	347	350	2.4 mm Hg

All at 298 K & 1 atm.

Table 4

A Summary of the Experimental Data Obtained for the Degradation of Phenol in the Media Hydrobac Run I

UBSTRATE :PHENOL

EDIA :HYDROBAC

ONCENTRATION:100 PPM NOMINAL

ATE :06-17-83

UN :I

EMPERATURE :33 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
10.0	80.9	289.0	--	108	415	--
67.0	56.4	62.0	--	97	418	--
99.0	36.4	55.0	--	--	418	--
132.0	18.7	32.0	--	89	364	--
157.0	4.3	28.0	--	--	489	--
190.0	1.1	19.0	--	101	394	--

Table 5

A Summary of the Experimental Data Obtained for the Degradation of Phenol in the Media Hydrobac Run II

SUBSTRATE :PHENOL

MEDIA :HYDROBAC

CONCENTRATION:100 PPM NOMINAL

DATE :06-17-83

RUN :II

TEMPERATURE :33 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
9.0	103.7	112.0	--	91	373	--
41.0	90.0	114.0	--	--	360	--
65.0	82.4	109.0	--	122	355	--
103.0	76.4	114.0	--	--	349	--
125.0	72.3	88.0	--	94	340	--
158.0	58.3	76.0	--	--	329	--
185.0	52.0	--	--	87	261	--
220.0	35.2	--	--	--	276	--
249.0	24.7	--	--	108	253	--
276.0	4.4	--	--	--	256	--
309.0	0.6	--	--	86	267	--

Table 6

A Summary of the Experimental Data Obtained for the Degradation of Phenol in the Media BI-CHEM Run I

SUBSTRATE :PHENOL

MEDIA :BI-CHEM

CONCENTRATION:100 PPM NOMINAL

DATE :06-17-83

RUN :I

TEMPERATURE :33 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
9.0	74.9	--	--	124	349	--
35.0	58.4	--	--	--	383	--
66.0	2.2	--	--	130	358	--
94.0	0.4	--	--	--	322	--

Table 7

A Summary of the Experimental Data Obtained for the Degradation of Phenol in the Media BI-CHEM Run II

SUBSTRATE :PHENOL

MEDIA :BI-CHEM

CONCENTRATION:100 PPM NOMINAL

DATE :06-17-83

RUN :II

TEMPERATURE :33 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
9.0	99.4	125.0	--	134	241	--
40.0	69.0	85.0	--	--	273	--
64.0	44.7	61.0	--	140	242	--
103.0	17.5	39.0	--	--	233	--
126.0	1.2	--	--	124	255	--

Table 8

A Summary of the Experimental Data Obtained for the Degradation of Phenol in the Media Livingston Run I

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON

CONCENTRATION:100 PPM NOMINAL

DATE :07-07-83

RUN :I

TEMPERATURE :27 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
9.0	87.1	120.0	6.3	382	564	--
20.0	71.0	111.0	6.3	--	605	--
37.0	53.6	81.0	6.2	--	580	--
51.0	32.1	74.0	6.2	--	692	--
66.0	10.9	68.0	6.2	335	608	--
82.0	1.9	23.0	6.2	--	615	--

Table 9

A Summary of the Experimental Data Obtained for the Degradation of Phenol in the Media Livingston Run II

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON

CONCENTRATION:100 PPM NOMINAL

DATE :07-07-83

RUN :II

TEMPERATURE :27 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
9.0	120.1	147.0	6.2	249	577	--
20.0	95.8	106.0	6.2	--	507	--
36.0	75.2	99.0	6.3	--	519	--
52.0	51.8	87.0	6.1	--	519	--
66.0	27.6	50.0	6.1	280	571	--
78.0	3.2	33.0	6.0	--	531	--
97.0	0.8	37.0	6.1	--	513	--

Table 10

A Summary of the Experimental Data Obtained for the Degradation of Phenol in the Media LLMO Run I

SUBSTRATE :PHENOL

MEDIA :LLMO

CONCENTRATION:100 PPM NOMINAL

DATE :09-26-83

RUN :I

TEMPERATURE :25 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
7.0	87.8	--	8.2	74	77	--
37.0	86.9	--	--	--	--	--
67.0	86.2	--	8.3	85	72	--
97.0	80.3	--	--	--	--	--
127.0	72.1	--	8.2	78	73	--
157.0	68.3	--	--	--	--	--
187.0	63.3	--	8.2	76	67	--
217.0	59.7	--	--	--	--	--
247.0	56.5	--	8.2	82	69	--
277.0	54.3	--	--	--	--	--
307.0	52.5	--	8.1	85	69	--
337.0	49.5	--	--	--	--	--
367.0	47.3	--	8.1	81	65	--
397.0	43.7	--	--	--	--	--
427.0	39.6	--	8.0	70	62	--
457.0	37.2	--	--	--	--	--
487.0	32.4	--	7.9	88	58	--
517.0	28.1	--	--	--	--	--
640.0	12.0	--	7.8	75	57	--
705.0	4.1	--	7.8	95	--	--

Table 11

A Summary of the Experimental Data Obtained for the Degradation of Phenol in the Media LLMO Run II

SUBSTRATE :PHENOL
MEDIA :LLMO
CONCENTRATION:100 PPM NOMINAL
DATE :09-27-83
RUN :II
TEMPERATURE :26 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
8.0	101.0	--	7.8	50	55	--
36.0	98.5	175.0	--	--	--	--
64.0	90.9	167.0	7.6	65	50	--
106.0	86.7	--	--	--	--	--
124.0	86.0	7.6	61.0	46	--	--
157.0	79.5	--	7.5	--	--	--
185.0	75.9	--	7.5	54	46	--
213.0	68.7	--	--	--	--	--
292.0	57.6	158.0	7.5	65	44	--
305.0	55.6	--	--	--	--	--
335.0	51.3	--	--	--	43	--
364.0	47.0	--	7.5	61	--	--
395.0	42.2	151.0	7.5	--	42	--
431.0	36.7	--	7.5	58	--	--
455.0	34.5	--	7.5	--	43	--
517.0	24.3	138.0	--	--	--	--
559.0	16.2	--	7.4	61	39	--
576.0	13.0	--	7.4	--	--	--
605.0	7.9	--	--	62	37	--
635.0	2.5	184.0	7.4	--	--	--
663.0	0.1	171.0	7.5	66	38	--

Table 12

A Summary of the Experimental Data Obtained for the Degradation of Phenol in the Media LLMO Run III

SUBSTRATE :PHENOL
MEDIA :LLMO
CONCENTRATION:100 PPM NOMINAL
DATE :09-28-83
RUN :III
TEMPERATURE :29 C

TIME MINS	CONC. PPM	COD PPM	pH mg/l	MLSS PPM	NH4+ PPM	CL- PPM
17.0	94.7	--	7.6	35	58	--
40.0	96.7	--	--	--	--	--
65.0	89.1	--	7.6	38	37	--
94.0	84.9	--	--	--	--	--
127.0	81.1	--	7.5	34	--	--
159.0	76.7	--	7.5	--	34	--
186.0	70.8	--	--	--	--	--
228.0	65.6	--	7.5	--	34	--
240.0	61.0	--	7.5	33	--	--
274.0	51.7	--	7.4	--	35	--
306.0	47.4	--	7.4	35	--	--
334.0	42.4	--	--	--	--	--
368.0	36.4	--	7.4	30	--	--
396.0	29.4	--	--	--	30	--
423.0	23.6	--	7.4	19	--	--
452.0	16.9	--	--	--	27	--
488.0	8.3	--	7.3	--	--	--
507.0	3.7	--	7.3	32	27	--
604.0	0.1	--	7.5	20	--	--

Table 13

A Summary of the Experimental Data Obtained for the Degradation of Phenol in the Media Livingston/BI-CHEM Run I

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:100 PPM NOMINAL

DATE :07-26-83

RUN :I

TEMPERATURE :25 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
8.0	96.0	100.0	6.5	184	610	--
21.0	63.8	67.0	6.5	--	511	--
36.0	29.4	38.0	6.4	--	884	--
52.0	3.0	19.0	6.3	--	1085	--
63.0	1.1	35.0	6.4	180	1260	--

Table 14

A Summary of the Experimental Data Obtained for the Degradation of Phenol in the Media Livingston/BI-CHEM Run II

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:100 PPM NOMINAL

DATE :07-26-83

RUN :II

TEMPERATURE :25 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
6.0	95.2	115.0	6.3	196	622	--
21.0	65.0	75.0	6.2	--	365	--
34.0	31.5	71.0	6.1	--	364	--
53.0	2.2	28.0	6.1	--	317	--
65.0	2.1	33.0	6.1	177	392	--
80.0	1.7	40.0	6.1	--	430	--

Table 15

A Summary of the Experimental Data Obtained for the Degradation of Phenol in the Media Livingston/BI-CHEM Run III

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:100 PPM NOMINAL

DATE :07-27-83

RUN :III

TEMPERATURE :25 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
7.0	112.4	--	6.6	167	196	--
15.0	83.4	--	6.5	--	210	--
25.0	44.6	--	6.3	--	207	--
34.0	20.0	--	6.2	163	207	--
44.0	3.2	--	6.2	--	215	--
55.0	1.8	--	6.2	--	218	--

Table 16

A Summary of the Experimental Data Obtained for the Degradation of Phenol in the Media Livingston/Hydrobac Run I

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:100 PPM NOMINAL

DATE :07-29-83

RUN :I

TEMPERATURE :26 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
9.0	84.7	90.0	--	246	151	--
17.0	60.7	65.0	6.3	--	148	--
26.0	43.2	47.0	6.1	--	153	--
36.0	20.1	23.0	6.4	--	152	--
47.0	2.7	9.0	6.6	--	154	--
56.0	0.6	--	6.6	251	155	--

Table 17

A Summary of the Experimental Data Obtained for the Degradation of Phenol in the Media Livingston/Hydrobac Run II

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:100 PPM NOMINAL

DATE :07-29-83

RUN :II

TEMPERATURE :26 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
9.0	91.4	--	6.8	215	131	--
18.0	71.9	--	6.5	--	129	--
27.0	53.5	--	6.5	--	125	--
37.0	26.3	--	6.4	--	113	--
58.0	1.9	--	6.3	247	123	--

Table 18

A Summary of the Experimental Data Obtained for the Degradation of Phenol in the Media Livingston/Hydrobac Run III

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:100 PPM NOMINAL

DATE :08-02-83

RUN :III

TEMPERATURE :26 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
9.0	107.0	--	7.0	315	68	--
17.0	84.7	--	6.7	--	69	--
24.0	62.5	--	--	--	71	--
30.0	46.0	--	6.7	273	69	--
37.0	30.6	--	--	--	72	--
44.0	15.3	--	6.6	--	72	--
55.0	0.2	--	--	269	68	--

Table 19

A Summary of the Experimental Data Obtained for the Degradation of Phenol in the Media Livingston/LLMO Run I

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:100 PPM NOMINAL

DATE :08-23-83

RUN :I

TEMPERATURE :NONE

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
6.0	71.7	115.0	6.8	223	70	--
11.0	65.4	102.0	--	--	60	--
15.0	59.9	--	6.8	--	60	--
20.0	51.0	98.0	--	--	68	--
25.0	43.2	--	--	--	59	--
30.0	34.6	80.0	6.8	--	69	--
35.0	25.4	--	--	--	57	--
40.0	18.0	--	--	--	51	--
45.0	11.6	73.0	6.8	--	53	--
51.0	0.1	--	--	238	50	--

Table 20

A Summary of the Experimental Data Obtained for the Degradation of Phenol in the Media Livingston/LLMO Run II

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:100 PPM NOMINAL

DATE :08-23-83

RUN :II

TEMPERATURE :NONE

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
6.0	77.1	--	6.8	206	42	--
13.0	72.1	--	6.8	--	38	--
20.0	59.6	--	--	--	42	--
26.0	50.1	--	6.8	--	40	--
34.0	36.7	--	6.7	243	40	--
39.0	26.0	--	--	--	40	--
45.0	18.3	--	6.6	--	39	--
53.0	8.0	--	--	--	40	--
59.0	0.1	--	6.7	245	--	--

Table 21

A Summary of the Experimental Data Obtained for the Degradation of Phenol in the Media Livingston/LLMO Run III

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:100 PPM NOMINAL

DATE :08-23-83

RUN :III

TEMPERATURE :NONE

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
8.0	85.7	--	6.8	230	29	--
14.0	70.7	--	6.5	--	25	--
21.0	59.3	--	--	--	24	--
28.0	43.9	--	6.5	197	23	--
36.0	33.0	--	--	--	23	--
43.0	17.2	--	6.4	--	22	--
48.0	0.1	--	--	--	22	--

Table 22

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media Hydrobac Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :06-22-83

RUN :I

TEMPERATURE :23 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
6.0	15.5	15.0	--	114	454	--
39.0	8.9	19.0	--	--	450	--
70.0	5.2	0.0	--	116	523	--
96.0	3.8	12.0	--	--	373	--
126.0	1.4	0.0	--	103	564	--
154.0	0.1	7.0	--	--	489	--

Table 23

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media Hydrobac Run II

SUBSTRATE :O-CHLOROPHENOL

MEDIA :HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :06-22-83

RUN :II

TEMPERATURE :23 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
8.0	21.1	--	--	104	415	--
41.0	19.9	--	--	--	442	--
68.0	20.3	--	--	102	376	--
96.0	18.4	--	--	--	403	--
126.0	18.5	--	--	108	416	--
157.0	19.2	--	--	--	485	--
185.0	18.3	--	--	106	436	--
279.0	19.9	--	--	--	491	--
353.0	17.6	--	--	95	493	--
435.0	16.7	--	--	--	--	--
499.0	16.0	--	--	--	--	--

Table 24

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media Hydrobac Run III

SUBSTRATE :O-CHLOROPHENOL

MEDIA :HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :06-23-83

RUN :III

TEMPERATURE :23 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
7.0	15.0	--	--	118	121	--
36.0	7.4	--	--	--	105	--
65.0	9.1	--	--	89	101	--
97.0	9.1	--	--	--	101	--
140.0	7.6	--	--	144	90	--
161.0	6.3	--	--	--	95	--
186.0	5.2	--	--	119	90	--
216.0	4.4	--	--	--	98	--
244.0	3.4	--	--	102	78	--
279.0	2.6	--	--	--	77	--
303.0	2.0	--	--	108	86	--
342.0	0.8	--	--	--	96	--

Table 25

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media Hydrobac Run IV

SUBSTRATE :O-CHLOROPHENOL

MEDIA :HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :06-24-83

RUN :IV

TEMPERATURE :24

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
8.0	18.4	--	--	117	79	--
37.0	16.8	--	--	--	78	--
67.0	11.6	--	--	--	74	--
96.0	11.8	--	--	--	81	--
133.0	10.1	--	--	114	80	--
156.0	6.7	--	--	--	78	--
186.0	8.6	--	--	16	72	--
216.0	7.7	--	--	--	77	--
246.0	6.8	--	--	121	71	--
276.0	6.1	--	--	--	69	--
307.0	5.5	--	--	116	59	--
337.0	4.5	--	--	--	59	--
366.0	4.8	--	--	--	61	--
396.0	3.9	--	--	--	64	--

Table 26

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media BI-CHEM Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :06-22-83

RUN :I

TEMPERATURE :23 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
8.0	15.6	--	--	--	--	--
39.0	3.2	--	--	--	86	--
70.0	0.9	--	--	145	89	--

Table 27

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media BI-CHEM Run II

SUBSTRATE :O-CHLOROPHENOL

MEDIA :BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :06-22-83

RUN :II

TEMPERATURE :23 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
8.0	19.9	--	--	137	--	--
42.0	18.4	--	--	--	70	--
68.0	21.0	--	--	145	67	--
96.0	9.6	--	--	--	61	--
126.0	21.0	--	--	130	68	--
157.0	21.0	--	--	--	81	--
185.0	17.5	--	--	123	76	--
279.0	16.6	--	--	116	105	--
353.0	15.0	--	--	127	106	--
436.0	14.5	--	--	--	112	--

CONCENTRATION:20 PPM NOMINAL

DATE :06-23-83

RUN :III

TEMPERATURE :23 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
7.0	13.9	41.0	--	129	150	--
36.0	12.6	27.0	--	--	129	--
66.0	5.6	--	--	136	139	--
98.0	4.0	17.0	--	--	114	--
140.0	2.7	--	--	110	98	--
163.0	2.4	28.0	--	--	103	--
187.0	1.6	--	--	149	112	--

Table 29

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media BI-CHEM Run IV

SUBSTRATE :O-CHLOROPHENOL

MEDIA :BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :06-24-83

RUN :IV

TEMPERATURE :24 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
8.0	15.6	--	--	157	77	--
38.0	9.7	--	--	--	62	--
67.0	7.9	--	--	158	53	--
97.0	6.2	--	--	--	77	--
134.0	3.7	--	--	157	82	--
156.0	3.2	--	--	--	54	--
185.0	2.2	--	--	159	56	--
216.0	0.8	--	--	--	47	--

Table 30

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media Livingston Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON

CONCENTRATION:20 PPM NOMINAL

DATE :07-13-83

RUN :I

TEMPERATURE :27 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
6.0	24.3	70.0	7.2	374	1006	45.0
22.0	18.4	60.0	7.2	--	1316	66.0
36.0	14.6	47.0	7.2	--	956	90.0
53.0	10.5	41.0	7.2	292	916	103.0
82.0	5.3	25.0	7.2	--	927	119.0
97.0	3.9	32.0	7.2	--	891	129.0
112.0	2.8	46.0	7.2	295	923	63.0
127.0	2.0	49.0	7.2	--	846	59.0
140.0	1.4	49.0	7.2	--	791	52.0

Table 31

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media Livingston Run II

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON

CONCENTRATION:20 PPM NOMINAL

DATE :07-14-83

RUN :II

TEMPERATURE :UNKNOWN

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
8.0	22.3	49.0	6.7	363	668	66.0
21.0	16.1	55.0	6.7	--	665	72.0
38.0	12.2	49.0	6.7	--	612	71.0
54.0	8.0	55.0	6.7	--	605	75.0
66.0	4.9	58.0	6.7	273	580	73.0
85.0	2.0	42.0	6.7	--	608	74.0
98.0	1.3	45.0	6.7	--	589	72.0

Table 32

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media Livingston Run III

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON

CONCENTRATION:20 PPM NOMINAL

DATE :07-15-83

RUN :III

TEMPERATURE :28 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
5.0	20.9	68.0	6.7	233	548	63.0
22.0	17.5	63.0	6.6	--	505	65.0
35.0	14.3	75.0	6.6	--	542	61.0
55.0	13.4	66.0	6.6	--	513	64.0
65.0	11.5	52.0	6.6	232	548	62.0
80.0	9.3	63.0	6.6	--	515	53.0
96.0	7.2	72.0	6.6	--	591	60.0

Table 33

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media LLMO Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :03-01-84

RUN :I

TEMPERATURE :23 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
7.0	22.8	--	--	--	--	--
37.0	18.3	--	--	--	--	--
73.0	18.4	--	--	--	--	--
126.0	16.3	--	--	--	--	--
159.0	17.2	--	--	--	--	--
188.0	20.5	--	--	--	--	--
243.0	15.8	--	--	--	--	--
304.0	15.7	--	--	--	--	--
370.0	16.5	--	--	--	--	--
423.0	14.9	--	--	--	--	--
483.0	18.4	--	--	--	--	--

Table 34

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media LLMO Run II

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :03-02-84

RUN :II

TEMPERATURE :23 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
7.0	15.5	--	--	--	--	--
84.0	14.2	--	--	--	--	--
129.0	14.0	--	--	--	--	--
160.0	14.4	--	--	--	--	--
252.0	14.4	--	--	--	--	--
300.0	14.4	--	--	--	--	--
363.0	12.4	--	--	--	--	--
420.0	10.8	--	--	--	--	--
482.0	13.3	--	--	--	--	--

Table 35

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media LLMO

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :03-04-84

RUN :III

TEMPERATURE :23 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
6.0	17.4	--	--	--	--	--
63.0	16.1	--	--	--	--	--
148.0	17.0	--	--	--	--	--
244.0	16.4	--	--	--	--	--
302.0	16.4	--	--	--	--	--
363.0	17.0	--	--	--	--	--
423.0	18.4	--	--	--	--	--
481.0	19.2	--	--	--	--	--

Table 36

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media Livingston/BI-CHEM Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :07-28-83

RUN :I

TEMPERATURE :26 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
7.0	19.7	25.0	7.8	277	152	--
15.0	15.6	14.0	7.7	--	149	--
25.0	11.9	--	7.7	--	149	--
35.0	8.6	39.0	7.7	--	154	--
45.0	4.6	--	7.8	--	139	--
56.0	1.5	5.0	7.8	246	137	--

Table 37

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media Livingston/BIII-CHEM Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :07-29-83

RUN :III

TEMPERATURE :26 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
5.0	17.7	52.0	7.0	221	37	--
11.0	15.8	39.0	--	--	36	183.0
17.0	12.3	--	--	--	33	--
23.0	8.8	64.0	--	--	32	--
29.0	5.4	--	6.9	226	31	--
35.0	1.7	44.0	--	--	31	170.0

Table 38

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media Livingston/BI-CHEM Run IV

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :08-12-83

RUN :IV

TEMPERATURE :24 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
5.0	22.7	--	7.0	248	--	--
11.0	20.5	--	--	--	--	--
16.0	19.2	--	--	--	--	--
22.0	15.0	--	--	--	--	--
28.0	11.6	--	6.9	244	--	--
34.0	8.4	--	--	--	--	--
40.0	5.2	--	--	--	--	--
45.0	3.4	--	--	--	--	--
51.0	1.9	--	--	--	--	--

Table 39

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media Livingston/Hydrobac Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :08-03-83

RUN :I

TEMPERATURE :26 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
7.0	18.4	--	6.6	307	86	--
14.0	15.9	58.0	6.6	--	61	--
20.0	13.9	--	--	--	58	--
26.0	13.1	--	--	--	59	--
31.0	11.1	--	6.7	306	59	--
38.0	10.2	--	--	--	58	--
45.0	7.7	58.0	--	--	57	--
52.0	6.2	--	--	--	60	--
58.0	5.0	--	--	300	59	--
65.0	4.2	--	--	--	59	--
72.0	3.8	--	--	--	60	--
75.0	3.7	--	--	--	58	--
86.0	2.7	--	--	299	60	--
95.0	2.2	47.0	--	--	55	--
103.0	2.4	--	--	--	61	--
112.0	1.8	--	--	--	60	--

Table 40

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media Livingston/Hydrobac Run I A

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :08-16-83

RUN :I A

TEMPERATURE :27 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
6.0	18.3	--	7.1	229	42	101.0
11.0	14.7	--	7.1	--	34	--
16.0	11.5	--	7.1	--	34	--
24.0	6.9	--	7.1	--	33	111.0
36.0	0.9	--	7.1	--	34	--

Table 41

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media Livingston/Hydrobac Run II A

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :08-16-83

RUN :II A

TEMPERATURE :25 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
4.0	18.9	101.0	6.9	190	42	126.0
10.0	17.5	102.0	--	--	37	--
16.0	14.8	--	6.9	--	37	--
21.0	12.7	81.0	--	--	37	--
25.0	10.5	--	--	--	37	--
30.0	8.4	--	6.9	201	35	--
35.0	6.7	--	--	--	34	125.0
39.0	4.8	70.0	--	--	35	--
44.0	3.7	86.0	6.9	--	35	--
50.0	2.2	--	--	--	34	--
54.0	1.1	83.0	--	--	35	--

Table 42

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media Livingston/Hydrobac Run III A

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :08-16-83

RUN :III A

TEMPERATURE :25 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
5.0	21.8	--	7.0	175	--	107.0
10.0	20.9	--	--	--	--	--
17.0	20.0	--	--	--	--	--
23.0	19.6	--	7.0	--	--	--
30.0	19.4	--	--	159	--	--
37.0	15.9	--	7.0	--	--	--
43.0	16.8	--	--	--	--	113.0
49.0	17.4	--	--	--	--	--
55.0	17.9	--	--	--	--	--
64.0	17.0	--	7.0	162	--	--
70.0	15.5	--	--	--	--	112.0
76.0	15.0	--	--	--	--	--
83.0	14.7	--	--	--	--	--
89.0	14.0	--	--	--	--	--

Table 43

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media Livingston/LLMO Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :08-24-83

RUN :I

TEMPERATURE :27 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
5.0	22.4	--	7.5	214	--	184.0
13.0	13.5	--	7.3	--	--	--
22.0	5.6	--	--	--	--	--
27.0	0.1	--	7.3	243	--	202.0

Table 44

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media Livingston/LLMO Run II

SUBSTRATE :O-CHLOROPHENOL

CONCENTRATION:20 PPM NOMINAL

DATE :08-24-83

RUN :II

TEMPERATURE :27 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
7.0	16.0	--	7.5	246	--	--
14.0	11.3	--	7.3	--	--	--
23.0	5.6	--	--	--	--	--
30.0	0.1	--	7.3	220	--	--

Table 45

A Summary of the Experimental Data Obtained for the Degradation of O-Chlorophenol in the Media Livingston/LLMO Run III

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :08-24-83

RUN :III

TEMPERATURE :27 C

TIME MINS	CONC. PPM	COD PPM	pH	MLSS mg/l	NH4+ PPM	CL- PPM
5.0	16.3	--	7.5	233	--	191.0
11.0	13.6	--	--	--	--	--
15.0	9.1	--	7.3	--	--	--
21.0	5.9	--	--	--	--	--
26.0	0.1	--	--	--	--	186.0

Table 46

The Regression of the Phenol Concentration Versus Time to Fit the Zero Order Model in the Media Hydrobac Run I

SUBSTRATE :PHENOL

MEDIA :HYDROBAC

CONCENTRATION:100 PPM NOMINAL

DATE :06-17-83

RUN :I

TEMPERATURE :33 C

TIME (MIN)	PPMEXP	PPMCAL	DY
10.000	80.900	80.289	-0.61107
67.000	56.400	53.089	-3.3114
99.000	36.400	37.818	1.4182
132.00	18.700	22.071	3.3706
157.00	4.3000	10.141	5.8406
190.00	1.1000	-5.6070	-6.7070

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 85.061 + 5.86 mg/l

K2= -28.632 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.97881

THE ABSOLUTE AVERAGE RESIDUAL = 1.6981

Table 47

The Regression of the Phenol Concentration Versus Time to Fit the Zero Order Model in the Media Hydrobac Run II

SUBSTRATE :PHENOL

MEDIA :HYDROBAC

CONCENTRATION:100 PPM NOMINAL

DATE :06-17-83

RUN :II

TEMPERATURE :33 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	103.70	106.02	2.3248
41.000	90.000	94.982	4.9823
65.000	82.400	86.700	4.3004
103.00	76.400	73.587	-2.8125
125.00	72.300	65.996	-6.3043
158.00	58.300	54.608	-3.6918
185.00	52.000	45.291	-6.7090
220.00	35.200	33.213	-1.9867
249.00	24.700	23.206	-1.4939
276.00	4.4000	13.889	9.4889
309.00	0.60000	2.5014	1.9014

Table 48

The Regression of the Phenol Concentration Versus Time to Fit the Zero Order Model in the Media BI-CHEM Run I

SUBSTRATE :PHENOL

MEDIA :BI-CHEM

CONCENTRATION:100 PPM NOMINAL

DATE :06-17-83

RUN :I

TEMPERATURE :33 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	74.900	75.318	0.41838
35.000	58.400	49.725	-8.6751
66.000	2.2000	19.209	17.009
94.000	0.40000	-8.3528	-8.7528

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 84.178 +32.75 mg/l

K2= -59.062 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.89988

THE ABSOLUTE AVERAGE RESIDUAL = 5.2522

Table 49

The Regression of the Phenol Concentration Versus Time to Fit the Zero Order Model in the Media BI-CHEM Run II

SUBSTRATE :PHENOL

MEDIA :BI-CHEM

CONCENTRATION:100 PPM NOMINAL

DATE :06-17-83

RUN :II

TEMPERATURE :33 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	99.400	95.827	-3.5734
40.000	69.000	70.011	1.0107
64.000	44.700	50.024	5.3242
103.00	17.500	17.546	0.46097E-01
126.00	1.2000	-1.6077	-2.8077

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 103.322 + 5.92 mg/l

K2= -49.966 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.99193

THE ABSOLUTE AVERAGE RESIDUAL = 1.4145

Table 50

The Regression of the Phenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston Run I

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON

CONCENTRATION:100 PPM NOMINAL

DATE :07-07-83

RUN :I

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	87.100	85.349	-1.7514
20.000	71.000	72.029	1.0291
37.000	53.600	51.444	-2.1555
51.000	32.100	34.492	2.3924
66.000	10.900	16.329	5.4295
82.000	1.9000	-3.0443	-4.9443

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 96.246 + 4.85 mg/l

K2= -72.652 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.98795

THE ABSOLUTE AVERAGE RESIDUAL = 1.3786

Table 51

The Regression of the Phenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston Run II

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON

CONCENTRATION:100 PPM NOMINAL

DATE :07-07-83

RUN :II

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	120.10	113.74	-6.3590
20.000	95.800	98.017	2.2171
36.000	75.200	75.146	-0.54092E-01
52.000	51.800	52.275	0.47475
66.000	27.600	32.262	4.6625
78.000	3.2000	15.109	11.909
97.000	0.80000	-12.050	--2.850

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 126.606 + 8.63 mg/l

K2= -85.767 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.97048

THE ABSOLUTE AVERAGE RESIDUAL = 2.7638

Table 52

The Regression of the Phenol Concentration Versus Time to Fit the Zero Order Model in the Media LLMO Run I

SUBSTRATE :PHENOL
MEDIA :LLMO
CONCENTRATION:100 PPM NOMINAL
DATE :09-26-83
RUN :I
TEMPERATURE :25 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	87.800	88.394	0.59412
37.000	86.900	84.817	-2.0834
67.000	86.200	81.239	-4.9609
97.000	80.300	77.662	-2.6384
127.00	72.100	74.084	1.9840
157.00	68.300	70.507	2.2065
187.00	63.300	66.929	3.6290
217.00	59.700	63.352	3.6515
247.00	56.500	59.774	3.2740
277.00	54.300	56.196	1.8965
307.00	52.500	52.619	0.11896
337.00	49.500	49.041	-0.45856
367.00	47.300	45.464	-1.8361
397.00	43.700	41.886	-1.8136
427.00	39.600	38.309	-1.2911
457.00	37.200	34.731	-2.4686
487.00	32.400	31.154	-1.2461
517.00	28.100	27.576	-0.52368
640.00	12.000	12.909	0.90851
705.00	4.1000	5.1572	1.0572

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 89.229 + 1.14 mg/l

K2= -7.155 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.99020

THE ABSOLUTE AVERAGE RESIDUAL = 0.51065

Table 53

The Regression of the Phenol Concentration Versus Time to Fit the Zero Order Model in the Media LLMO Run II

SUBSTRATE :PHENOL
MEDIA :LLMO
CONCENTRATION:100 PPM NOMINAL
DATE :09-27-83
RUN :II
TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	101.00	102.17	1.1669
36.000	98.500	97.800	-0.69995
64.000	90.900	93.433	2.5332
106.00	86.700	86.883	0.18301
124.00	86.000	84.076	-1.9242
157.00	79.500	78.929	-0.57086
185.00	75.900	74.562	-1.3377
213.00	68.700	70.195	1.4955
292.00	57.600	57.875	0.27480
305.00	55.600	55.847	0.24734
335.00	51.300	51.169	-0.13139
364.00	47.000	46.646	-0.35417
395.00	42.200	41.811	-0.38887
431.00	36.700	36.197	-0.50336
455.00	34.500	32.454	-2.0464
517.00	24.300	22.784	-1.5158
559.00	16.200	16.234	0.34012E-01
576.00	13.000	13.583	0.58272
605.00	7.9000	9.0599	1.1599
635.00	2.5000	4.3812	1.8812
663.00	0.10000	0.14374E-01	-0.85626E-01

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 103.415 + 0.56 mg/l

K2= -9.357 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.99866

THE ABSOLUTE AVERAGE RESIDUAL = 0.25536

Table 54

The Regression of the Phenol Concentration Versus Time to Fit the Zero Order Model in the Media LLMO Run III

SUBSTRATE :PHENOL
MEDIA :LLMO
CONCENTRATION:100 PPM NOMINAL
DATE :09-28-83
RUN :III
TEMPERATURE :29 C

TIME (MIN)	PPMEXP	PPMCAL	DY
17.000	94.700	99.776	5.0759
40.000	96.700	95.553	-1.1469
65.000	89.100	90.963	1.8631
94.000	84.900	85.639	0.73878
127.00	81.100	79.580	-1.5200
159.00	76.700	73.705	-2.9952
186.00	70.800	68.748	-2.0524
228.00	65.600	61.036	-4.5636
240.00	61.000	58.833	-2.1667
274.00	51.700	52.591	0.89088
306.00	47.400	46.716	-0.68430
334.00	42.400	41.575	-0.82509
368.00	36.400	35.333	-1 675
396.00	29.400	30.192	0.79175
423.00	23.600	25.235	1.6346
452.00	16.900	19.910	3.0102
488.00	8.3000	13.301	5.0006
507.00	3.7000	9.8122	6.1122
604.00	0.10000	-7.9969	-8.0969

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 102.897 + 1.73 mg/l

K2= -11.016 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.98816

THE ABSOLUTE AVERAGE RESIDUAL = 0.77259

Table 55

The Regression of the Phenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston/BI-CHEM Run I

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:100 PPM NOMINAL

DATE :07-26-83

RUN :I

TEMPERATURE :25 C

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	96.000	88.752	-7.2475
21.000	63.800	65.495	1.6953
36.000	29.400	38.660	9.2600
52.000	3.0000	10.036	7.0357
63.000	1.1000	-9.6434	-10.743

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 103.065 +15.01 mg/l

K2= -107.341 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.95424

THE ABSOLUTE AVERAGE RESIDUAL = 3.4990

Table 56

The Regression of the Phenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston/BI-CHEM Run III

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:100 PPM NOMINAL

DATE :07-26-83

RUN :II

TEMPERATURE :25 C

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	95.200	82.078	-13.122
21.000	65.000	62.251	-2.7493
34.000	31.500	45.067	13.567
53.000	2.2000	19.952	17.752
65.000	2.1000	4.0900	1.9900
80.000	1.7000	-15.738	--7.438

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 90.009 +18.39 mg/l

K2= -79.310 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.87311

THE ABSOLUTE AVERAGE RESIDUAL = 5.2360

Table 57

The Regression of the Phenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston/BI-CHEM Run IV

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:100 PPM NOMINAL

DATE :07-27-83

RUN :III

TEMPERATURE :25 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	112.40	99.590	-12.810
15.000	83.400	80.335	-3.0647
25.000	44.600	56.267	11.667
34.000	20.000	34.606	14.606
44.000	3.2000	10.538	7.3379
55.000	1.8000	-15.937	--7.737

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 116.437 +17.84 mg/l

K2= -144.408 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.91306

THE ABSOLUTE AVERAGE RESIDUAL = 4.9760

Table 58

The Regression of the Phenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston/Hydrobac Run I

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:100 PPM NOMINAL

DATE :07-29-83

RUN :I

TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	84.700	77.213	-7.4870
17.000	60.700	62.540	1.8398
26.000	43.200	46.033	2.8325
36.000	20.100	27.691	7.5911
47.000	2.7000	7.5155	4.8155
56.000	0.60000	-8.9918	-9.5918

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 93.720 + 9.29 mg/l

K2= -110.049 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.95744

THE ABSOLUTE AVERAGE RESIDUAL = 2.5835

Table 59

The Regression of the Phenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston/Hydrobac Run II

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:100 PPM NOMINAL

DATE :07-29-83

RUN :II

TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	91.400	87.725	-3.6748
18.000	71.900	70.969	-0.93089
27.000	53.500	54.213	0.71301
37.000	26.300	35.595	9.2951
58.000	1.9000	-3.5024	-5.4024

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 104.481 + 9.86 mg/l

K2= -111.707 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.97430

THE ABSOLUTE AVERAGE RESIDUAL = 2.2844

Table 60

The Regression of the Phenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston/Hydrobac Run III

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:100 PPM NOMINAL

DATE :08-02-83

RUN :III

TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	107.00	101.36	-5.6434
17.000	84.700	82.366	-2.3340
24.000	62.500	65.749	3.2491
30.000	46.000	51.506	5.5061
37.000	30.600	34.889	4.2892
44.000	15.300	18.272	2.9724
55.000	0.20000	-7.8398	-8.0398

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 122.721 + 6.04 mg/l

K2= -142.430 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.98042

THE ABSOLUTE AVERAGE RESIDUAL = 1.8628

Table 61

The Regression of the Phenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston/LLMO Run I

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:100 PPM NOMINAL

DATE :08-23-83

RUN :I

TEMPERATURE :NONE

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	71.700	73.179	1.4790
11.000	65.400	65.131	-0.26894
15.000	59.900	58.693	-1.2073
20.000	51.000	50.645	-0.35522
25.000	43.200	42.597	-0.60316
30.000	34.600	34.549	-0.51117E-01
35.000	25.400	26.501	1.1010
40.000	18.000	18.453	0.45302
45.000	11.600	10.405	-1.1949
51.000	0.10000	0.74756	0.64756

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 82.837 + 0.75 mg/l

K2= -96.575 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.99858

THE ABSOLUTE AVERAGE RESIDUAL = 0.27339

Table 62

The Regression of the Phenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston/LLMO Run II

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:100 PPM NOMINAL

DATE :08-23-83

RUN :II

TEMPERATURE :NONE

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	77.100	79.776	2.6758
13.000	72.100	69.029	-3.0706
20.000	59.600	58.283	-1.3170
26.000	50.100	49.072	-1 281
34.000	36.700	36.790	0.90302E-01
39.000	26.000	29.114	3.1143
45.000	18.300	19.903	1.6031
53.000	8.0000	7.6216	-0.37840
59.000	0.10000	-1.5896	--.6896

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 88.987 + 1.85 mg/l

K2= -92.112 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.99438

THE ABSOLUTE AVERAGE RESIDUAL = 0.65409

Table 63

The Regression of the Phenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston/LLMO Run III

Table 63

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:100 PPM NOMINAL

DATE :08-23-83

RUN :III

TEMPERATURE :NONE

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	85.700	85.095	-0.60486
14.000	70.700	73.021	2.3205
21.000	59.300	58.933	-0.36655
28.000	43.900	44.846	0.94640
36.000	33.000	28.747	-4.2531
43.000	17.200	14.660	-2.5402
48.000	0.10000	4.5976	4.4976

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 101.195 + 3.34 mg/l

K2= -120.746 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.99054

THE ABSOLUTE AVERAGE RESIDUAL = 1.0257

Table 64

The Regression of the Phenol Concentration Versus Time to Fit the Monod Model in the Media Hydrobac Run I

SUBSTRATE :PHENOL

MEDIA :HYDROBAC

CONCENTRATION:100 PPM NOMINAL

DATE :06-17-83

RUN :I

TEMPERATURE :33 C

TIME (MIN)	PPMEXP	PPMCAL	DY
10.000	80.900	80.900	0.00000
77.000	56.400	35.589	20.811
109.00	36.400	20.824	15.576
142.00	18.700	10.758	7.9420
167.00	4.3000	6.1269	-1.8269
200.00	1.1000	2.7521	-1.6521

KINETIC CONSTANTS

MONOD MODEL

K1= 47.851 + 0.00 mg/l

K2= 75.766 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 4.5486

Table 65

The Regression of the Phenol Concentration Versus Time to Fit the Monod Model in the Media Hydrobac Run II

SUBSTRATE :PHENOL

MEDIA :HYDROBAC

CONCENTRATION:100 PPM NOMINAL

DATE :06-17-83

RUN :II

TEMPERATURE :33 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	103.70	103.70	0.00000
50.000	90.000	92.669	-2.6686
74.000	82.400	86.154	-3.7543
112.00	76.400	75.731	0.66924
134.00	72.300	69.620	2.6805
167.00	58.300	60.313	-2.0134
194.00	52.000	52.532	-0.53203
229.00	35.200	42.105	-6.9046
258.00	24.700	32.971	-8.2712
285.00	4.4000	1.5285	2.8715
318.00	0.60000	19.843	-19.243

KINETIC CONSTANTS

MONOD MODEL

K1= -8.067 + 0.00 mg/l

K2= 14.816 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 2.0886

Table 66

The Regression of the Phenol Concentration Versus Time to Fit the Monod Model in the Media BI-CHEM Run I

SUBSTRATE :PHENOL

MEDIA :BI-CHEM

CONCENTRATION:100 PPM NOMINAL

DATE :06-17-83

RUN :I

TEMPERATURE :33 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	74.900	74.900	0.00000
44.000	58.400	90.466	-32.066
75.000	2.2000	1.2534	0.94661
103.00	0.40000	0.83638	-0.43638

KINETIC CONSTANTS

MONOD MODEL

K1= -23.165 + 0.00 mg/l

K2= -19.186 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 8.0208

Table 67

The Regression of the Phenol Concentration Versus Time to Fit the Monod Model in the Media BI-CHEM Run II

SUBSTRATE :PHENOL

MEDIA :BI-CHEM

CONCENTRATION:100 PPM NOMINAL

DATE :06-17-83

RUN :II

TEMPERATURE :33 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	99.400	99.400	0.00000
49.000	69.000	65.182	3.8179
73.000	44.700	45.146	-0.44644
112.00	17.500	14.830	2.6703
135.00	1.2000	2.2617	-1 617

KINETIC CONSTANTS

MONOD MODEL

K1= 4.339 + 0.00 mg/l

K2= 54.073 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.95987

Table 68

The Regression of the Phenol Concentration Versus Time to Fit the Monod Model in the Media Livingston Run I

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON

CONCENTRATION:100 PPM NOMINAL

DATE :07-07-83

RUN :I

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	87.100	87.100	0.00000
29.000	71.000	86.219	-15.219
46.000	53.600	85.466	-31.866
60.000	32.100	84.844	-52.744
75.000	10.900	6.5731	4.3269
91.000	1.9000	6.7007	-4.8007

KINETIC CONSTANTS

MONOD MODEL

K1= -30.433 + 0.00 mg/l

K2= 1.715 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 10.634

Table 69

The Regression of the Phenol Concentration Versus Time to Fit the Monod Model in the Media Livingston Run II

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON

CONCENTRATION:100 PPM NOMINAL

DATE :07-07-83

RUN :II

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	120.10	120.10	0.00000
29.000	95.800	73.569	22.231
45.000	75.200	44.392	30.808
61.000	51.800	23.756	28.044
75.000	27.600	12.495	15.105
87.000	3.2000	6.8125	-3.6125
106.00	0.80000	2.4433	-1.6433

KINETIC CONSTANTS

MONOD MODEL

K1= 71.159 + 0.00 mg/l

K2= 244.217 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 7.1052

Table 70

The Regression of the Phenol Concentration Versus Time to Fit the Monod Model in the Media LLMO Run I

SUBSTRATE :PHENOL
MEDIA :LLMO
CONCENTRATION:100 PPM NOMINAL
DATE :09-26-83
RUN :I
TEMPERATURE :25 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	87.800	87.800	0.00000
44.000	86.900	84.660	2.2401
74.000	86.200	82.087	4.1126
104.00	80.300	79.489	0.81119
134.00	72.100	76.862	-4.7615
164.00	68.300	74.202	-5.9025
194.00	63.300	71.508	-8.2080
224.00	59.700	68.774	-9.0737
254.00	56.500	65.994	-9.4944
284.00	54.300	63.163	-8.8635
314.00	52.500	60.273	-7.7729
344.00	49.500	57.312	-7.8120
374.00	47.300	54.267	-6.9673
404.00	43.700	51.120	-7.4199
434.00	39.600	47.843	-8.2433
464.00	37.200	44.397	-7.1973
494.00	32.400	40.717	-8.3168
524.00	28.100	36.681	-8.5815
647.00	12.000	12.356	-0.35573
712.00	4.1000	31.660	-27.560

KINETIC CONSTANTS

MONOD MODEL

K1= -19.900 + 0.00 mg/l

K2= 3.917 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 2.0284

Table 71

The Regression of the Phenol Concentration Versus Time to Fit the Monod Model in the Media LLMD Run II

SUBSTRATE :PHENOL
MEDIA :LLMD
CONCENTRATION:100 PPM NOMINAL
DATE :09-27-83
RUN :II
TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	101.00	101.00	0.00000
44.000	98.500	95.955	2.5452
72.000	90.900	92.023	-1.1235
114.00	86.700	86.113	0.58713
132.00	86.000	83.574	2.4257
165.00	79.500	78.911	0.58934
193.00	75.900	74.943	0.95703
221.00	68.700	70.964	-2.2642
300.00	57.600	59.666	-2.0659
313.00	55.600	57.794	-2.1943
343.00	51.300	53.459	-2.1586
372.00	47.000	49.242	-2.2423
403.00	42.200	44.702	-2.5019
439.00	36.700	39.375	-2.6751
463.00	34.500	35.783	-1.2827
525.00	24.300	26.272	-1.9720
567.00	16.200	19.498	-3.2984
584.00	13.000	16.609	-3.6088
613.00	7.9000	11.247	-3.3467
643.00	2.5000	8.5887	-6.0887
671.00	0.10000	0.38079	-0.28079

KINETIC CONSTANTS

MONOD MODEL

K1= -3.723 + 0.00 mg/l

K2= 8.091 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.54364

Table 72

The Regression of the Phenol Concentration Versus Time to Fit the Monod Model in the Media LLMO Run III

SUBSTRATE :PHENOL
MEDIA :LLMO
CONCENTRATION:100 PPM NOMINAL
DATE :09-28-83
RUN :III
TEMPERATURE :29 C

TIME (MIN)	PPMEXP	PPMCAL	DY
17.000	94.700	94.700	0.00000
57.000	96.700	92.879	3.8210
82.000	89.100	91.734	-2.6339
111.00	84.900	90.399	-5.4986
144.00	81.100	88.870	-7.7695
176.00	76.700	87.376	-10.676
203.00	70.800	86.108	-15.308
245.00	65.600	84.120	-18.520
257.00	61.000	83.548	-22.548
291.00	51.700	81.918	-30.218
323.00	47.400	80.370	-32.970
351.00	42.400	79.003	-36.603
385.00	36.400	77.329	-40.929
413.00	29.400	75.937	-46.537
440.00	23.600	4.9868	18.613
469.00	16.900	5.2239	11.676
505.00	8.3000	5.5383	2.7617
524.00	3.7000	5.7140	-2.0140
621.00	0.10000	6.7336	-6.6336

KINETIC CONSTANTS

MONOD MODEL

K1= -25.727 + 0.00 mg/l

K2= 1.982 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 5.0017

Table 73

The Regression of the Phenol Concentration Versus Time to Fit the Monod Model in the Media Livingston/BI-CHEM Run I

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:100 PPM NOMINAL

DATE :07-26-83

RUN :I

TEMPERATURE :25 C

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	96.000	96.000	0.00000
29.000	63.800	48.264	15.536
44.000	29.400	21.330	8.0704
60.000	3.0000	5.0663	-2.0663
71.000	1.1000	1.3437	-0.24374

KINETIC CONSTANTS

MONOD MODEL

K1= 22.009 + 0.00 mg/l

K2= 179.629 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 3.5260

Table 74

The Regression of the Phenol Concentration Versus Time to Fit the Monod Model in the Media Livingston/BI-CHEM Run II

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:100 PPM NOMINAL

DATE :07-26-83

RUN :II

TEMPERATURE :25 C

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	95.200	95.200	0.00000
27.000	65.000	17.891	47.109
40.000	31.500	9.9337	21.566
59.000	2.2000	4.5060	-2.3060
71.000	2.1000	2.7879	-0.68786
86.000	1.7000	1.5453	0.15468

KINETIC CONSTANTS

MONOD MODEL

K1= -89.366 + 0.00 mg/l

K2= -205.949 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 8.6445

Table 75

The Regression of the Phenol Concentration Versus Time to Fit the Monod Model in the Media Livingston/BI-CHEM Run III

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:100 PPM NOMINAL

DATE :07-27-83

RUN :III

TEMPERATURE :25 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	112.40	112.40	0.00000
22.000	83.400	59.825	23.575
32.000	44.600	32.959	11.641
41.000	20.000	16.374	3.6261
51.000	3.2000	6.2915	-3.0915
62.000	1.8000	1.9025	-0.10253

KINETIC CONSTANTS

MONOD MODEL

K1= 46.577 + 0.00 mg/l

K2= 327.796 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 4.4535

Table 76

The Regression of the Phenol Concentration Versus Time to Fit the Monod Model in the Media Livingston/Hydrobac Run I

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:100 PPM NOMINAL

DATE :07-29-83

RUN :I

TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	84.700	84.700	0.00000
26.000	60.700	48.357	12.343
35.000	43.200	31.202	11.998
45.000	20.100	15.387	4.7126
56.000	2.7000	4.5368	-1.8368
65.000	0.60000	1.1510	-0.55101

KINETIC CONSTANTS

MONOD MODEL

K1= 14.751 + 0.00 mg/l

K2= 157.452 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 2.9917

Table 77

The Regression of the Phenol Concentration Versus Time to Fit the Monod Model in the Media Livingston/Hydrobac Run II

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:100 PPM NOMINAL

DATE :07-29-83

RUN :II

TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	91.400	91.400	0.00000
27.000	71.900	104.58	-32.676
36.000	53.500	110.78	-57.278
46.000	26.300	7.3257	18.974
67.000	1.9000	5.5672	-3.6672

KINETIC CONSTANTS

MONOD MODEL

K1= -39.690 + 0.00 mg/l

K2= -26.103 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 13.743

Table 78

The Regression of the Phenol Concentration Versus Time to Fit the Monod Model in the Media Livingston/Hydrobac Run III

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:100 PPM NOMINAL

DATE :08-02-83

RUN :III

TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	107.00	107.00	0.00000
26.000	84.700	49.221	35.479
33.000	62.500	32.573	29.927
39.000	46.000	21.837	24.163
46.000	30.600	13.045	17.555
53.000	15.300	7.4725	7.8275
64.000	0.20000	2.9463	-2.7463

KINETIC CONSTANTS

MONOD MODEL

K1= 76.733 + 0.00 mg/l

K2= 414.219 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 7.9734

Table 79

The Regression of the Phenol Concentration Versus Time to Fit the Monod Model in the Media Livingston/LLMO Run I

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:100 PPM NOMINAL

DATE :08-23-83

RUN :I

TEMPERATURE :NONE

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	71.700	71.700	0.00000
17.000	65.400	60.050	5.3500
21.000	59.900	55.757	4.1429
26.000	51.000	50.335	0.66476
31.000	43.200	44.835	-1.6352
36.000	34.600	39.232	-4.6315
41.000	25.400	33.482	-8.0825
46.000	18.000	27.513	-9.5126
51.000	11.600	21.156	-9.5564
57.000	0.10000	2.2119	-2.1119

KINETIC CONSTANTS

MONOD MODEL

K1= -5.825 + 0.00 mg/l

K2= 57.912 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 1.7943

Table 80

The Regression of the Phenol Concentration Versus Time to Fit the Monod Model in the Media Livingston/LLMO Run II

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:100 PPM NOMINAL

DATE :08-23-83

RUN :II

TEMPERATURE :NONE

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	77.100	77.100	0.00000
19.000	72.100	66.140	5.9599
26.000	59.600	60.113	-0.51262
32.000	50.100	54.852	-4.7525
40.000	36.700	47.660	-10.960
45.000	26.000	43.024	-17.024
51.000	18.300	37.256	-18.956
59.000	8.0000	1.7447	6.2553
65.000	0.10000	3.1737	-3.0737

KINETIC CONSTANTS

MONOD MODEL

K1= -9.696 + 0.00 mg/l

K2= 43.723 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 3.2890

Table 81

The Regression of the Phenol Concentration Versus Time to Fit the Monod Model in the Media Livingston/LLMO Run III

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:100 PPM NOMINAL

DATE :08-23-83

RUN :III

TEMPERATURE :NONE

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	85.700	85.700	0.00000
22.000	70.700	66.137	4.5631
29.000	59.300	56.228	3.0724
36.000	43.900	46.184	-2.2837
44.000	33.000	34.437	-1.4372
51.000	17.200	23.703	-6.5034
56.000	0.10000	0.32412	-0.22412

KINETIC CONSTANTS

MONOD MODEL

K1= -3.903 + 0.00 mg/l

K2= 79.507 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 1.2769

Table 82

The Regression of the Phenol Concentration Versus Time to Fit the Haldane Model in the Media Hydrobac Run I

SUBSTRATE :PHENOL

MEDIA :HYDROBAC

CONCENTRATION:100 PPM NOMINAL

DATE :06-17-83

RUN :I

TEMPERATURE :33 C

TIME (MIN)	PPMEXP	PPMCAL	DY
10.000	80.900	68.552	12.348
77.000	56.400	59.166	-2.7663
109.00	36.400	53.969	-17.569
142.00	18.700	5.7179	12.982
167.00	4.3000	8.0856	-3.7856
200.00	1.1000	14.272	-13.172

KINETIC CONSTANTS

HALDANE MODEL

K1= 60.712 + 0.00 mg/l

K2= 41.779 + 0.00 mg/l.hr

K3= -0.039 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 4.7876

Table 83

The Regression of the Phenol Concentration Versus Time to Fit the Haldane Model in the Media Hydrobac Run II

SUBSTRATE :PHENOL

MEDIA :HYDROBAC

CONCENTRATION:100 PPM NOMINAL

DATE :06-17-83

RUN :II

TEMPERATURE :33 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	103.70	81.259	22.441
50.000	90.000	77.486	12.514
74.000	82.400	75.244	7.1556
112.00	76.400	71.641	4.7590
134.00	72.300	69.521	2.7792
167.00	58.300	66.288	-7.9877
194.00	52.000	63.589	-11.589
229.00	35.200	60.009	-24.809
258.00	24.700	56.958	-32.258
285.00	4.4000	3.7104	0.68964
318.00	0.60000	4.3713	-3.7713

KINETIC CONSTANTS

HALDANE MODEL

K1= 19.198 + 0.00 mg/l

K2= 4.517 + 0.00 mg/l.hr

K3= -0.000 + 0.00 1/mg

THE ABSOLUTE AVERAGE RESIDUAL = 4.6449

Table 84

The Regression of the Phenol Concentration Versus Time to Fit the Haldane Model in the Media BI-CHEM Run I

SUBSTRATE :PHENOL

MEDIA :BI-CHEM

CONCENTRATION:100 PPM NOMINAL

DATE :06-17-83

RUN :I

TEMPERATURE :33 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	74.900	68.216	6.6836
44.000	58.400	63.406	-5.0060
75.000	2.2000	3.9567	-1.7567
103.00	0.40000	6.4500	-6.0500

KINETIC CONSTANTS

HALDANE MODEL

K1= -17.084 + 0.00 mg/l

K2= -21.594 + 0.00 mg/l.hr

K3= 0.029 + 0.00 1/mg

THE ABSOLUTE AVERAGE RESIDUAL = 2.6151

Table 85

The Regression of the Phenol Concentration Versus Time to Fit the Haldane Model in the Media BI-CHEM Run II

SUBSTRATE :PHENOL

MEDIA :BI-CHEM

CONCENTRATION:100 PPM NOMINAL

DATE :06-17-83

RUN :II

TEMPERATURE :33 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	99.400	83.655	15.745
49.000	69.000	72.960	-3.9595
73.000	44.700	65.660	-20.960
112.00	17.500	7.9119	9.5881
135.00	1.2000	14.002	-12.802

KINETIC CONSTANTS

HALDANE MODEL

K1= 41.787 + 0.00 mg/l

K2= 41.609 + 0.00 mg/l.hr

K3= -0.014 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 6.1925

Table 86

The Regression of the Phenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston Run I

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON

CONCENTRATION:100 PPM NOMINAL

DATE :07-07-83

RUN :I

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	87.100	70.050	17.050
29.000	71.000	63.451	7.5493
46.000	53.600	57.738	-4.1385
60.000	32.100	52.926	-20.826
75.000	10.900	3.3035	7.5965
91.000	1.9000	4.3565	-2.4565

KINETIC CONSTANTS

HALDANE MODEL

K1= 15.737 + 0.00 mg/l

K2= 12.411 + 0.00 mg/l.hr

K3= 0.001 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 4.8941

Table 87

The Regression of the Phenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston Run II

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON

CONCENTRATION:100 PPM NOMINAL

DATE :07-07-83

RUN :II

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	120.10	97.569	22.531
29.000	95.800	90.047	5.7531
45.000	75.200	83.558	-8.3577
61.000	51.800	76.515	-24.715
75.000	27.600	69.733	-42.133
87.000	3.2000	7.0326	-3.8326
106.00	0.80000	11.837	-11.037

KINETIC CONSTANTS

HALDANE MODEL

K1= 42.368 + 0.00 mg/l

K2= 51.825 + 0.00 mg/l.hr

K3= -0.009 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 7.9964

Table 88

The Regression of the Phenol Concentration Versus Time to Fit the Haldane Model in the Media LLMO Run I

SUBSTRATE :PHENOL
MEDIA :LLMO
CONCENTRATION:100 PPM NOMINAL
DATE :09-26-83
RUN :I
TEMPERATURE :25 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	87.800	68.449	19.351
44.000	86.900	67.016	19.884
74.000	86.200	65.857	20.343
104.00	80.300	64.701	15.599
134.00	72.100	63.548	8.5522
164.00	68.300	62.396	5.9039
194.00	63.300	61.246	2.0539
224.00	59.700	60.097	-0.39734
254.00	56.500	58.950	-2.4495
284.00	54.300	57.802	-3.5022
314.00	52.500	56.655	-4.1550
344.00	49.500	55.507	-6.0075
374.00	47.300	54.359	-7.0592
404.00	43.700	53.210	-9.5096
434.00	39.600	52.058	-12.458
464.00	37.200	50.905	-13.705
494.00	32.400	49.748	-17.348
524.00	28.100	48.587	-20.487
647.00	12.000	3.1382	8.8618
712.00	4.1000	3.5418	0.55820

KINETIC CONSTANTS

HALDANE MODEL

K1= 13.898 + 0.00 mg/l

K2= 1.185 + 0.00 mg/l.hr

K3= 0.002 + 0.00 1/mg

THE ABSOLUTE AVERAGE RESIDUAL = 2.6897

Table 89

The Regression of the Phenol Concentration Versus Time to Fit the Haldane Model in the Media LLMO Run II

SUBSTRATE :PHENOL
MEDIA :LLMO
CONCENTRATION:100 PPM NOMINAL
DATE :09-27-83
RUN :II
TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	101.00	81.038	19.962
44.000	98.500	79.068	19.432
72.000	90.900	77.509	13.391
114.00	86.700	75.123	11.577
132.00	86.000	74.083	11.917
165.00	79.500	72.144	7.3561
193.00	75.900	70.466	5.4343
221.00	68.700	68.755	-0.54581E-01
300.00	57.600	63.724	-6.1243
313.00	55.600	62.864	-7.2641
343.00	51.300	60.839	-9.5390
372.00	47.000	58.823	-11.823
403.00	42.200	56.597	-14.397
439.00	36.700	53.904	-17.204
463.00	34.500	52.033	-17.533
525.00	24.300	46.846	-22.546
567.00	16.200	8.0065	8.1935
584.00	13.000	8.6795	4.3205
613.00	7.9000	10.065	-2.1648
643.00	2.5000	11.990	-9.4896
671.00	0.10000	14.732	-14.632

KINETIC CONSTANTS

HALDANE MODEL

K1= 26.176 + 0.00 mg/l

K2= 4.881 + 0.00 mg/l.hr

K3= -0.005 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 2.7561

Table 90

The Regression of the Phenol Concentration Versus Time to Fit the Haldane Model in the Media LLMO Run III

SUBSTRATE :PHENOL
MEDIA :LLMO
CONCENTRATION:100 PPM NOMINAL
DATE :09-28-83
RUN :III
TEMPERATURE :29 C

TIME (MIN)	PPMEXP	PPMCAL	DY
17.000	94.700	78.307	16.393
57.000	96.700	75.928	20.772
82.000	89.100	74.412	14.688
111.00	84.900	72.625	12.275
144.00	81.100	70.549	10.551
176.00	76.700	68.491	8.2090
203.00	70.800	66.716	4.0839
245.00	65.600	63.878	1.7219
257.00	61.000	63.048	-2.0485
291.00	51.700	60.648	-8.9476
323.00	47.400	58.313	-10.913
351.00	42.400	56.202	-13.802
385.00	36.400	53.539	-17.139
413.00	29.400	51.251	-21.851
440.00	23.600	48.948	-25.348
469.00	16.900	6.1647	10.735
505.00	8.3000	7.2966	1.0034
524.00	3.7000	8.0214	-4.3214
621.00	0.10000	15.490	-15.390

KINETIC CONSTANTS

HALDANE MODEL

K1= 24.678 + 0.00 mg/l

K2= 4.931 + 0.00 mg/l.hr

K3= -0.005 + 0.00 1/mg

THE ABSOLUTE AVERAGE RESIDUAL = 3.0889

Table 91

The Regression of the Phenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston/BI-CHEM Run I

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:100 PPM NOMINAL

DATE :07-26-83

RUN :I

TEMPERATURE :25 C

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	96.000	83.086	12.914
29.000	63.800	74.538	-10.738
44.000	29.400	5.3892	24.011
60.000	3.0000	9.9232	-6.9232
71.000	1.1000	15.556	-14.456

KINETIC CONSTANTS

HALDANE MODEL

K1= -50.452 + 0.00 mg/l

K2= -121.569 + 0.00 mg/l.hr

K3= 0.042 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 6.6798

Table 92

The Regression of the Phenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston/BI-CHEM Run II

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:100 PPM NOMINAL

DATE :07-26-83

RUN :II

TEMPERATURE :25 C

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	95.200	85.257	9.9428
27.000	65.000	80.268	-15.268
40.000	31.500	11.966	19.534
59.000	2.2000	18.143	-15.943
71.000	2.1000	22.819	-20.719
86.000	1.7000	30.589	-28.889

KINETIC CONSTANTS

HALDANE MODEL

K1= 1.044 + 0.00 mg/l

K2= -11.714 + 0.00 mg/l.hr

K3= 0.011 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 7.8732

Table 93

The Regression of the Phenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston/BI-CHEM Run III

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:100 PPM NOMINAL

DATE :07-27-83

RUN :III

TEMPERATURE :25 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	112.40	94.032	18.368
22.000	83.400	84.033	-0.63330
32.000	44.600	76.646	-32.046
41.000	20.000	4.9556	15.044
51.000	3.2000	7.6290	-4.4290
62.000	1.8000	13.353	-11.553

KINETIC CONSTANTS

HALDANE MODEL

K1= 42.336 + 0.00 mg/l

K2= 91.552 + 0.00 mg/l.hr

K3= -0.010 + 0.00 1/mg

THE ABSOLUTE AVERAGE RESIDUAL = 6.9604

Table 94

The Regression of the Phenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston/Hydrobac Run I

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:100 PPM NOMINAL

DATE :07-29-83

RUN :I

TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	84.700	69.621	15.079
26.000	60.700	62.493	-1.7927
35.000	43.200	58.228	-15.028
45.000	20.100	5.6415	14.458
56.000	2.7000	8.9088	-6.2088
65.000	0.60000	13.720	-13.120

KINETIC CONSTANTS

HALDANE MODEL

K1= 680.015 + 0.00 mg/l

K2= 1538.554 + 0.00 mg/l.hr

K3= -0.533 + 0.00 1/mg

THE ABSOLUTE AVERAGE RESIDUAL = 4.9333

Table 95

The Regression of the Phenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston/Hydrobac Run II

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:100 PPM NOMINAL

DATE :07-29-83

RUN :II

TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	91.400	73.615	17.785
27.000	71.900	66.375	5.5248
36.000	53.500	62.670	-9.1700
46.000	26.300	58.466	-32.166
67.000	1.9000	3.6862	-1.7862

KINETIC CONSTANTS

HALDANE MODEL

K1= 17.171 + 0.00 mg/l

K2= 16.765 + 0.00 mg/l.hr

K3= 0.000 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 7.6649

Table 96

The Regression of the Phenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston/Hydrobac Run III

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:100 PPM NOMINAL

DATE :08-02-83

RUN :III

TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
9.0000	107.00	84.276	22.724
26.000	84.700	72.913	11.787
33.000	62.500	67.485	-4.9851
39.000	46.000	62.287	-16.287
46.000	30.600	55.236	-24.636
53.000	15.300	14.935	0.36514
64.000	0.20000	10.124	-9.9241

KINETIC CONSTANTS

HALDANE MODEL

K1= 160.904 + 0.00 mg/l

K2= 455.646 + 0.00 mg/l.hr

K3= -0.079 + 0.00 1/mg

THE ABSOLUTE AVERAGE RESIDUAL = 5.8046

Table 97

The Regression of the Phenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston/LLMO Run I

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:100 PPM NOMINAL

DATE :08-23-83

RUN :I

TEMPERATURE :NONE

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	71.700	57.036	14.664
17.000	65.400	52.008	13.392
21.000	59.900	50.046	9.8545
26.000	51.000	47.467	3.5333
31.000	43.200	44.718	-1.5176
36.000	34.600	41.751	-7.1510
41.000	25.400	38.491	-13.091
46.000	18.000	34.800	-16.800
51.000	11.600	9.1582	2.4418
57.000	0.10000	15.139	-15.039

KINETIC CONSTANTS

HALDANE MODEL

K1= 30.521 + 0.00 mg/l

K2= 66.938 + 0.00 mg/l.hr

K3= -0.018 + 0.00 1/mg

THE ABSOLUTE AVERAGE RESIDUAL = 3.5259

Table 98

The Regression of the Phenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston/LLMO Run II

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:100 PPM NOMINAL

DATE :08-23-83

RUN :II

TEMPERATURE :NONE

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	77.100	63.356	13.744
19.000	72.100	57.449	14.651
26.000	59.600	53.913	5.6869
32.000	50.100	50.608	-0.50778
40.000	36.700	45.642	-8.9423
45.000	26.000	42.052	-16.052
51.000	18.300	10.424	7.8756
59.000	8.0000	22.213	-14.213
65.000	0.10000	29.822	-29.722

KINETIC CONSTANTS

HALDANE MODEL

K1= 133.350 + 0.00 mg/l

K2= 340.976 + 0.00 mg/l.hr

K3= -0.114 + 0.00 1/mg

THE ABSOLUTE AVERAGE RESIDUAL = 4.8702

Table 99

The Regression of the Phenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston/LLMO Run III

SUBSTRATE :PHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:100 PPM NOMINAL

DATE :08-23-83

RUN :III

TEMPERATURE :NONE

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	85.700	67.420	18.280
22.000	70.700	59.511	11.189
29.000	59.300	54.978	4.3218
36.000	43.900	49.840	-5.9397
44.000	33.000	42.702	-9.7017
51.000	17.200	15.097	2.1030
56.000	0.10000	0.49882	-0.39882

KINETIC CONSTANTS

HALDANE MODEL

K1= 132.441 + 0.00 mg/l

K2= 379.254 + 0.00 mg/l.hr

K3= -0.097 + 0.00 1/mg

THE ABSOLUTE AVERAGE RESIDUAL = 3.5341

Table 100

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media Hydrobac Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :06-22-83

RUN :I

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	15.500	13.334	-2.1664
39.000	8.9000	10.063	1.1625
70.000	5.2000	6.9896	1.7896
96.000	3.8000	4.4124	0.61239
126.00	1.4000	1.4386	0.38644E-01
154.00	0.10000	-1.3369	--.4369

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 13.928 + 1.97 mg/l

K2= -5.947 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.92691

THE ABSOLUTE AVERAGE RESIDUAL = 0.56981

Table 101

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media Hydrobac Run II

SUBSTRATE :O-CHLOROPHENOL

MEDIA :HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :06-22-83

RUN :II

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	21.100	20.294	-0.80598
41.000	19.900	20.029	0.12907
68.000	20.300	19.812	-0.48772
96.000	18.400	19.587	1.1875
126.00	18.500	19.347	0.84660
157.00	19.200	19.098	-0.10228
185.00	18.300	18.873	0.57289
279.00	19.900	18.118	-1.7818
353.00	17.600	17.524	-0.75974E-01
435.00	16.700	16.866	0.16566
499.00	16.000	16.352	0.35181

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 20.358 + 0.59 mg/l

K2= -0.482 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.72353

THE ABSOLUTE AVERAGE RESIDUAL = 0.23534

Table 102

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media Hydrobac Run III

SUBSTRATE :O-CHLOROPHENOL

MEDIA :HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :06-23-83

RUN :III

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	15.000	11.665	-3.3352
36.000	7.4000	10.688	3.2883
65.000	9.1000	9.7117	0.61173
97.000	9.1000	8.6342	-0.46582
140.00	7.6000	7.1862	-0.41378
161.00	6.3000	6.4791	0.17908
186.00	5.2000	5.6372	0.43724
216.00	4.4000	4.6270	0.22703
244.00	3.4000	3.6842	0.28418
279.00	2.6000	2.5056	-0.94398E-01
303.00	2.0000	1.6974	-0.30256
342.00	0.80000	0.38417	-0.41583

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 11.901 + 0.99 mg/l

K2= -2.020 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.86223

THE ABSOLUTE AVERAGE RESIDUAL = 0.40249

Table 103

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media Hydrobac Run IV

SUBSTRATE :O-CHLOROPHENOL

MEDIA :HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :06-24-83

RUN :IV

TEMPERATURE :24

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	18.400	15.217	-3.1825
37.000	16.800	14.259	-2.5411
67.000	11.600	13.267	1.6672
96.000	11.800	12.309	0.50864
133.00	10.100	11.086	0.98559
156.00	6.7000	10.325	3.6253
186.00	8.6000	9.3337	0.73366
216.00	7.7000	8.3420	0.64201
246.00	6.8000	7.3504	0.55035
276.00	6.1000	6.3587	0.25869
307.00	5.5000	5.3340	-0.16602
337.00	4.5000	4.3423	-0.15768
366.00	4.8000	3.3837	-1.4163
396.00	3.9000	2.3921	-1.5079

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 15.482 + 1.06 mg/l

K2= -1.983 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.84910

THE ABSOLUTE AVERAGE RESIDUAL = 0.44830

Table 104

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media BI-CHEM Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :06-22-83

RUN :I

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	15.600	13.917	-1.6833
39.000	3.2000	6.5667	3.3667
70.000	0.90000	-0.78332	-1.6833

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 15.813 +31.15 mg/l

K2= -14.226 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.86404

THE ABSOLUTE AVERAGE RESIDUAL = 1.3744

Table 105

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media BI-CHEM Run II

SUBSTRATE :O-CHLOROPHENOL

MEDIA :BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :06-22-83

RUN :II

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	19.900	19.151	-0.74908
42.000	18.400	18.807	0.40715
68.000	21.000	18.544	-2.4557
96.000	9.6000	18.261	8.6611
126.00	21.000	17.958	-3.0422
157.00	21.000	17.644	-3.3556
185.00	17.500	17.361	-0.13875
279.00	16.600	16.411	-0.18921
353.00	15.000	15.663	0.66258
436.00	14.500	14.823	0.32336
500.00	14.300	14.176	-0.12376

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 19.232 + 2.32 mg/l

K2= -0.607 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.21322

THE ABSOLUTE AVERAGE RESIDUAL = 0.92219

Table 106

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media BI-CHEM Run III

SUBSTRATE :O-CHLOROPHENOL

MEDIA :BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :06-23-83

RUN :III

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	13.900	12.553	-1.3474
36.000	12.600	10.536	-2.0643
66.000	5.6000	8.4492	2.8492
98.000	4.0000	6.2236	2.2236
140.00	2.7000	3.3025	0.60247
163.00	2.4000	1.7028	-0.69718
187.00	1.6000	0.33616E-01	-1.5664

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 13.039 + 2.08 mg/l

K2= -4.173 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.85356

THE ABSOLUTE AVERAGE RESIDUAL = 0.67675

Table 107

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media BI-CHEM Run IV

SUBSTRATE :O-CHLOROPHENOL

MEDIA :BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :06-24-83

RUN :IV

TEMPERATURE :24 C

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	15.600	12.799	-2.8011
38.000	9.7000	10.896	1.1960
67.000	7.9000	9.0565	1.1565
97.000	6.2000	7.1536	0.95360
134.00	3.7000	4.8067	1.1067
156.00	3.2000	3.4112	0.21121
185.00	2.2000	1.5717	-0.62827
216.00	0.80000	-0.39461	-1.1946

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 13.306 + 1.37 mg/l

K2= -3.806 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.91083

THE ABSOLUTE AVERAGE RESIDUAL = 0.47786

Table 108

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON

CONCENTRATION:20 PPM NOMINAL

DATE :07-13-83

RUN :I

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	24.300	20.606	-3.6938
22.000	18.400	17.972	-0.42839
36.000	14.600	15.666	1.0663
53.000	10.500	12.867	2.3670
82.000	5.3000	8.0918	2.7918
97.000	3.9000	5.6218	1.7218
112.00	2.8000	3.1519	0.35189
127.00	2.0000	0.68193	-1.3181
140.00	1.4000	-1.4587	-2.8587

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 21.594 + 1.95 mg/l

K2= -9.880 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.92347

THE ABSOLUTE AVERAGE RESIDUAL = 0.71457

Table 109

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston Run II

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON

CONCENTRATION:20 PPM NOMINAL

DATE :07-14-83

RUN :II

TEMPERATURE :UNKNOWN

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	22.300	19.892	-2.4082
21.000	16.100	16.893	0.79256
38.000	12.200	12.971	0.77052
54.000	8.0000	9.2792	1.2792
66.000	4.9000	6.5107	1.6107
85.000	2.0000	2.1272	0.12723
98.000	1.3000	-0.87198	-2.1720

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 21.737 + 1.78 mg/l

K2= -13.843 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.95579

THE ABSOLUTE AVERAGE RESIDUAL = 0.57117

Table 110

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston Run III

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON

CONCENTRATION:20 PPM NOMINAL

DATE :07-15-83

RUN :III

TEMPERATURE :28 C

TIME (MIN)	PPMEXP	PPMCAL	DY
5.0000	20.900	20.065	-0.83488
22.000	17.500	17.625	0.12534
35.000	14.300	15.760	1.4596
55.000	13.400	12.889	-0.51071
65.000	11.500	11.454	-0.45876E-01
80.000	9.3000	9.3014	0.13762E-02
96.000	7.2000	7.0051	-0.19489

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 20.783 + 0.79 mg/l

K2= -8.611 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.97631

THE ABSOLUTE AVERAGE RESIDUAL = 0.25331

Table 111

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media LLMO Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :03-01-84

RUN :I

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	22.800	19.380	-3.4201
37.000	18.300	19.144	0.84389
73.000	18.400	18.861	0.46065
126.00	16.300	18.444	2.1436
159.00	17.200	18.184	0.98401
188.00	20.500	17.956	-2.5442
243.00	15.800	17.523	1.7231
304.00	15.700	17.043	1.3432
370.00	16.500	16.524	0.23880E-01
423.00	14.900	16.107	1.2069
483.00	18.400	15.635	-2.7652

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 19.435 + 1.42 mg/l

K2= -0.472 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.29027

THE ABSOLUTE AVERAGE RESIDUAL = 0.56432

Table 112

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media LLMO Run II

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :03-02-84

RUN :II

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	15.500	15.218	-0.28236
84.000	14.200	14.728	0.52841
129.00	14.000	14.442	0.44249
160.00	14.400	14.246	-0.15447
252.00	14.400	13.661	-0.73901
300.00	14.400	13.356	-1 440
363.00	12.400	12.956	0.55573
420.00	10.800	12.594	1.7936
482.00	13.300	12.200	-1.1004

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 15.262 + 0.79 mg/l

K2= -0.381 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.54595

THE ABSOLUTE AVERAGE RESIDUAL = 0.29294

Table 113

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media LLMO Run III

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :03-04-84

RUN :III

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	17.400	16.281	-1.1194
63.000	16.100	16.501	0.40073
148.00	17.000	16.829	-0.17097
244.00	16.400	17.200	0.79984
302.00	16.400	17.424	1.0238
363.00	17.000	17.659	0.65945
423.00	18.400	17.891	-0.50879
481.00	19.200	18.115	-1 848

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 16.257 + 0.79 mg/l

K2= 0.232 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.37801

THE ABSOLUTE AVERAGE RESIDUAL = 0.27955

Table 114

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston/BI-CHEM Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :07-28-83

RUN :I

TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	19.700	18.960	-0.74001
15.000	15.600	16.018	0.41758
25.000	11.900	12.340	0.43957
35.000	8.6000	8.6616	0.61555E-01
45.000	4.6000	4.9836	0.38355
56.000	1.5000	0.93773	-0.56227

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 21.535 + 0.70 mg/l

K2= -22.068 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.99404

THE ABSOLUTE AVERAGE RESIDUAL = 0.19595

Table 115

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston/BI-CHEM Run III

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :07-29-83

RUN :III

TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
5.0000	17.700	18.476	0.77617
11.000	15.800	15.199	-0.60097
17.000	12.300	11.922	-0.37811
23.000	8.8000	8.6447	-0.15525
29.000	5.4000	5.3676	-0.32395E-01
35.000	1.7000	2.0905	0.39047

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 21.207 + 0.70 mg/l

K2= -32.771 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.99321

THE ABSOLUTE AVERAGE RESIDUAL = 0.18887

Table 116

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston/BI-CHEM Run IV

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :08-12-83

RUN :IV

TEMPERATURE :24 C

TIME (MIN)	PPMEXP	PPMCAL	DY
5.0000	22.700	23.243	0.54343
11.000	20.500	20.307	-0.19254
16.000	19.200	17.861	-1.3392
22.000	15.000	14.925	-0.75147E-01
28.000	11.600	11.989	0.38888
34.000	8.4000	9.0529	0.65292
40.000	5.2000	6.1169	0.91694
45.000	3.4000	3.6703	0.27030
51.000	1.9000	0.73433	-1.1657

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 25.690 + 0.71 mg/l

K2= -29.360 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.98968

THE ABSOLUTE AVERAGE RESIDUAL = 0.24799

Table 117

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston/Hydrobac Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :08-03-83

RUN :I

TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	18.400	15.361	-3.0386
14.000	15.900	14.263	-1.6369
20.000	13.900	13.322	-0.57831
26.000	13.100	12.380	-0.71973
31.000	11.100	11.596	0.49576
38.000	10.200	10.497	0.29743
45.000	7.7000	9.3991	1.6991
52.000	6.2000	8.3008	2.1008
58.000	5.0000	7.3594	2.3594
65.000	4.2000	6.2610	2.0610
72.000	3.8000	5.1627	1.3627
75.000	3.7000	4.6920	0.99200
86.000	2.7000	2.9661	0.26607
95.000	2.2000	1.5539	-0.64606
103.00	2.4000	0.29872	-2.1013
112.00	1.8000	-1.1134	-2.9134

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 16.460 + 1.00 mg/l

K2= -9.414 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.89402

THE ABSOLUTE AVERAGE RESIDUAL = 0.42595

Table 118

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston/Hydrobac Run I A

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :08-16-83

RUN :I A

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	18.300	17.706	-0.59412
11.000	14.700	14.831	0.13053
16.000	11.500	11.955	0.45517
24.000	6.9000	7.3546	0.45460
36.000	0.90000	0.45374	-0.44626

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 21.156 + 0.88 mg/l

K2= -34.504 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.99467

THE ABSOLUTE AVERAGE RESIDUAL = 0.19829

Table 119

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston/Hydrobac Run II A

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :08-16-83

RUN :II A

TEMPERATURE :25 C

TIME (MIN)	PPMEXP	PPMCAL	DY
4.0000	18.900	18.912	0.12466E-01
10.000	17.500	16.657	-0.84256
16.000	14.800	14.402	-0.39756
21.000	12.700	12.523	-0.17673
25.000	10.500	11.020	0.51993
30.000	8.4000	9.1408	0.74075
35.000	6.7000	7.2616	0.56158
39.000	4.8000	5.7582	0.95823
44.000	3.7000	3.8791	0.17907
50.000	2.2000	1.6241	-0.57595
54.000	1.1000	0.12071	-0.97929

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 20.416 + 0.50 mg/l

K2= -22.550 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.98873

THE ABSOLUTE AVERAGE RESIDUAL = 0.18796

Table 120

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston/Hydrobac Run III A

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :08-16-83

RUN :III A

TEMPERATURE :25 C

TIME (MIN)	PPMEXP	PPMCAL	DY
5.0000	21.800	21.023	-0.77660
10.000	20.900	20.607	-0.29335
17.000	20.000	20.023	0.23178E-01
23.000	19.600	19.523	-0.76950E-01
30.000	19.400	18.940	-0.46040
37.000	15.900	18.356	2.4561
43.000	16.800	17.856	1.0560
49.000	17.400	17.356	-0.44098E-01
55.000	17.900	16.856	-1 442
64.000	17.000	16.106	-0.89441
70.000	15.500	15.605	0.10549
76.000	15.000	15.105	0.10537
83.000	14.700	14.522	-0.17810
89.000	14.000	14.022	0.21781E-01

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 21.440 + 0.55 mg/l

K2= -5.001 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.87190

THE ABSOLUTE AVERAGE RESIDUAL = 0.22590

Table 121

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston/LLMO Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :08-24-83

RUN :I

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
5.0000	22.400	22.094	-0.30573
13.000	13.500	14.132	0.63221
22.000	5.6000	5.1749	-0.42510
27.000	0.10000	0.19859	0.98593E-01

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 27.071 + 1.40 mg/l

K2= -59.716 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.99758

THE ABSOLUTE AVERAGE RESIDUAL = 0.20670

Table 122

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston/LLMO Run II

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :08-24-83

RUN :II

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	16.000	16.111	0.11147
14.000	11.300	11.326	0.26225E-01
23.000	5.6000	5.1738	-0.42623
30.000	0.10000	0.38853	0.28853

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 20.897 + 0.89 mg/l

K2= -41.016 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.99805

THE ABSOLUTE AVERAGE RESIDUAL = 0.13182

Table 123

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Zero Order Model in the Media Livingston/LLMO Run III

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :08-24-83

RUN :III

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
5.0000	16.300	17.126	0.82587
11.000	13.600	12.526	-1 737
15.000	9.1000	9.4600	0.35995
21.000	5.9000	4.8604	-1 396
26.000	0.10000	1.0274	0.92744

KINETIC CONSTANTS

ZERO ORDER MODEL

K1= 20.959 + 1.84 mg/l

K2= -45.996 + 0.00 mg/l.hr

THE CORRELATION COEFFICIENT = 0.97608

THE ABSOLUTE AVERAGE RESIDUAL = 0.39524

Table 124

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media Hydrobac Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :06-22-83

RUN :I

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	15.500	15.500	0.95367E-06
45.000	8.9000	9.8099	-0.90986
76.000	5.2000	5.7505	-0.55054
102.00	3.8000	2.9464	0.85364
132.00	1.4000	0.88458	0.51542
160.00	0.10000	0.18352	-0.83517E-01

KINETIC CONSTANTS

MONOD MODEL

K1= 2.720 + 0.00 mg/l

K2= 10.668 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.24337

Table 125

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media Hydrobac Run II

SUBSTRATE :O-CHLOROPHENOL

MEDIA :HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :06-22-83

RUN :II

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	21.100	21.100	0.00000
49.000	19.900	21.339	-1.4391
76.000	20.300	21.480	-1.1796
104.00	18.400	18.024	0.37616
134.00	18.500	17.904	0.59578
165.00	19.200	21.882	-2.6822
193.00	18.300	17.691	0.60909
287.00	19.900	22.342	-2.4417
361.00	17.600	17.188	0.41225
443.00	16.700	16.979	-0.27905
507.00	16.000	16.828	-0.82791

KINETIC CONSTANTS

MONOD MODEL

K1= -19.765 + 0.00 mg/l

K2= -0.024 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.39016

Table 126

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media Hydrobac Run III

SUBSTRATE :O-CHLOROPHENOL

MEDIA :HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :06-23-83

RUN :III

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	15.000	15.000	0.19073E-05
43.000	7.4000	11.434	-4.0340
72.000	9.1000	9.2982	-0.19822
104.00	9.1000	7.4641	1.6359
147.00	7.6000	5.6111	1.9889
168.00	6.3000	4.8961	1.4039
193.00	5.2000	4.1713	1.0287
223.00	4.4000	3.4500	0.95001
251.00	3.4000	2.8953	0.50471
286.00	2.6000	2.3304	0.26957
310.00	2.0000	2.0104	-0.10366E-01
349.00	0.80000	1.5837	-0.78369

KINETIC CONSTANTS

MONOD MODEL

K1= -61.899 + 0.00 mg/l

K2= -22.062 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.43952

Table 127

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media Hydrobac Run IV

SUBSTRATE :O-CHLOROPHENOL

MEDIA :HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :06-24-83

RUN :IV

TEMPERATURE :24

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	18.400	18.400	0.00000
45.000	16.800	13.653	3.1469
75.000	11.600	11.755	-0.15498
104.00	11.800	10.409	1.3905
141.00	10.100	9.0777	1.0223
164.00	6.7000	8.3943	-1.6943
194.00	8.6000	7.6228	0.97725
224.00	7.7000	6.9567	0.74327
254.00	6.8000	6.3739	0.42607
284.00	6.1000	5.8586	0.24138
315.00	5.5000	5.3848	0.11523
345.00	4.5000	4.9739	-0.47395
374.00	4.8000	4.6150	0.18505
404.00	3.9000	4.2777	-0.37772

KINETIC CONSTANTS

MONOD MODEL

K1= -21.148 + 0.00 mg/l

K2= -2.535 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.30253

Table 128

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media BI-CHEM Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :06-22-83

RUN :I

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	15.600	15.600	0.95367E-06
47.000	3.2000	3.2000	0.34332E-04
78.000	0.90000	0.90001	-0.56624E-05

KINETIC CONSTANTS

MONOD MODEL

K1= 811.466 + 0.00 mg/l

K2= 1996.718 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.11603E-04

Table 129

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media BI-CHEM Run II

SUBSTRATE :O-CHLOROPHENOL

MEDIA :BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :06-22-83

RUN :II

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	19.900	19.900	0.00000
50.000	18.400	19.646	-1.2460
76.000	21.000	19.484	1.5160
104.00	9.6000	10.682	-1 822
134.00	21.000	19.107	1.8929
165.00	21.000	18.896	2.1044
193.00	17.500	18.697	-1.1975
287.00	16.600	17.968	-1.3684
361.00	15.000	17.289	-2.2894
444.00	14.500	16.288	-1.7879
508.00	14.300	14.048	0.25176

KINETIC CONSTANTS

MONOD MODEL

K1= -14.571 + 0.00 mg/l

K2= 0.095 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.45310

Table 130

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media BI-CHEM Run III

SUBSTRATE :O-CHLORDPHENOL

MEDIA :BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :06-23-83

RUN :III

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	13.900	13.900	0.00000
43.000	12.600	7.4535	5.1465
73.000	5.6000	5.3283	0.27171
105.00	4.0000	3.9073	0.92651E-01
147.00	2.7000	2.6991	0.91743E-03
170.00	2.4000	2.2280	0.17200
194.00	1.6000	1.8340	-0.23395

KINETIC CONSTANTS

MONOD MODEL

K1= -17.676 + 0.00 mg/l

K2= -7.616 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.73753

Table 131

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media BI-CHEM Run IV

SUBSTRATE :O-CHLOROPHENOL

MEDIA :BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :06-24-83

RUN :IV

TEMPERATURE :24 C

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	15.600	15.600	0.95367E-06
46.000	9.7000	11.038	-1.3382
75.000	7.9000	8.1766	-0.27664
105.00	6.2000	5.7956	0.40436
142.00	3.7000	3.6255	0.74537E-01
164.00	3.2000	2.6873	0.51273
193.00	2.2000	1.7768	0.42324
224.00	0.80000	1.1208	-0.32079

KINETIC CONSTANTS

MONOD MODEL

K1= 17.167 + 0.00 mg/l

K2= 16.579 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.20083

Table 132

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media Livingston Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON

CONCENTRATION:20 PPM NOMINAL

DATE :07-13-83

RUN :I

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	24.300	24.300	0.00000
28.000	18.400	17.624	0.77565
42.000	14.600	13.998	0.60152
59.000	10.500	10.284	0.21613
88.000	5.3000	5.6587	-0.35872
103.00	3.9000	4.0252	-0.12523
118.00	2.8000	2.8134	-0.13400E-01
133.00	2.0000	1.9389	0.61054E-01
146.00	1.4000	1.3920	0.80061E-02

KINETIC CONSTANTS

MONOD MODEL

K1= 23.994 + 0.00 mg/l

K2= 39.225 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.11959

Table 133

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media Livingston Run II

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON

CONCENTRATION:20 PPM NOMINAL

DATE :07-14-83

RUN :II

TEMPERATURE :UNKNOWN

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	22.300	22.300	0.00000
29.000	16.100	16.048	0.51743E-01
46.000	12.200	11.418	0.78243
62.000	8.0000	7.5783	0.42166
74.000	4.9000	5.1532	-0.25322
93.000	2.0000	2.3433	-0.34326
106.00	1.3000	1.1958	0.10424

KINETIC CONSTANTS

MONOD MODEL

K1= 5.804 + 0.00 mg/l

K2= 23.317 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.14182

Table 134

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media Livingston Run III

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON

CONCENTRATION:20 PPM NOMINAL

DATE :07-15-83

RUN :III

TEMPERATURE :28 C

TIME (MIN)	PPMEXP	PPMCAL	DY
5.0000	20.900	20.900	0.00000
27.000	17.500	16.120	1.3799
40.000	14.300	14.096	0.20413
60.000	13.400	11.654	1.7464
70.000	11.500	10.652	0.84779
85.000	9.3000	9.3552	-0.55229E-01
101.00	7.2000	8.1878	-0.98782

KINETIC CONSTANTS

MONOD MODEL

K1= -41.549 + 0.00 mg/l

K2= -16.390 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.36959

Table 135

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media LLMO Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :03-01-84

RUN :I

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	22.800	22.800	0.00000
44.000	18.300	16.368	1.9318
80.000	18.400	16.366	2.0340
133.00	16.300	16.363	-0.62820E-01
166.00	17.200	16.361	0.83917
195.00	20.500	22.814	-2.3142
250.00	15.800	16.356	-0.55571
311.00	15.700	16.352	-0.65205
377.00	16.500	16.348	0.15190
430.00	14.900	16.345	-1.4449
490.00	18.400	16.341	2.0587

KINETIC CONSTANTS

MONOD MODEL

K1= -19.408 + 0.00 mg/l

K2= -0.001 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.41675

Table 136

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media LLMO Run II

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :03-02-84

RUN :II

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	15.500	15.500	-0.28610E-05
91.000	14.200	15.221	-1 213
136.00	14.000	15.061	-1 609
167.00	14.400	14.945	-0.54487
259.00	14.400	14.565	-0.16526
307.00	14.400	14.338	0.62301E-01
370.00	12.400	13.987	-1.5870
427.00	10.800	11.868	-1 677
489.00	13.300	12.573	0.72681

KINETIC CONSTANTS

MONOD MODEL

K1= -12.699 + 0.00 mg/l

K2= 0.034 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.28725

Table 137

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media LLMO Run III

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :03-04-84

RUN :III

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	17.400	17.400	0.00000
69.000	16.100	16.939	-0.83911
154.00	17.000	18.160	-1.1595
250.00	16.400	16.488	-0.87936E-01
308.00	16.400	16.386	0.14145E-01
369.00	17.000	18.590	-1.5904
429.00	18.400	18.686	-0.28606
487.00	19.200	18.773	0.42746

KINETIC CONSTANTS

MONOD MODEL

K1= -17.414 + 0.00 mg/l

K2= -0.006 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.27529

Table 138

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media Livingston/BI-CHEM Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :07-28-83

RUN :I

TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	19.700	19.700	0.00000
22.000	15.600	15.573	0.26657E-01
32.000	11.900	12.705	-0.80530
42.000	8.6000	9.6617	-1 617
52.000	4.6000	6.1904	-1.5904
63.000	1.5000	2.0865	-0.58650

KINETIC CONSTANTS

MONOD MODEL

K1= -2.497 + 0.00 mg/l

K2= 14.159 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.35939

Table 139

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media Livingston/BI-CHEM Run III

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :07-29-83

RUN :III

TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
5.0000	17.700	17.700	0.00000
16.000	15.800	14.461	1.3386
22.000	12.300	12.572	-0.27206
28.000	8.8000	10.529	-1.7287
34.000	5.4000	8.1718	-2.7718
40.000	1.7000	5.2084	-3.5084

KINETIC CONSTANTS

MONOD MODEL

K1= -4.123 + 0.00 mg/l

K2= 13.121 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.83077

Table 140

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media Livingston/BI-CHEM Run IV

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :08-12-83

RUN :IV

TEMPERATURE :24 C

TIME (MIN)	PPMEXP	PPMCAL	DY
5.0000	22.700	22.700	0.00000
16.000	20.500	20.251	0.24879
21.000	19.200	19.088	0.11166
27.000	15.000	17.637	-2.6373
33.000	11.600	16.105	-4.5052
39.000	8.4000	14.455	-6.0547
45.000	5.2000	3.2044	1.9956
50.000	3.4000	4.0425	-0.64254
56.000	1.9000	7.7005	-5.8005

KINETIC CONSTANTS

MONOD MODEL

K1= -6.865 + 0.00 mg/l

K2= 9.083 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 1.1223

Table 141

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media Livingston/Hydrobac Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :08-03-83

RUN :I

TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	18.400	18.400	0.00000
21.000	15.900	13.708	2.1920
27.000	13.900	12.085	1.8154
33.000	13.100	10.654	2.4460
38.000	11.100	9.5925	1.5075
45.000	10.200	8.2821	1.9179
52.000	7.7000	7.1511	0.54887
59.000	6.2000	6.1748	0.25151E-01
65.000	5.0000	5.4450	-0.44499
72.000	4.2000	4.7020	-0.50197
79.000	3.8000	4.0604	-0.26044
82.000	3.7000	3.8131	-0.11306
93.000	2.7000	3.0283	-0.32825
102.00	2.2000	2.5080	-0.30798
110.00	2.4000	2.1211	0.27890
119.00	1.8000	1.7568	0.43244E-01

KINETIC CONSTANTS

MONOD MODEL

K1=-3422.828 + 0.00 mg/l

K2=-4298.125 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.28742

Table 142

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media Livingston/Hydrobac Run I A

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :08-16-83

RUN :I A

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	18.300	18.300	0.00000
17.000	14.700	14.147	0.55326
22.000	11.500	12.187	-0.68708
30.000	6.9000	8.8762	-1.9762
42.000	0.90000	1.3978	-0.49780

KINETIC CONSTANTS

MONOD MODEL

K1= -2.237 + 0.00 mg/l

K2= 19.513 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.44412

Table 143

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media Livingston/Hydrobac Run II A

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :08-16-83

RUN :II A

TEMPERATURE :25 C

TIME (MIN)	PPMEXP	PPMCAL	DY
4.0000	18.900	18.900	0.00000
14.000	17.500	20.915	-3.4150
20.000	14.800	22.021	-7.2212
25.000	12.700	22.901	-10.201
29.000	10.500	4.0872	6.4128
34.000	8.4000	3.8414	4.5586
39.000	6.7000	3.6175	3.0825
43.000	4.8000	3.4520	1.3480
48.000	3.7000	3.2602	0.43978
54.000	2.2000	3.0494	-0.84935
58.000	1.1000	2.9191	-1.8191

KINETIC CONSTANTS

MONOD MODEL

K1= -11.123 + 0.00 mg/l

K2= -5.329 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 1.4239

Table 144

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media Livingston/Hydrobac Run III A

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :08-16-83

RUN :III A

TEMPERATURE :25 C

TIME (MIN)	PPMEXP	PPMCAL	DY
5.0000	21.800	21.800	0.00000
15.000	20.900	21.837	-0.93729
22.000	20.000	21.863	-1.8632
28.000	19.600	21.885	-2.2852
35.000	19.400	21.911	-2.5108
42.000	15.900	15.689	0.21075
48.000	16.800	15.672	1.1280
54.000	17.400	15.655	1.7451
60.000	17.900	22.001	-4.1007
69.000	17.000	15.612	1.3876
75.000	15.500	15.596	-0.95654E-01
81.000	15.000	15.579	-0.57903
88.000	14.700	15.560	-0.85968
94.000	14.000	15.543	-1.5433

KINETIC CONSTANTS

MONOD MODEL

K1= -18.639 + 0.00 mg/l

K2= -0.033 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.46535

Table 145

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media Livingston/LLMO Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :08-24-83

RUN :I

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
5.0000	22.400	22.400	0.00000
18.000	13.500	13.028	0.47246
27.000	5.6000	6.2822	-0.68221
32.000	0.10000	1.9981	-1.8981

KINETIC CONSTANTS

MONOD MODEL

K1= -0.725 + 0.00 mg/l

K2= 41.444 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.51789

Table 146

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media Livingston/LLMO Run II

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :08-24-83

RUN :II

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	16.000	16.000	0.00000
21.000	11.300	10.545	0.75499
30.000	5.6000	6.8563	-1.2563
37.000	0.10000	0.16112	-0.61121E-01

KINETIC CONSTANTS

MONOD MODEL

K1= -1.120 + 0.00 mg/l

K2= 21.377 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.36674

Table 147

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Monod Model in the Media Livingston/LLMO Run III

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :08-24-83

RUN :III

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
5.0000	16.300	16.300	0.00000
16.000	13.600	11.953	1.6473
20.000	9.1000	10.316	-1.2163
26.000	5.9000	7.7580	-1.8580
31.000	0.10000	0.21469	-0.11469

KINETIC CONSTANTS

MONOD MODEL

K1= -1.615 + 0.00 mg/l

K2= 20.979 + 0.00 mg/l.hr

THE ABSOLUTE AVERAGE RESIDUAL = 0.55347

Table 148

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media Hydrobac Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :06-22-83

RUN :I

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	15.500	13.950	1.5501
45.000	8.9000	12.334	-3.4344
76.000	5.2000	4.6761	0.52392
102.00	3.8000	0.12963	3.6704
132.00	1.4000	0.64748E-01	1.3353
160.00	0.10000	0.34818E-01	0.65182E-01

KINETIC CONSTANTS

HALDANE MODEL

K1= 1.094 + 0.00 mg/l

K2= -1.390 + 0.00 mg/l.hr

K3= 0.056 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 0.90878

Table 149

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media Hydrobac Run II

SUBSTRATE :O-CHLOROPHENOL

MEDIA :HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :06-22-83

RUN :II

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	21.100	18.967	2.1325
49.000	19.900	18.930	0.96974
76.000	20.300	18.906	1.3943
104.00	18.400	18.880	-0.48022
134.00	18.500	18.853	-0.35292
165.00	19.200	18.825	0.37531
193.00	18.300	18.799	-0.49921
287.00	19.900	18.713	1.1866
361.00	17.600	18.646	-1 457
443.00	16.700	18.571	-1.8707
507.00	16.000	18.512	-2.5120

KINETIC CONSTANTS

HALDANE MODEL

K1= 6.246 + 0.00 mg/l

K2= 0.033 + 0.00 mg/l.hr

K3= 0.002 + 0.00 1/mg

THE ABSOLUTE AVERAGE RESIDUAL = 0.41149

Table 150

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media Hydrobac Run III

SUBSTRATE :O-CHLOROPHENOL

MEDIA :HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :06-23-83

RUN :III

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	15.000	11.262	3.7380
43.000	7.4000	10.761	-3.3611
72.000	9.1000	10.331	-1.2313
104.00	9.1000	9.8229	-0.72287
147.00	7.6000	9.0630	-1.4630
168.00	6.3000	8.6472	-2.3472
193.00	5.2000	8.0948	-2.8948
223.00	4.4000	3.1549	1.2451
251.00	3.4000	3.9892	-0.58921
286.00	2.6000	5.5986	-2.9986
310.00	2.0000	4.0671	-2.0671
349.00	0.80000	4.2573	-3.4573

KINETIC CONSTANTS

HALDANE MODEL

K1= 14.377 + 0.00 mg/l

K2= 3.106 + 0.00 mg/l.hr

K3= -0.183 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 0.69947

Table 151

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media Hydrobac Run IV

SUBSTRATE :O-CHLOROPHENOL

MEDIA :HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :06-24-83

RUN :IV

TEMPERATURE :24

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	18.400	13.347	5.0528
45.000	16.800	12.788	4.0116
75.000	11.600	12.329	-0.72924
104.00	11.800	11.879	-0.78734E-01
141.00	10.100	11.292	-1.1921
164.00	6.7000	10.919	-4.2191
194.00	8.6000	10.421	-1.8206
224.00	7.7000	9.9047	-2.2047
254.00	6.8000	9.3660	-2.5660
284.00	6.1000	8.7958	-2.6958
315.00	5.5000	8.1578	-2.6578
345.00	4.5000	7.4626	-2.9626
374.00	4.8000	6.6412	-1.8412
404.00	3.9000	7.0161	-3.1161

KINETIC CONSTANTS

HALDANE MODEL

K1= 4.601 + 0.00 mg/l

K2= 0.391 + 0.00 mg/l.hr

K3= 0.008 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 0.75711

Table 152

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media BI-CHEM Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :06-22-83

RUN :I

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	15.600	15.162	0.43757
47.000	3.2000	2.0782	1.1218
78.000	0.90000	3.9736	-3.0736

KINETIC CONSTANTS

HALDANE MODEL

K1= -0.477 + 0.00 mg/l

K2= -2.712 + 0.00 mg/l.hr

K3= 0.070 + 0.00 1/mg

THE ABSOLUTE AVERAGE RESIDUAL = 1.1003

Table 153

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media BI-CHEM Run II

SUBSTRATE :O-CHLOROPHENOL

MEDIA :BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :06-22-83

RUN :II

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	19.900	18.489	1.4115
50.000	18.400	18.307	0.92926E-01
76.000	21.000	18.194	2.8057
104.00	9.6000	18.073	-8.4726
134.00	21.000	17.942	3.0583
165.00	21.000	17.806	3.1940
193.00	17.500	17.683	-0.18311
287.00	16.600	17.267	-0.66734
361.00	15.000	16.937	-1.9366
444.00	14.500	16.562	-2.0616
508.00	14.300	16.269	-1.9694

KINETIC CONSTANTS

HALDANE MODEL

K1= 6.101 + 0.00 mg/l

K2= 0.153 + 0.00 mg/l.hr

K3= 0.002 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 0.96881

Table 154

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media BI-CHEM Run III

SUBSTRATE :O-CHLOROPHENOL

MEDIA :BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :06-23-83

RUN :III

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	13.900	12.472	1.4280
43.000	12.600	11.667	0.93272
73.000	5.6000	10.950	-5.3496
105.00	4.0000	2.0060	1.9940
147.00	2.7000	2.5420	0.15797
170.00	2.4000	2.9648	-0.56478
194.00	1.6000	3.6371	-2.0371

KINETIC CONSTANTS

HALDANE MODEL

K1= 6.059 + 0.00 mg/l

K2= 1.224 + 0.00 mg/l.hr

K3= -0.017 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 0.90347

Table 155

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media BI-CHEM Run IV

SUBSTRATE :O-CHLOROPHENOL

MEDIA :BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :06-24-83

RUN :IV

TEMPERATURE :24 C

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	15.600	13.039	2.5607
46.000	9.7000	12.146	-2.4465
75.000	7.9000	11.367	-3.4671
105.00	6.2000	10.419	-4.2186
142.00	3.7000	3.8455	-0.14546
164.00	3.2000	5.6493	-2.4493
193.00	2.2000	1.6069	0.59306
224.00	0.80000	15.879	-15.079

KINETIC CONSTANTS

HALDANE MODEL

K1= -1.966 + 0.00 mg/l

K2= -2.089 + 0.00 mg/l.hr

K3= 0.105 + 0.00 1/mg

THE ABSOLUTE AVERAGE RESIDUAL = 2.0771

Table 156

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON

CONCENTRATION:20 PPM NOMINAL

DATE :07-13-83

RUN :I

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	24.300	20.083	4.2173
28.000	18.400	18.980	-0.58003
42.000	14.600	18.229	-3.6288
59.000	10.500	17.251	-6.7512
88.000	5.3000	2.8528	2.4472
103.00	3.9000	3.4757	0.42432
118.00	2.8000	4.3285	-1.5285
133.00	2.0000	5.6958	-3.6958
146.00	1.4000	9.3935	-7.9935

KINETIC CONSTANTS

HALDANE MODEL

K1= 43.614 + 0.00 mg/l

K2= 27.742 + 0.00 mg/l.hr

K3= -0.268 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 1.4183

Table 157

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston Run II

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON

CONCENTRATION:20 PPM NOMINAL

DATE :07-14-83

RUN :II

TEMPERATURE :UNKNOWN

TIME (MIN)	PPMEXP	PPMCAL	DY
8.0000	22.300	18.129	4.1708
29.000	16.100	16.756	-0.65550
46.000	12.200	15.548	-3.3481
62.000	8.0000	14.303	-6.3033
74.000	4.9000	2.7148	2.1852
93.000	2.0000	3.6287	-1.6287
106.00	1.3000	4.7172	-3.4172

KINETIC CONSTANTS

HALDANE MODEL

K1= 9.109 + 0.00 mg/l

K2= 5.037 + 0.00 mg/l.hr

K3= -0.023 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 1.3391

Table 158

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston Run III

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON

CONCENTRATION:20 PPM NOMINAL

DATE :07-15-83

RUN :III

TEMPERATURE :28 C

TIME (MIN)	PPMEXP	PPMCAL	DY
5.0000	20.900	16.105	4.7945
27.000	17.500	15.275	2.2246
40.000	14.300	14.779	-0.47858
60.000	13.400	14.002	-0.60218
70.000	11.500	13.607	-2.1073
85.000	9.3000	13.004	-3.7045
101.00	7.2000	12.344	-5.1443

KINETIC CONSTANTS

HALDANE MODEL

K1= 5.214 + 0.00 mg/l

K2= 1.045 + 0.00 mg/l.hr

K3= 0.007 + 0.00 1/mg

THE ABSOLUTE AVERAGE RESIDUAL = 1.2219

Table 159

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media LLMO Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :03-01-84

RUN :I

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	22.800	18.346	4.4541
44.000	18.300	18.264	0.36011E-01
80.000	18.400	18.184	0.21582
133.00	16.300	18.066	-1.7664
166.00	17.200	17.993	-0.79282
195.00	20.500	17.928	2.5719
250.00	15.800	17.805	-2.0050
311.00	15.700	17.668	-1.9680
377.00	16.500	17.519	-1 191
430.00	14.900	17.399	-2.4992
490.00	18.400	17.263	1.1372

KINETIC CONSTANTS

HALDANE MODEL

K1= 6.142 + 0.00 mg/l

K2= 0.081 + 0.00 mg/l.hr

K3= 0.001 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 0.62139

Table 160

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media LLMO Run II

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :03-02-84

RUN :II

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	15.500	13.970	1.5303
91.000	14.200	13.910	0.29048
136.00	14.000	13.877	0.12278
167.00	14.400	13.855	0.54506
259.00	14.400	13.789	0.61129
307.00	14.400	13.754	0.64592
370.00	12.400	13.709	-1.3086
427.00	10.800	13.667	-2.8673
489.00	13.300	13.622	-0.32235

KINETIC CONSTANTS

HALDANE MODEL

K1= 5.163 + 0.00 mg/l

K2= 0.025 + 0.00 mg/l.hr

K3= 0.002 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 0.40926

Table 161

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media LLMO Run III

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :03-04-84

RUN :III

TEMPERATURE :23 C

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	17.400	17.372	0.28275E-01
69.000	16.100	17.348	-1.2477
154.00	17.000	17.315	-0.31514
250.00	16.400	17.278	-0.87839
308.00	16.400	17.256	-0.85614
369.00	17.000	17.233	-0.23273
429.00	18.400	17.210	1.1903
487.00	19.200	17.187	2.0126

KINETIC CONSTANTS

HALDANE MODEL

K1= 6.177 + 0.00 mg/l

K2= 0.015 + 0.00 mg/l.hr

K3= -0.001 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 0.36833

Table 162

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston/BI-CHEM Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :07-28-83

RUN :I

TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	19.700	15.777	3.9234
22.000	15.600	14.623	0.97663
32.000	11.900	13.827	-1.9269
42.000	8.6000	13.001	-4.4011
52.000	4.6000	2.1829	2.4171
63.000	1.5000	2.5140	-1 140

KINETIC CONSTANTS

HALDANE MODEL

K1= 5.540 + 0.00 mg/l

K2= 2.489 + 0.00 mg/l.hr

K3= 0.003 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 1.1341

Table 163

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston/BI-CHEM Run III

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :07-29-83

RUN :III

TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
5.0000	17.700	14.648	3.0517
16.000	15.800	13.702	2.0979
22.000	12.300	13.174	-0.87355
28.000	8.8000	12.634	-3.8338
34.000	5.4000	12.080	-6.6804
40.000	1.7000	2.0737	-0.37365

KINETIC CONSTANTS

HALDANE MODEL

K1= 5.090 + 0.00 mg/l

K2= 2.494 + 0.00 mg/l.hr

K3= 0.006 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 1.4332

Table 164

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston/BI-CHEM Run IV

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/BI-CHEM

CONCENTRATION:20 PPM NOMINAL

DATE :08-12-83

RUN :IV

TEMPERATURE :24 C

TIME (MIN)	PPMEXP	PPMCAL	DY
5.0000	22.700	18.391	4.3092
16.000	20.500	17.238	3.2624
21.000	19.200	16.707	2.4929
27.000	15.000	16.064	-1 638
33.000	11.600	15.411	-3.8114
39.000	8.4000	14.747	-6.3474
45.000	5.2000	2.1198	3.0802
50.000	3.4000	2.2694	1.1306
56.000	1.9000	2.4728	-0.57282

KINETIC CONSTANTS

HALDANE MODEL

K1= 5.686 + 0.00 mg/l

K2= 2.907 + 0.00 mg/l.hr

K3= 0.006 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 1.1247

Table 165

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston/Hydrobac Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :08-03-83

RUN :I

TEMPERATURE :26 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	18.400	13.824	4.5761
21.000	15.900	13.148	2.7520
27.000	13.900	12.852	1.0477
33.000	13.100	12.552	0.54760
38.000	11.100	12.299	-1.1989
45.000	10.200	11.938	-1.7381
52.000	7.7000	11.569	-3.8694
59.000	6.2000	11.191	-4.9915
65.000	5.0000	10.859	-5.8591
72.000	4.2000	2.2198	1.9802
79.000	3.8000	2.3659	1.4341
82.000	3.7000	2.4340	1.2660
93.000	2.7000	2.7193	-0.19314E-01
102.00	2.2000	3.0104	-0.81042
110.00	2.4000	3.3401	-0.94008
119.00	1.8000	3.8686	-2.0686

KINETIC CONSTANTS

HALDANE MODEL

K1= 5.104 + 0.00 mg/l

K2= 1.555 + 0.00 mg/l.hr

K3= 0.003 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 0.69030

Table 166

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston/Hydrobac Run I A

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :08-16-83

RUN :I A

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
6.0000	18.300	15.104	3.1956
17.000	14.700	14.101	0.59874
22.000	11.500	13.623	-2.1231
30.000	6.9000	12.822	-5.9218
42.000	0.90000	2.3630	-1.4630

KINETIC CONSTANTS

HALDANE MODEL

K1= 6.621 + 0.00 mg/l

K2= 4.674 + 0.00 mg/l.hr

K3= -0.011 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 1.4462

Table 167

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston/Hydrobac Run II A

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :08-16-83

RUN :II A

TEMPERATURE :25 C

TIME (MIN)	PPMEXP	PPMCAL	DY
4.0000	18.900	15.086	3.8145
14.000	17.500	14.235	3.2651
20.000	14.800	13.709	1.0905
25.000	12.700	13.261	-0.56132
29.000	10.500	12.895	-2.3950
34.000	8.4000	12.426	-4.0260
39.000	6.7000	11.943	-5.2426
43.000	4.8000	2.1874	2.6126
48.000	3.7000	2.3610	1.3390
54.000	2.2000	2.6034	-0.40342
58.000	1.1000	2.7923	-1.6923

KINETIC CONSTANTS

HALDANE MODEL

K1= 5.532 + 0.00 mg/l

K2= 2.998 + 0.00 mg/l.hr

K3= 0.001 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 0.85179

Table 168

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston/Hydrobac Run III A

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/HYDROBAC

CONCENTRATION:20 PPM NOMINAL

DATE :08-16-83

RUN :III A

TEMPERATURE :25 C

TIME (MIN)	PPMEXP	PPMCAL	DY
5.0000	21.800	18.213	3.5873
15.000	20.900	18.109	2.7907
22.000	20.000	18.037	1.9633
28.000	19.600	17.974	1.6256
35.000	19.400	17.902	1.4984
42.000	15.900	17.829	-1.9286
48.000	16.800	17.766	-0.96606
54.000	17.400	17.703	-0.30333
60.000	17.900	17.641	0.25948
69.000	17.000	17.546	-0.54614
75.000	15.500	17.483	-1.9830
81.000	15.000	17.420	-2.4199
88.000	14.700	17.346	-2.6461
94.000	14.000	17.283	-3.2827

KINETIC CONSTANTS

HALDANE MODEL

K1= 6.016 + 0.00 mg/l

K2= 0.362 + 0.00 mg/l.hr

K3= 0.002 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 0.56277

Table 169

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston/LLMO Run I

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :08-24-83

RUN :I

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
5.0000	22.400	19.221	3.1792
18.000	13.500	12.669	0.83103
27.000	5.6000	0.10444E-03	5.5999
32.000	0.10000	0.10218E-03	0.99898E-01

KINETIC CONSTANTS

HALDANE MODEL

K1= 0.490 + 0.00 mg/l

K2= -14.042 + 0.00 mg/l.hr

K3= 0.045 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 1.6234

Table 170

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston/LLMO Run II

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :08-24-83

RUN :II

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
7.0000	16.000	13.017	2.9828
21.000	11.300	0.28253	11.017
30.000	5.6000	0.31454	5.2855
37.000	0.10000	20.469	-20.369

KINETIC CONSTANTS

HALDANE MODEL

K1= 0.024 + 0.00 mg/l

K2= -11.304 + 0.00 mg/l.hr

K3= 0.069 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 5.9850

Table 171

The Regression of the O-Chlorophenol Concentration Versus Time to Fit the Haldane Model in the Media Livingston/LLMO Run III

SUBSTRATE :O-CHLOROPHENOL

MEDIA :LIVINGSTON/LLMO

CONCENTRATION:20 PPM NOMINAL

DATE :08-24-83

RUN :III

TEMPERATURE :27 C

TIME (MIN)	PPMEXP	PPMCAL	DY
5.0000	16.300	13.227	3.0730
16.000	13.600	9.1192	4.4808
20.000	9.1000	21.451	-12.351
26.000	5.9000	3829.5	-3823.6
31.000	0.10000	0.43741	-0.33741

KINETIC CONSTANTS

HALDANE MODEL

K1= -1.675 + 0.00 mg/l

K2= -19.723 + 0.00 mg/l.hr

K3= 0.091 + 0.00 l/mg

THE ABSOLUTE AVERAGE RESIDUAL = 764.72

Table 172

A Summary of the Kinetic constants for the Zero Order Model in the Degradation of Phenol

MEDIA	RUN	KO	K1	CORR
HYDROBAC	I	85.0609	28.6320	0.9788
HYDROBAC	II	109.1305	20.7047	0.9787
BICHEM	I	84.1777	-59.0620	0.8999
BICHEM	II	103.3216	-49.9663	0.9919
LIVINGSTON	I	96.2463	72.6517	0.9880
LIVINGSTON	II	126.6060	85.7668	0.9705
LLMO	I	89.2289	7.1550	0.9902
LLMO	II	103.4146	9.3575	0.9987
LLMO	III	102.8971	11.0160	0.9882

CORR=correlation coefficient

Table 173

A Summary of the Kinetic constants for the Monod Model in the Degradation of Phenol

MEDIA	RUN	KO	K1	AAR
HYDROBAC	I	47.8513	75.7659	4.547
HYDROBAC	II	-8.0667	14.8158	2.089
BI-CHEM	I	-23.1650	-19.1865	8.021
BI-CHEM	II	4.3394	54.0735	0.960
LIVINGSTON	I	-30.4328	1.7149	10.634
LIVINGSTON	II	71.1587	244.2172	7.105
LLMO	I	-19.8996	3.9169	2.028
LLMO	II	-3.7234	8.0906	0.544
LLMO	III	-25.7271	1.9822	5.002

AAR=Absoloute Average Residual

Table 174

A Summary of the Kinetic constants for the Haldane Model in the Degradation of Phenol

MEDIA	RUN	K1	K2	K3	AAR
HYDROBAC	I	60.7115	41.7795	-0.0385	4.788
HYDROBAC	II	19.1975	4.5168	-0.0004	4.645
BI-CHEM	I	-17.0839	-21.5941	0.0295	2.615
BI-CHEM	II	41.7874	41.6086	-0.0136	6.192
LIVINGSTON	I	15.7371	12.4107	0.0010	4.894
LIVINGSTON	II	42.3677	51.8255	-0.0093	7.996
LLMO	I	13.8976	1.1848	0.0021	2.690
LLMO	II	26.1763	4.8805	-0.0051	2.756
LLMO	III	24.6779	4.9314	-0.0046	3.089

AAR=Absoloute Average Residual

Table 175

A Summary of the Kinetic constants for the Zero Order Model in the Degradation of Phenol in Mixtures of Preperations

MEDIA	RUN	K0	K1	CORR
LIVINGSTON/BI-CHEM	I	103.0646	-107.3410	0.9542
LIVINGSTON/BI-CHEM	II	90.0092	-79.3100	0.8731
LIVINGSTON/BI-CHEM	III	116.4374	-144.4084	0.9131
LIVINGSTON/HYDROBAC	I	93.7203	-110.0487	0.9574
LIVINGSTON/HYDROBAC	II	104.4813	-111.7073	0.9743
LIVINGSTON/HYDROBAC	III	122.7212	-142.4302	0.9804
LIVINGSTON/LLMO	I	82.8365	-96.5753	0.9986
LIVINGSTON/LLMO	II	88.9869	-92.1117	0.9944
LIVINGSTON/LLMO	III	101.1946	-120.7463	0.9905

CORR=Correlation coefficient

Table 176

A Summary of the Kinetic constants for the Monod Model in the Degradation of Phenol in Mixtures of Preperations

MEDIA	RUN	K1	K2	AAR
LIVINGSTON/BI-CHEM	I	22.0091	179.6293	3.526
LIVINGSTON/BI-CHEM	II	-89.3657	-205.9492	8.644
LIVINGSTON/BI-CHEM	III	46.5771	327.7961	4.454
LIVINGSTON/HYDROBAC	I	14.7509	157.4521	2.992
LIVINGSTON/HYDROBAC	II	-39.6898	-26.1035	13.743
LIVINGSTON/HYDROBAC	III	76.7333	414.2195	7.973
LIVINGSTON/LLMO	I	-5.8249	57.9120	1.794
LIVINGSTON/LLMO	II	-9.6961	43.7225	3.289
LIVINGSTON/LLMO	III	-3.9032	79.5070	1.277

Table 177

A Summary of the Kinetic constants for the Haldane Model

in the Degradation of Phenol in Mixtures of Preperations

MEDIA	RUN	K1	K2	K3	AAR
LIVINGSTON/BI-CHEM	I	-50.4516	-121.5686	0.0420	6.680
LIVINGSTON/BI-CHEM	II	1.0441	-11.7145	0.0109	7.873
LIVINGSTON/BI-CHEM	III	42.3361	91.5520	-0.0099	6.960
LIVINGSTON/HYDROBAC	I	680.0154	1538.5537	-0.5333	4.933
LIVINGSTON/HYDROBAC	II	17.1713	16.7652	0.0004	7.665
LIVINGSTON/HYDROBAC	III	160.9037	455.6460	-0.0790	5.805
LIVINGSTON/LLMO	I	30.5215	66.9378	-0.0183	3.526
LIVINGSTON/LLMO	II	133.3504	340.9756	-0.1136	4.870
LIVINGSTON/LLMO	III	132.4413	379.2539	-0.0967	3.534

Table 178

A Summary of the Kinetic constants for the Zero Order Model in the Degradation of O-Chlorophenol

MEDIA	RUN	KO	K1	CORR
HYDROBAC	I	13.9284	-5.9475	0.9269
HYDROBAC	II	20.3583	-0.4817	0.7235
HYDROBAC	III	11.9005	-2.0204	0.8622
HYDROBAC	IV	15.4819	-1.9833	0.8491
BI-CHEM	I	15.8134	-14.2258	0.8640
BI-CHEM	II	19.2318	-0.6067	0.2132
BI-CHEM	III	13.0395	-4.1730	0.8536
BI-CHEM	IV	13.3063	-3.8058	0.9108
LIVINGSTON	I	21.5942	-9.8798	0.9235
LIVINGSTON	II	21.7374	-13.8425	0.9558
LIVINGSTON	III	20.7827	-8.6110	0.9763
LLMO	I	19.4350	-0.4721	0.2903
LLMO	II	15.2621	-0.3812	0.5460
LLMO	III	16.2574	0.2317	0.3780

CORR=correlation coefficient

Table 179

A Summary of the Kinetic constants for the Monod Model in the Degradation of O-Chlorophenol

MEDIA	RUN	KO	K1	AAR
HYDROBAC	I	2.7196	10.6680	0.243
HYDROBAC	II	-19.7650	-0.0240	0.390
HYDROBAC	III	-61.8992	-22.0616	0.440
HYDROBAC	IV	-21.1477	-2.5350	0.303
BI-CHEM	I	811.4656	1996.7183	0.000
BI-CHEM	II	-14.5708	0.0955	0.453
BI-CHEM	III	-17.6762	-7.6157	0.738
BI-CHEM	IV	17.1669	16.5788	0.201
LIVINGSTON	I	23.9938	39.2245	0.120
LIVINGSTON	II	5.8038	23.3174	0.142
LIVINGSTON	III	-41.5489	-16.3896	0.370
LLMO	I	-19.4081	-0.0007	0.417
LLMO	II	-12.6990	0.0345	0.287
LLMO	III	-17.4145	-0.0063	0.275

Table 180

A Summary of the Kinetic constants for the Haldane Model

in the Degradation of O-Chlorophenol

MEDIA	RUN	K1	K2	K3	AAR
HYDROBAC	I	1.0938	-1.3903	0.0562	0.909
HYDROBAC	II	6.2460	0.0331	0.0016	0.412
HYDROBAC	III	14.3768	3.1059	-0.1828	0.5839
HYDROBAC	IV	4.6013	0.3908	0.0083	0.699
BI-CHEM	I	-0.4767	-2.7121	0.0700	0.757
BI-CHEM	II	6.1013	0.1534	0.0021	1.100
BI-CHEM	III	6.0586	1.2242	-0.0172	0.969
BI-CHEM	IV	-1.9661	-2.0893	0.1047	0.903
LIVINGSTON	I	43.6141	27.7422	-0.2677	2.077
LIVINGSTON	II	9.1092	5.0372	-0.0231	1.339
LIVINGSTON	III	5.2140	1.0452	0.0066	1.222
LLMO	I	6.1424	0.0812	0.0014	0.621
LLMO	II	5.1634	0.0249	0.0018	0.409
LLMO	III	6.1773	0.0155	-0.0009	0.368

AAR=Absoloute Average Residual

Table 181

A Summary of the Kinetic constants for the Zero Order Model in the Degradation of O-Chlorophenol in Mixtures of Preperations

MEDIA	RUN	KO	K1	CORR
LIVINGSTON/BI-CHEM	I	21.5346	22.0681	0.9940
LIVINGSTON/BI-CHEM	III	21.2071	32.7714	0.9932
LIVINGSTON/BI-CHEM	IV	25.6901	29.3597	0.9897
LIVINGSTON/HYDROBAC	I	16.4598	9.4142	0.8940
LIVINGSTON/HYDROBAC	I A	21.1563	34.5043	0.9947
LIVINGSTON/HYDROBAC	II A	20.4158	22.5501	0.9887
LIVINGSTON/HYDROBAC	III A	21.4402	5.0012	0.8719
LIVINGSTON/LLMO	I	27.0706	59.7155	0.9976
LIVINGSTON/LLMO	II	20.8967	41.0164	0.9981
LIVINGSTON/LLMO	III	20.9588	45.9956	0.9761

CORR=Correlation coefficient

Table 182

A Summary of the Kinetic constants for the Monod Model in the Degradation of O-Chlorophenol in Mixtures of Preperations

MEDIA	RUN	KO	K1	AAR
LIVINGSTON/BI-CHEM	I	-2.4967	14.1591	0.359
LIVINGSTON/BI-CHEM	III	-4.1230	13.1206	0.831
LIVINGSTON/BI-CHEM	IV	-6.8650	9.0827	1.122
LIVINGSTON/HYDROBAC	I	-3422.8281	-4298.1250	0.287
LIVINGSTON/HYDROBAC	I A	-2.2371	19.5130	0.444
LIVINGSTON/HYDROBAC	II A	-11.1233	-5.3291	1.424
LIVINGSTON/HYDROBAC	III A	-18.6386	-0.0326	0.465
LIVINGSTON/LLMO	I	-0.7249	41.4440	0.518
LIVINGSTON/LLMO	II	-1.1201	21.3771	0.367
LIVINGSTON/LLMO	III	-1.6154	20.9790	0.553

AAR=Absoloute Average Residual

Table 183

A Summary of the Kinetic constants for the Haldane Model in the Degradation of O-Chlorophenol in Mixtures of Preperations

MEDIA	RUN	K1	K2	K3	AAR
LIVINGSTON/BI-CHEM	I	5.5401	2.4888	0.0032	1.134
LIVINGSTON/BI-CHEM	III	5.0899	2.4936	0.0056	1.433
LIVINGSTON/BI-CHEM	IV	5.6862	2.9065	0.0061	1.125
LIVINGSTON/HYDROBAC	I	5.1042	1.5549	0.0031	0.690
LIVINGSTON/HYDROBAC	I A	6.6211	4.6741	-0.0105	1.446
LIVINGSTON/HYDROBAC	II A	5.5319	2.9976	0.0012	0.852
LIVINGSTON/HYDROBAC	III A	6.0165	0.3619	0.0024	0.563
LIVINGSTON/LLMO	I	0.4896	-14.0416	0.0449	1.623
LIVINGSTON/LLMO	II	0.0244	-11.3037	0.0687	5.985
LIVINGSTON/LLMO	III	-1.6747	-19.7232	0.0909	764.720

AAR=Absoloute Average Residual

FIGURES

O=Substrate data point

+=COD data point

Figure 1

The Reactor

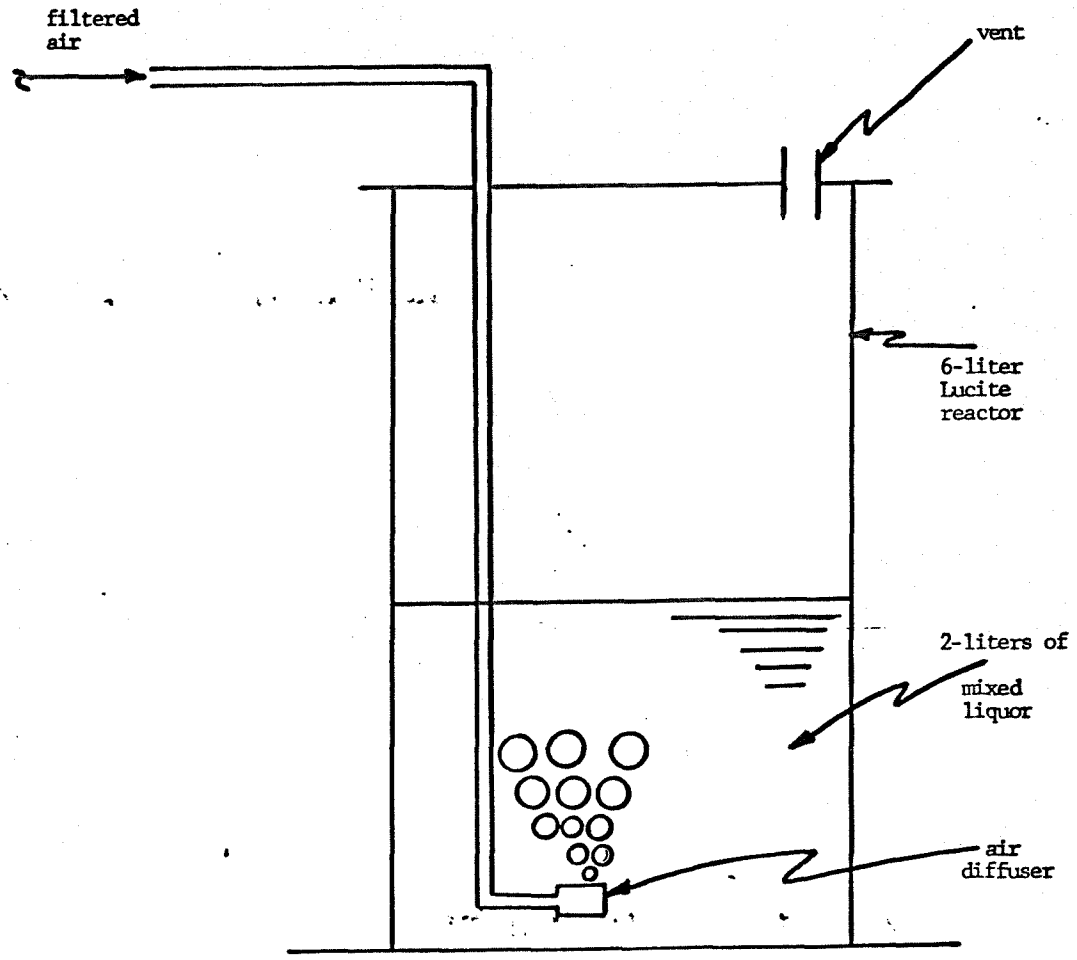
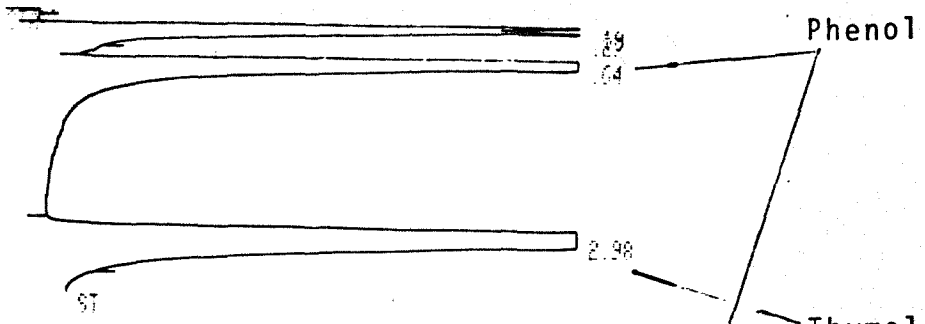


Figure 2

A Sample GC Output for a Phenol Injection



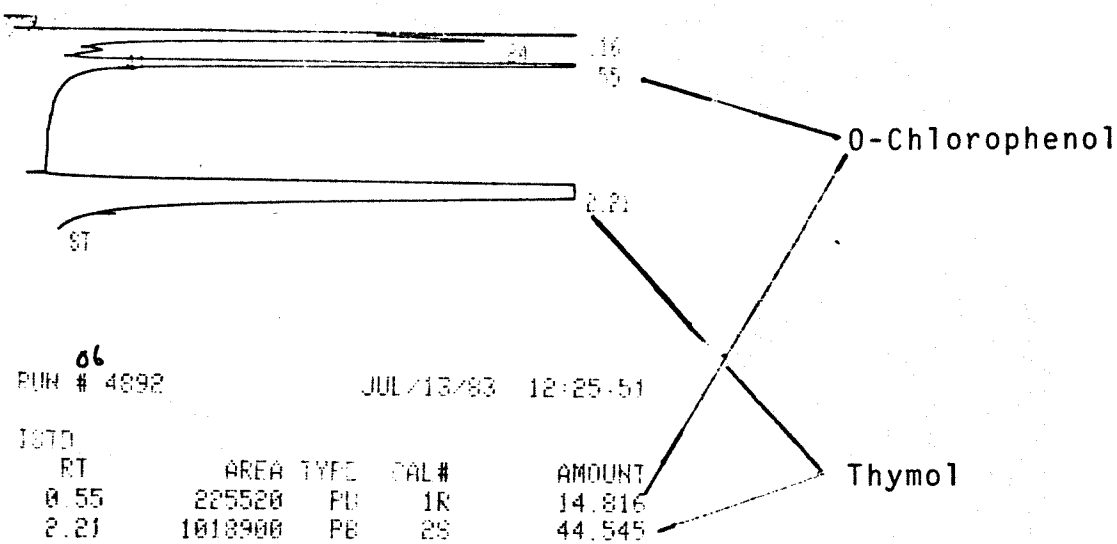
06 1

RUN # 5393 JUL/27/83 17:00:10

ISTD RT	AREA	TYPE	CAL#	AMOUNT
0.64	1887200	PB	1R	106.320
2.98	1135200	PB	2S	44.545

TOTAL AREA= 3022400
ISTD AMT= 4.4545E+01
MUL FACTOR= 1.0000E+00

Figure 3
A Sample GC Output for an O-Chlorophenol injection



06
RUN # 4892 JUL/13/83 12:25:51

ISTD

RT	AREA	TYPE	CAL#	AMOUNT
0.55	225520	PU	1R	14.816
2.21	1018900	PB	2S	44.545

TOTAL AREA= 1244400
ISTD AMT= 4.4545E+01
MUL FACTOR= 1.0000E+00

Figure 4
A Plot of Substrate and COD Concentration vs. Time for the Degradation of Phenol in the Media Hydrobac Run I

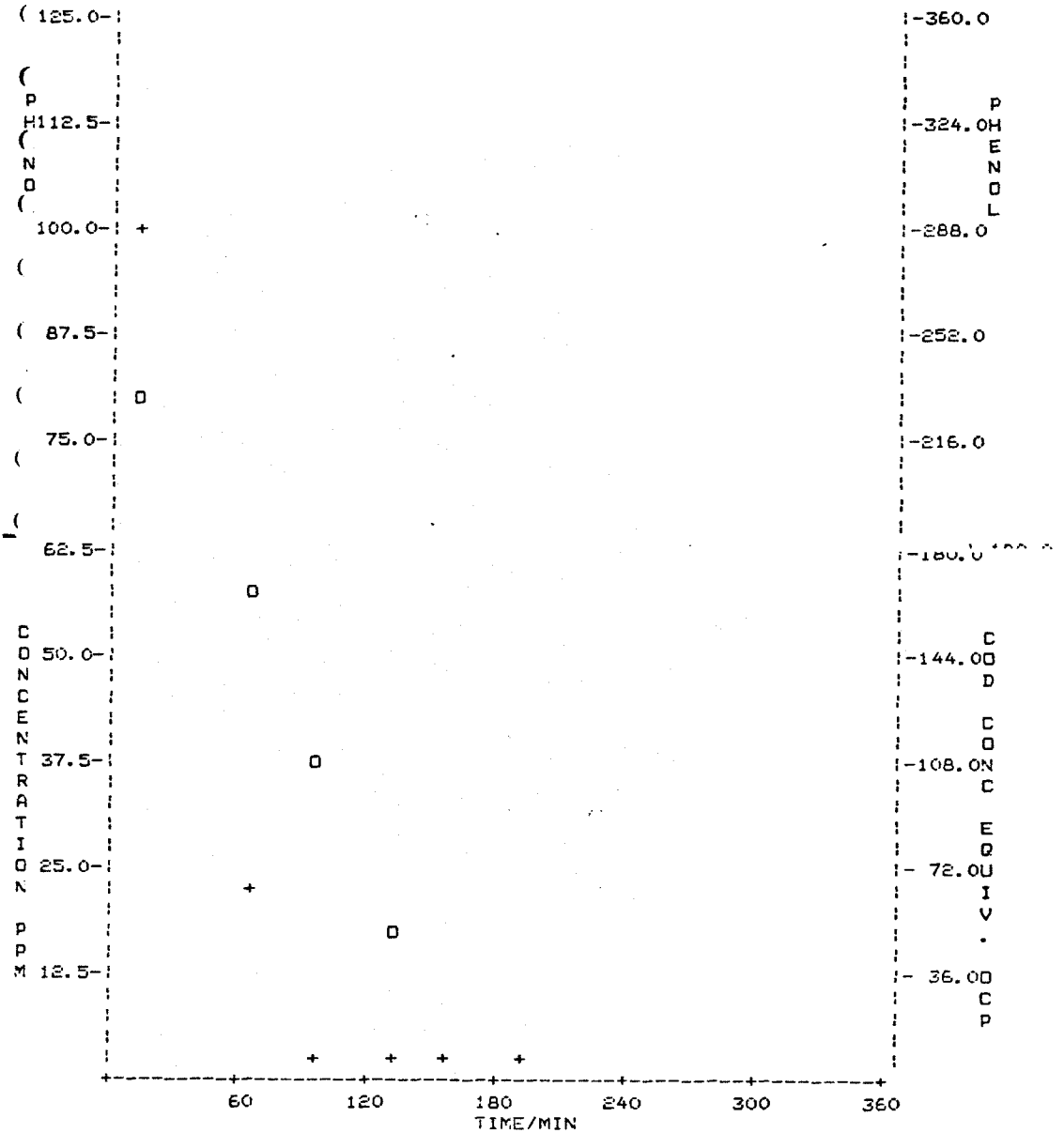


Figure 5
A Plot of Substrate and COD Concentration vs. Time for the Degradation of Phenol in the Media Hydrobac Run II

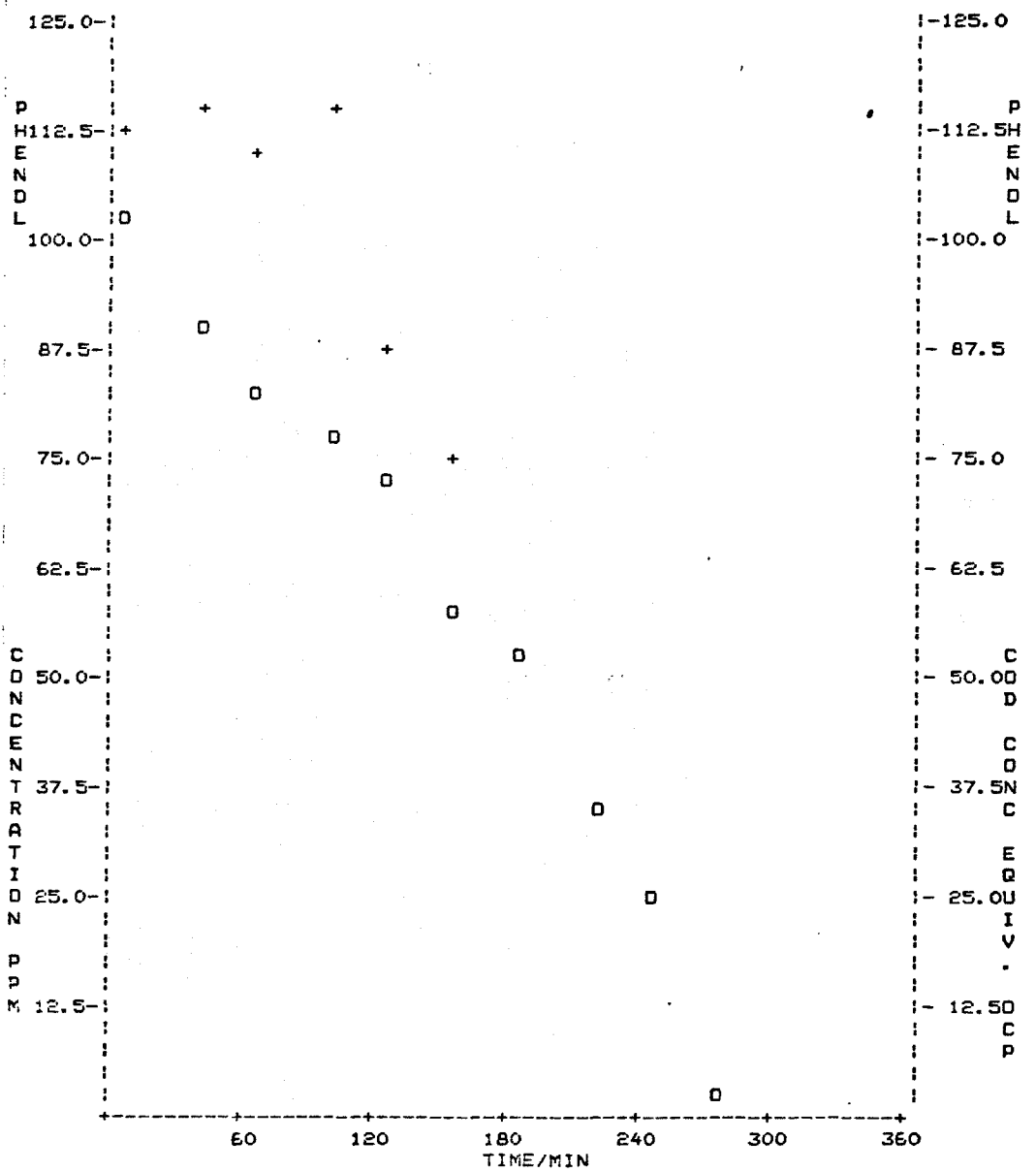


Figure 6
A Plot of Substrate and COD Concentration vs. Time for the Degradation of Phenol in the Media BI-CHEM Run I

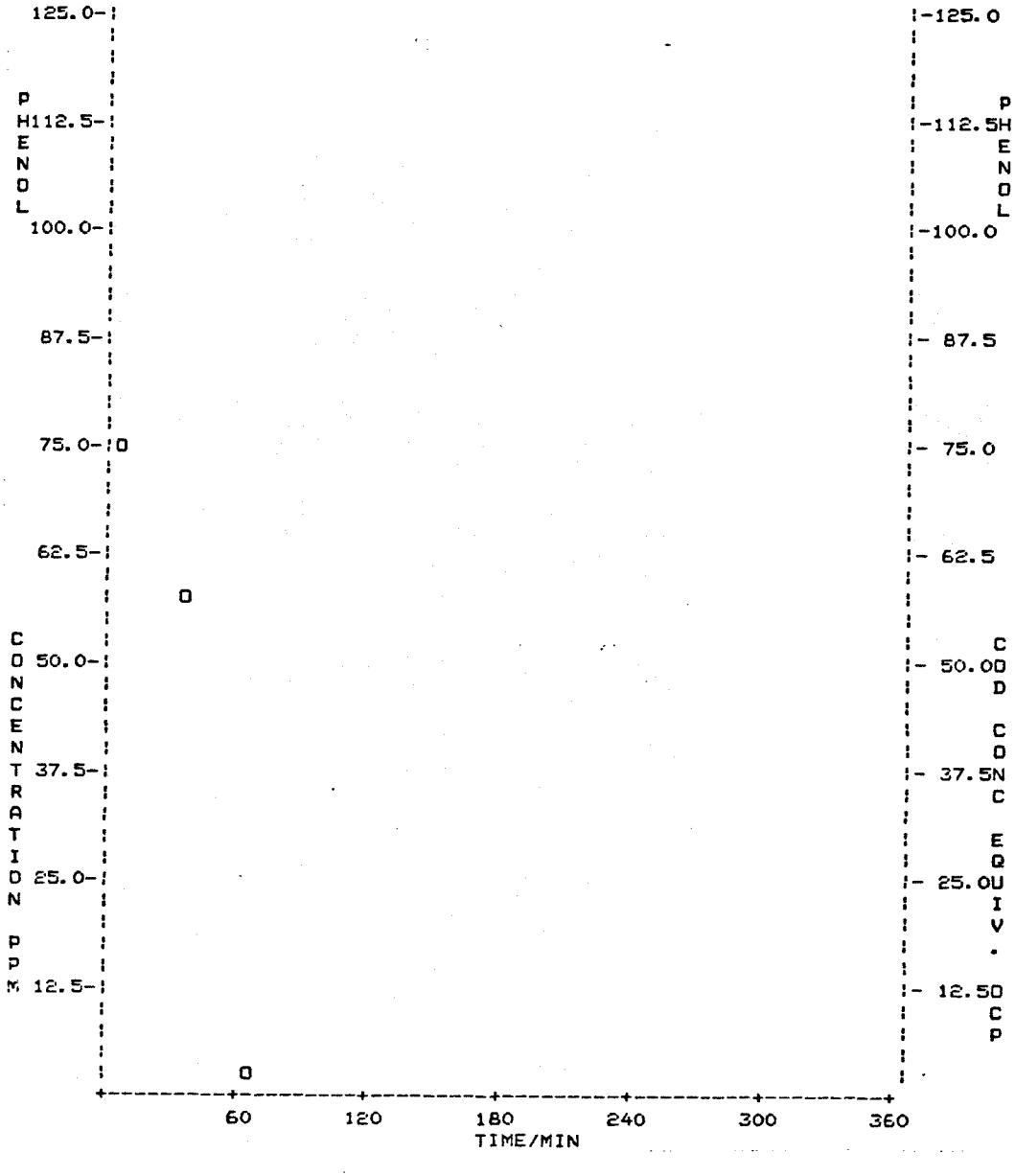


Figure 7
A Plot of Substrate and COD Concentration vs. Time for the Degradation of Phenol in the Media BI-CHEM Run II

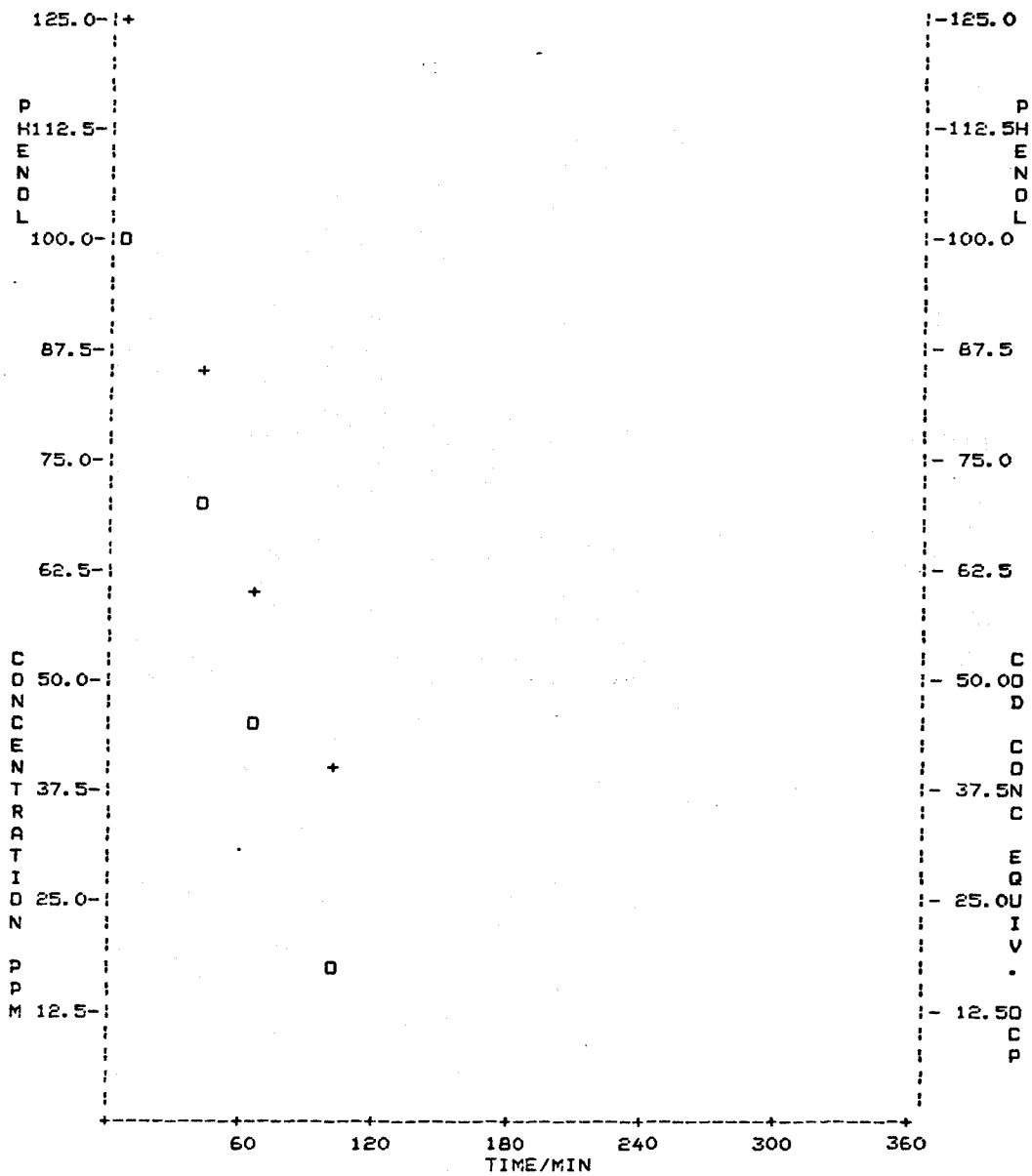


Figure 8
A Plot of Substrate and COD Concentration vs. Time for the Degradation of Phenol in the Media Livingston Run I

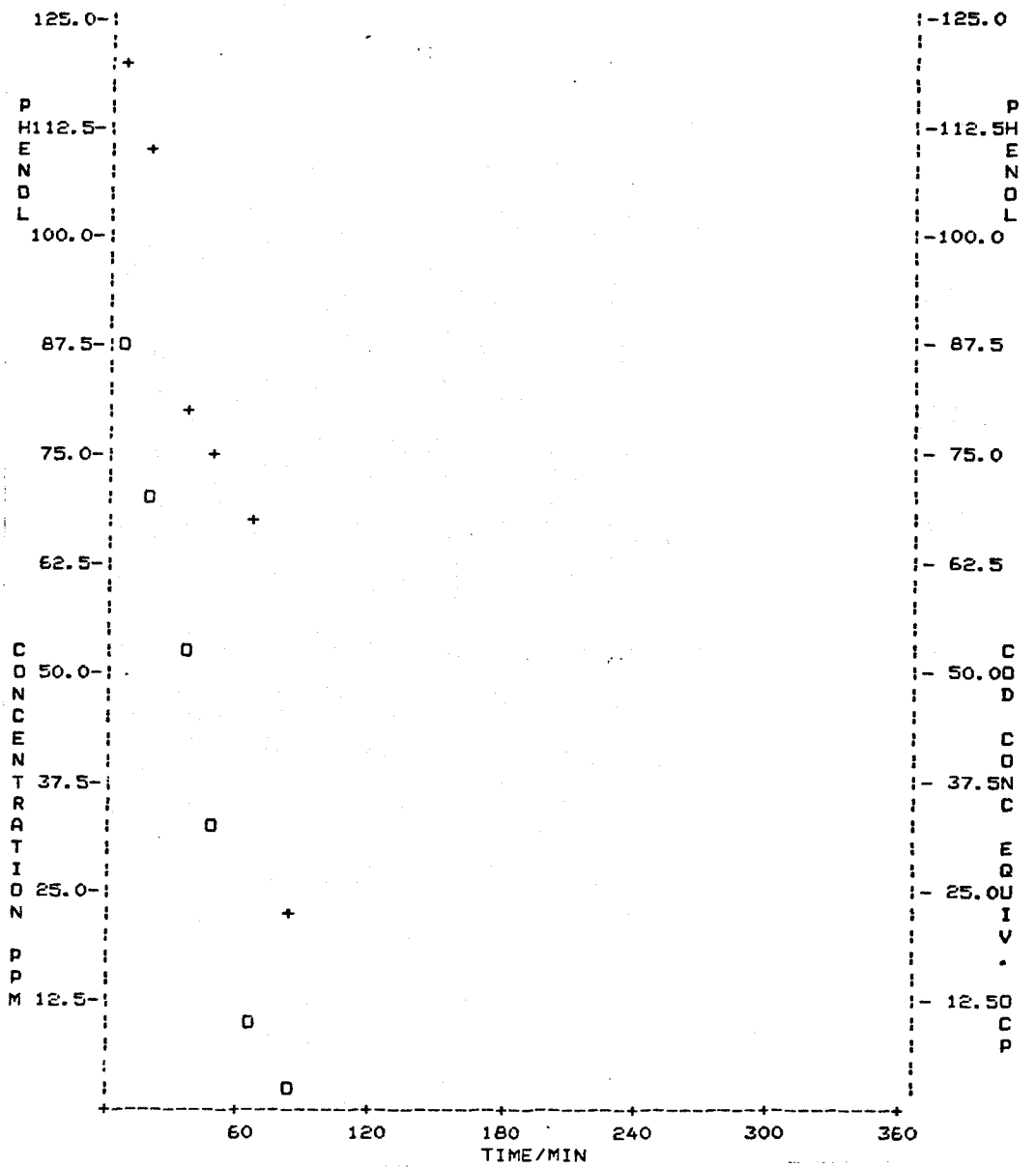


Figure 9
A Plot of Substrate and COD Concentration vs. Time for the Degradation of Phenol in the Media Livingston Run II

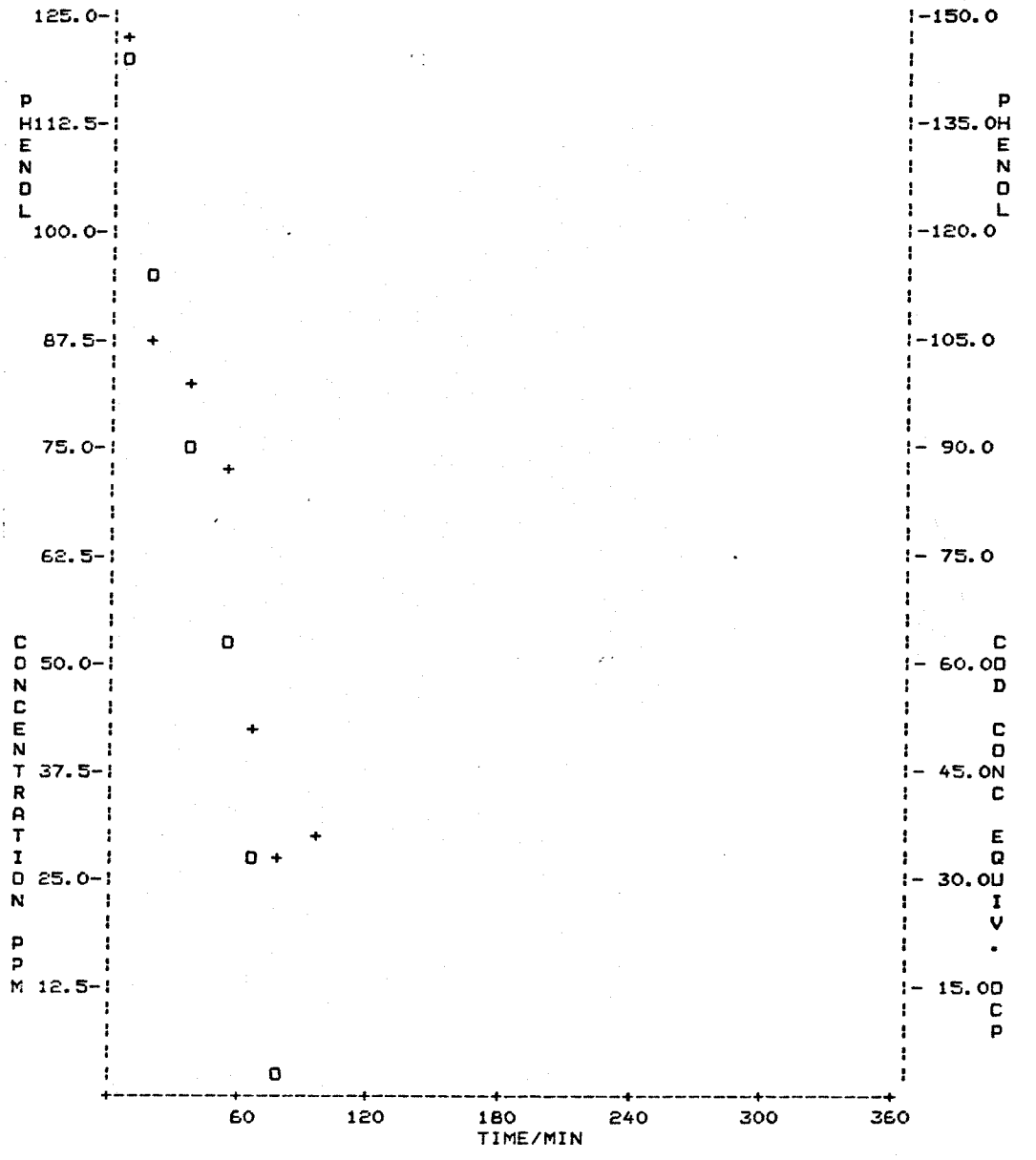


Figure 10
A Plot of Substrate and COD Concentration vs. Time for the Degradation of Phenol in the Media LLMO Run I

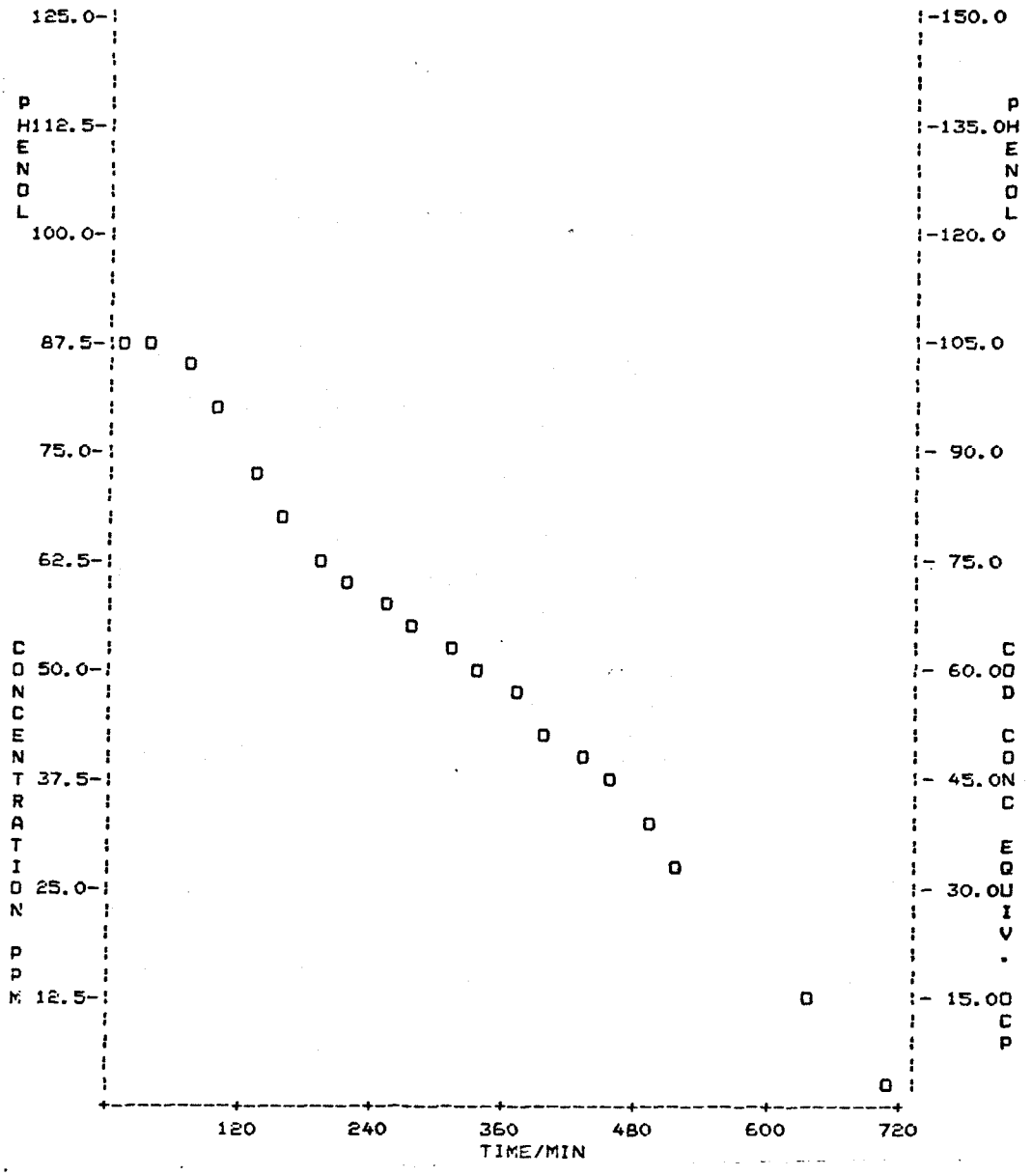


Figure 11
A Plot of Substrate and COD Concentration vs. Time for the Degradation of Phenol in the Media LLMO Run II

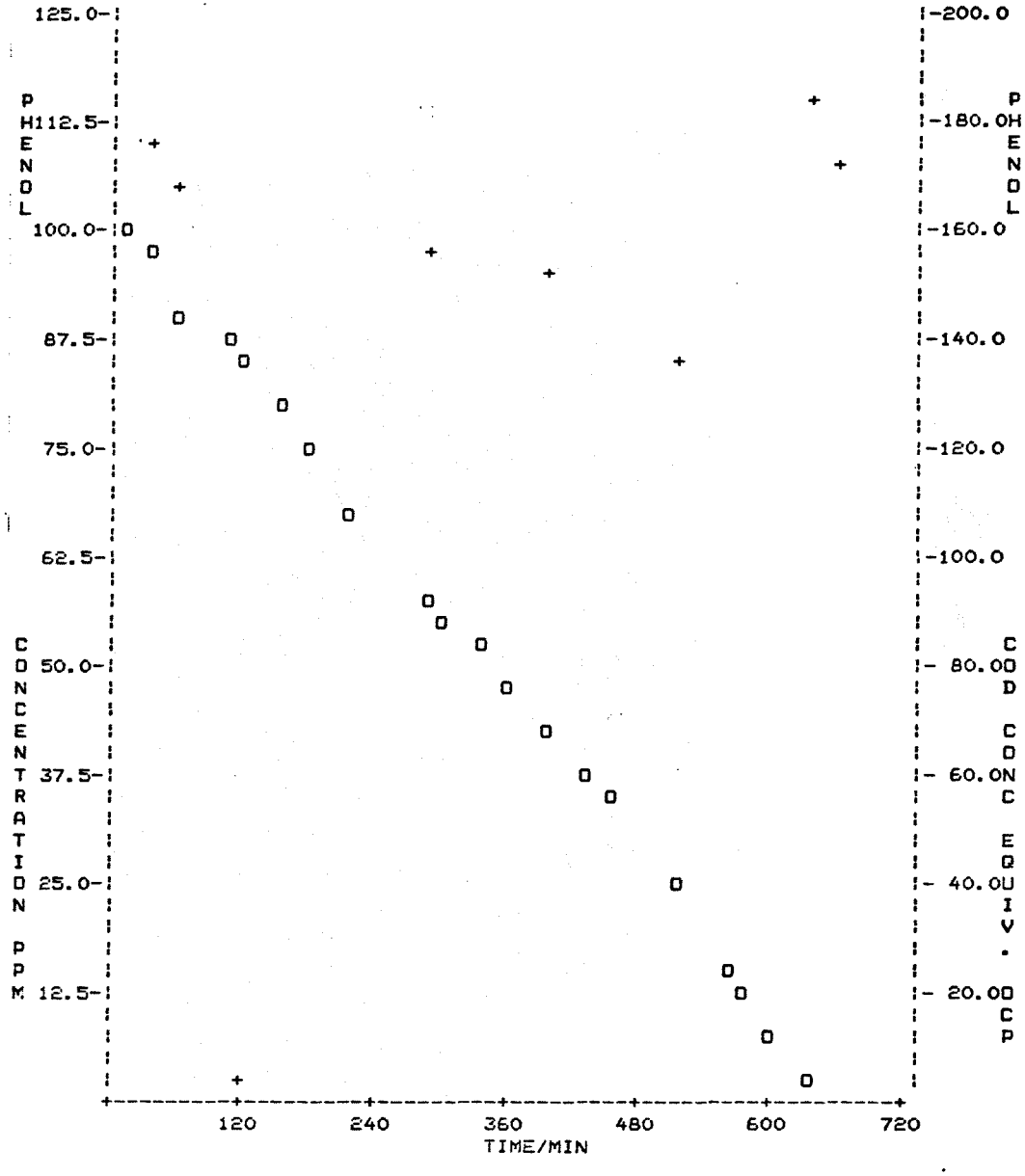


Figure 12
A Plot of Substrate and COD Concentration vs. Time for the Degradation of Phenol in the Media LLMO Run III

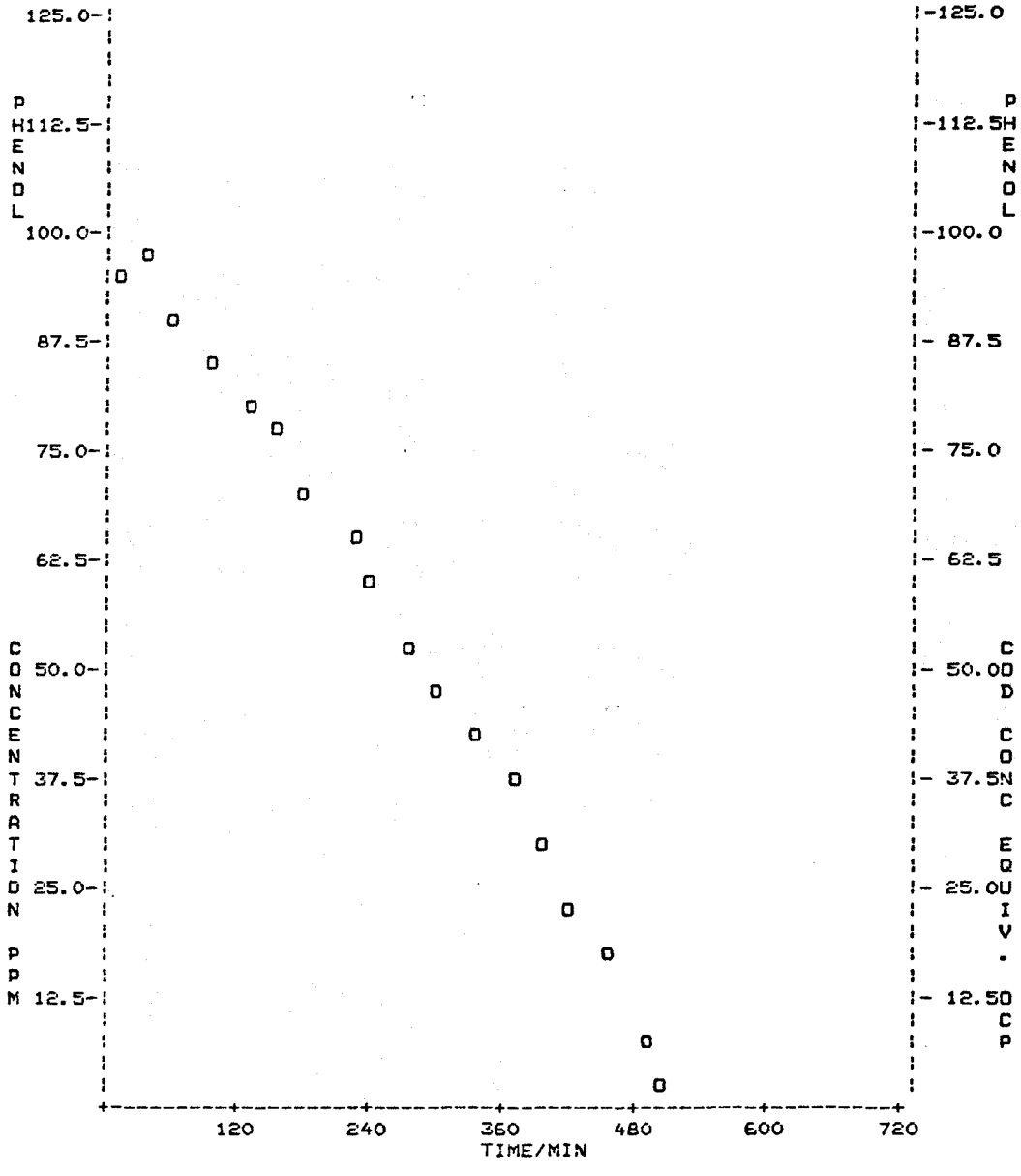


Figure 13
A Plot of Substrate and COD Concentration vs. Time for the Degradation of Phenol in the Media Livingston/BI-CHEM Run I

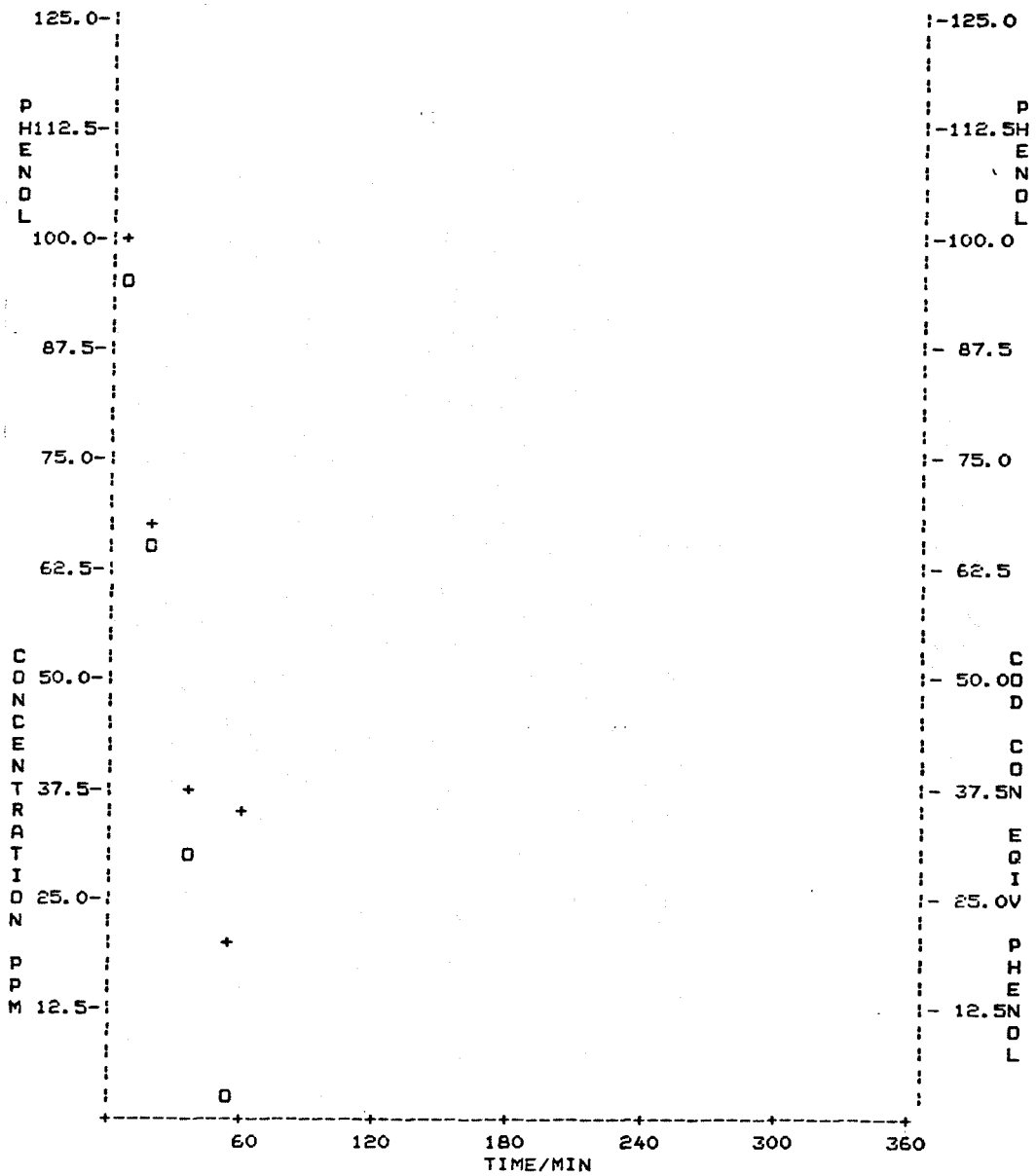


Figure 14
A Plot of Substrate and COD Concentration vs. Time for the Degradation of Phenol in the Media Livingston/BI-CHEM Run II

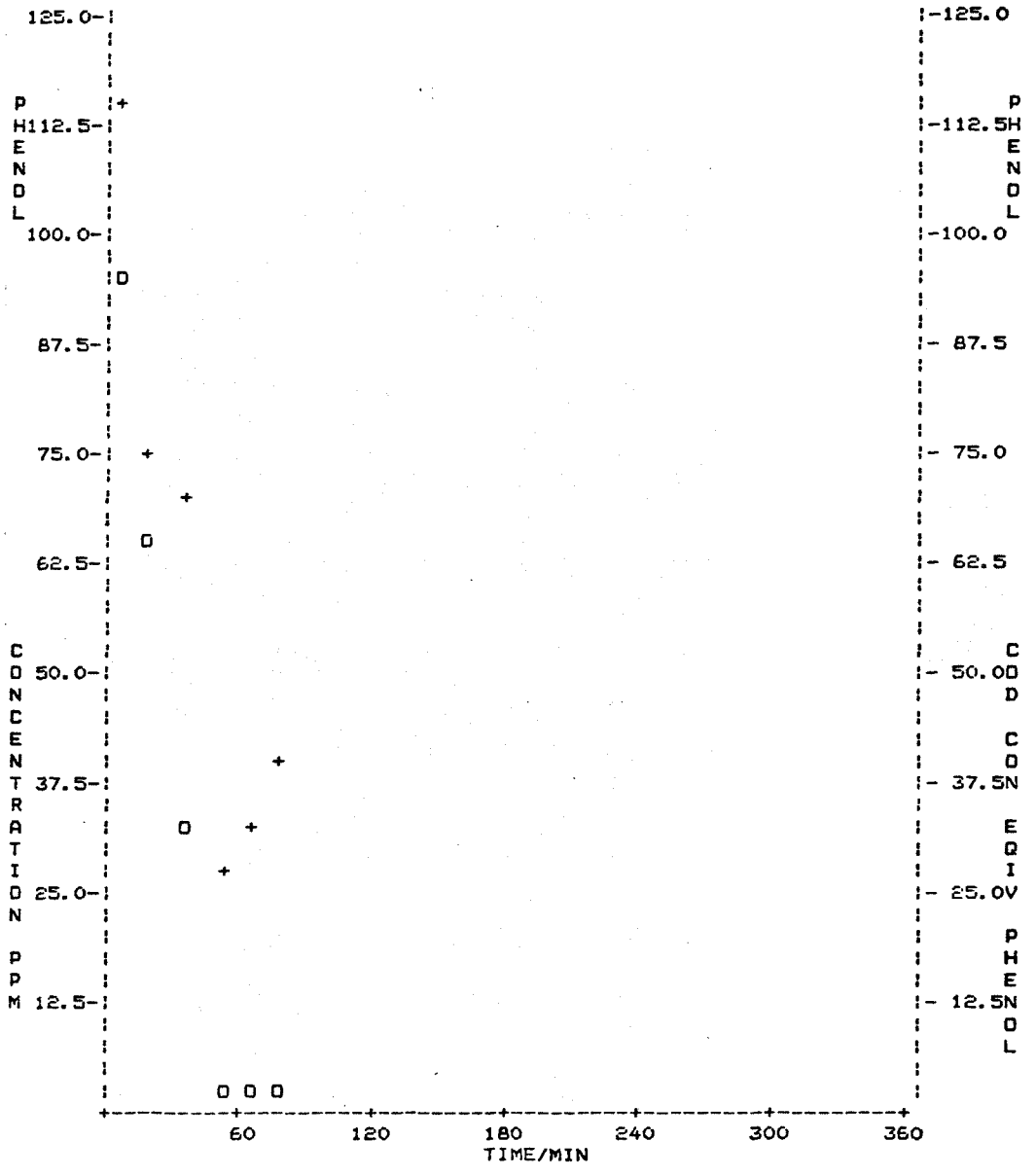


Figure 15
A Plot of Substrate and COD Concentration vs. Time for the Degradation of Phenol in the Media Livingston/BI-CHEM Run III

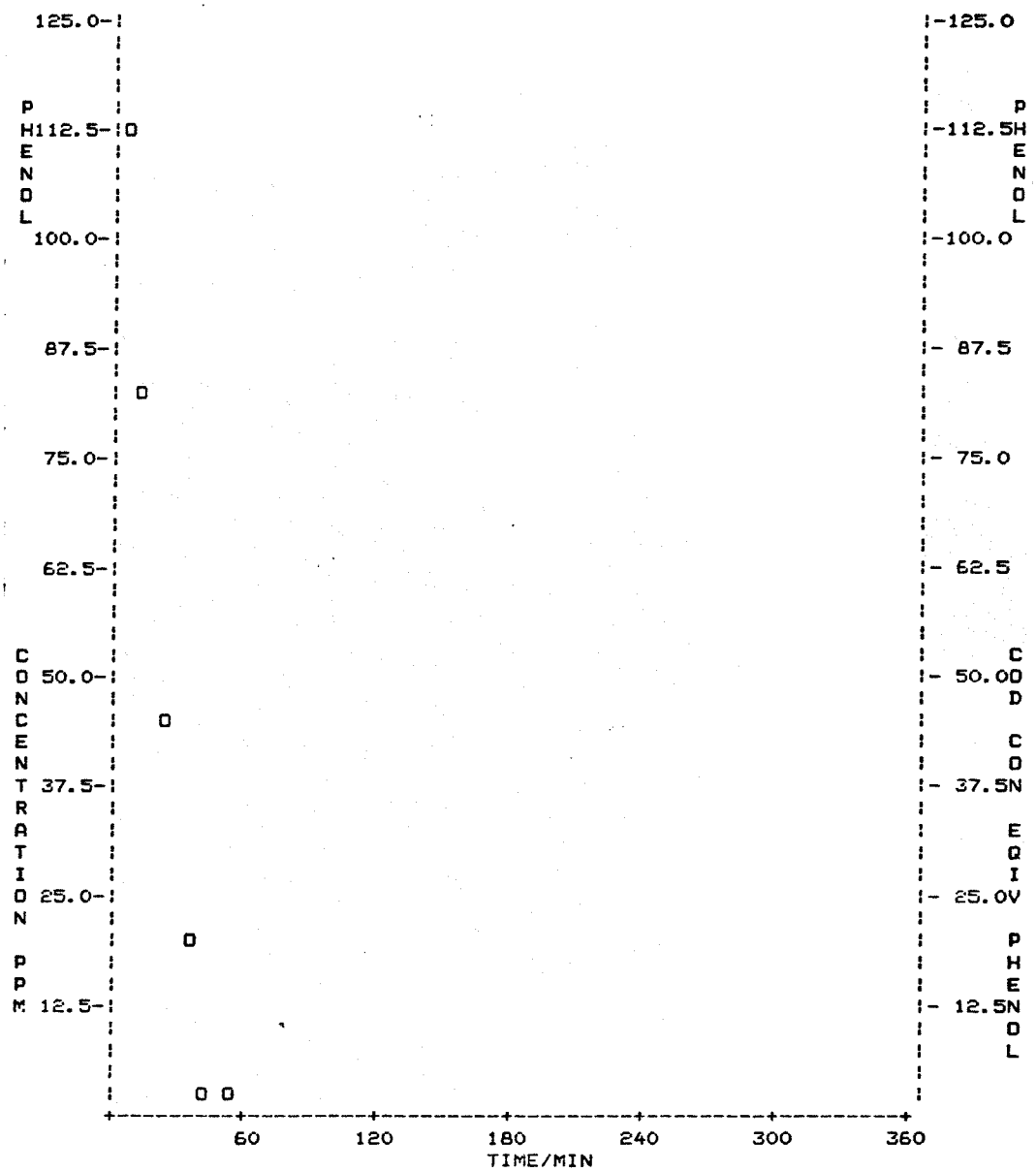


Figure 16
A Plot of Substrate and COD Concentration vs. Time for the Degradation of Phenol in the Media Livingston/Hydrobac Run I

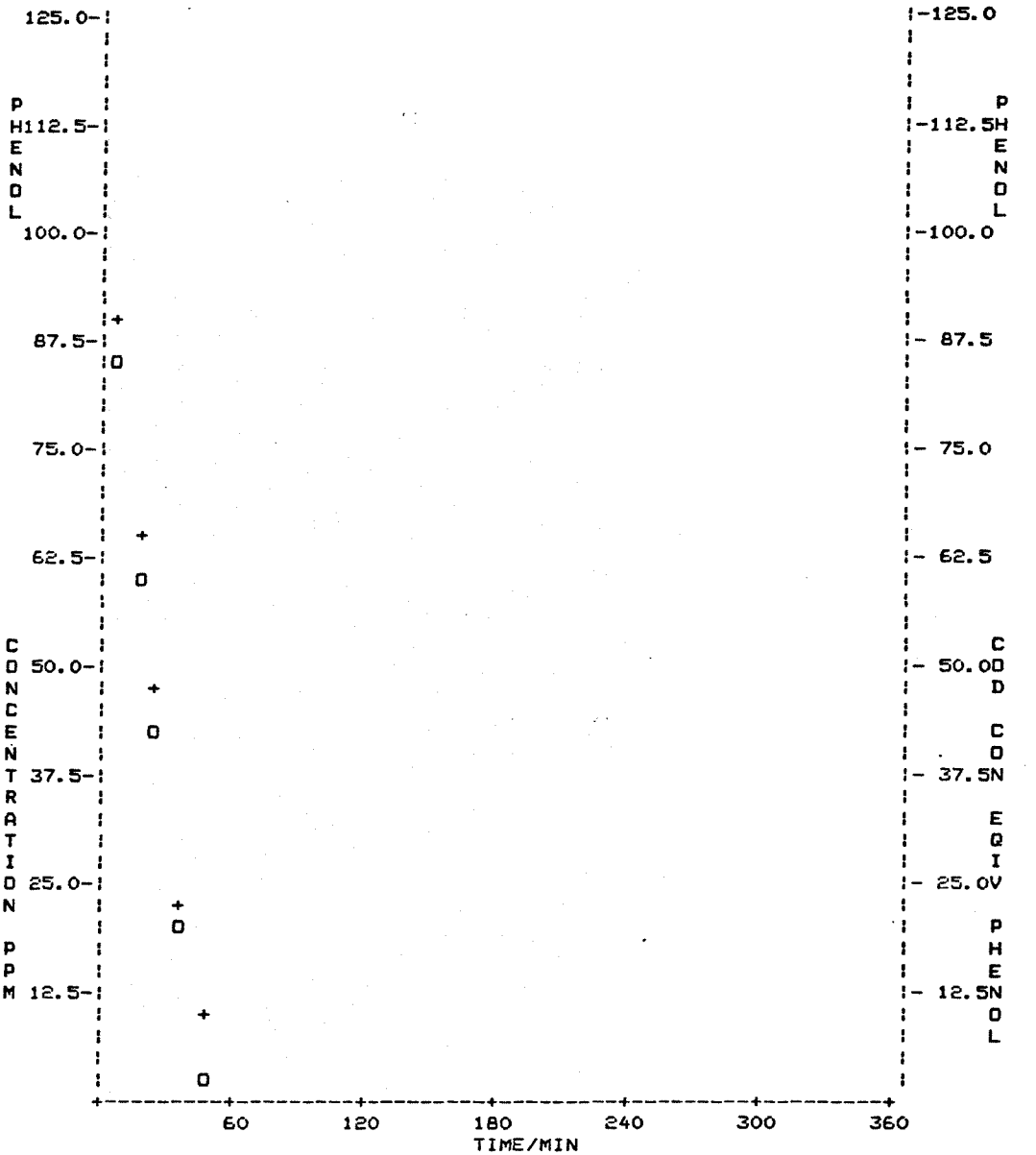


Figure 17
A Plot of Substrate and COD Concentration vs. Time for the Degradation of Phenol in the Media Livingston/Hydrobac Run II

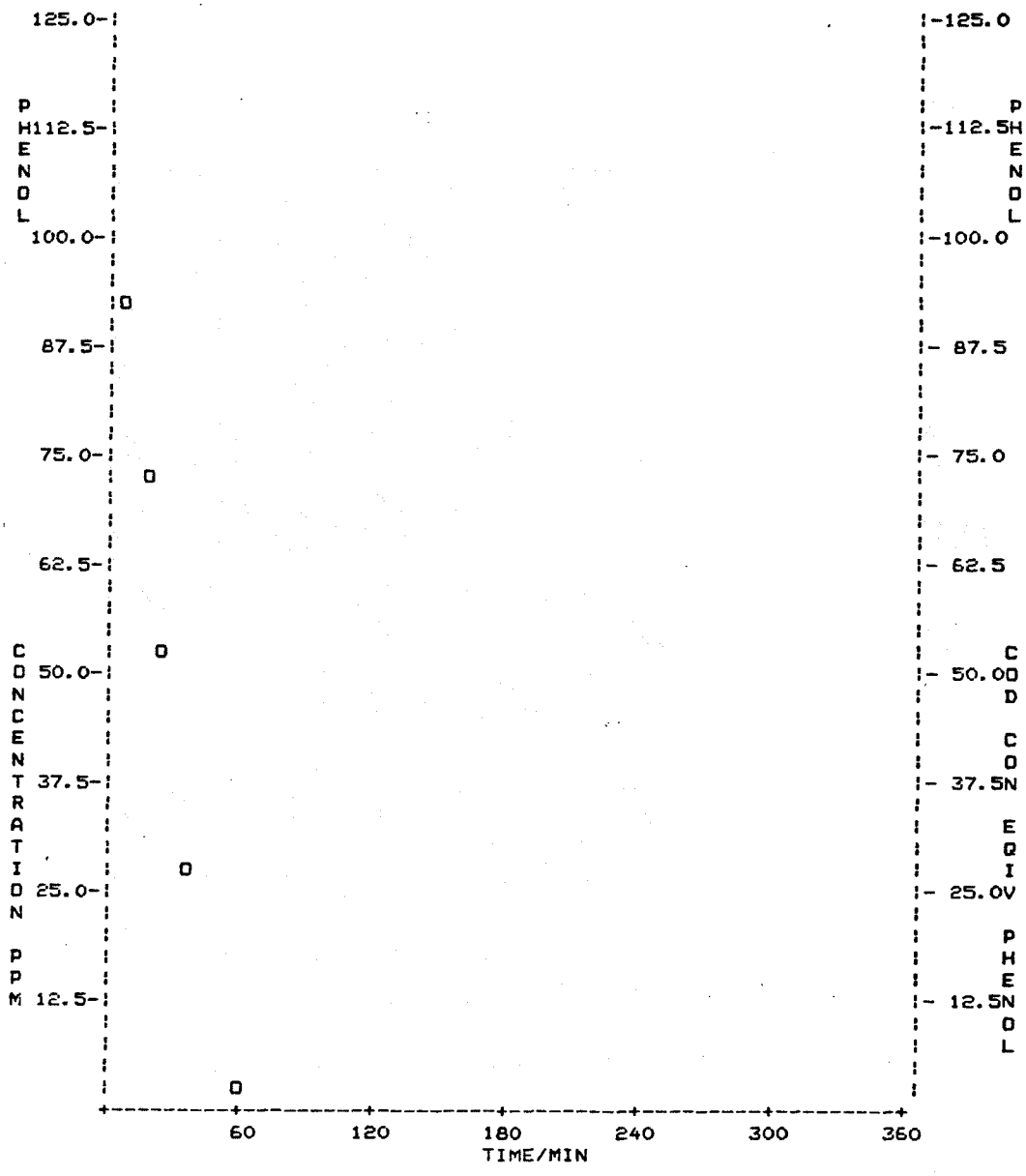


Figure 18
A Plot of Substrate and COD Concentration vs. Time for the Degradation of Phenol in the Media Livingston/Hydrobac Run III

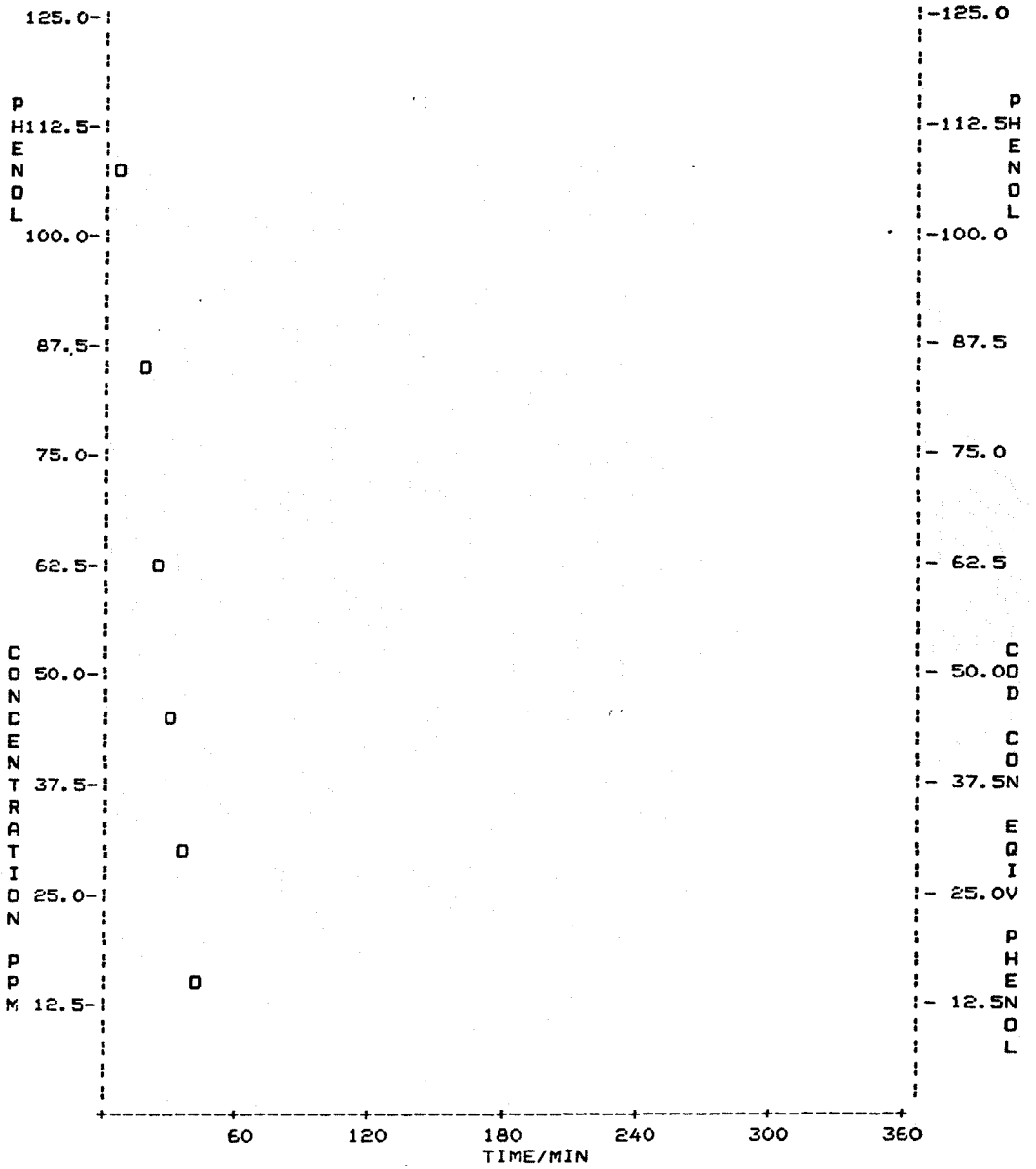


Figure 19
A Plot of Substrate and COD Concentration vs. Time for the Degradation of Phenol in the Media Livingston/LLMO Run I

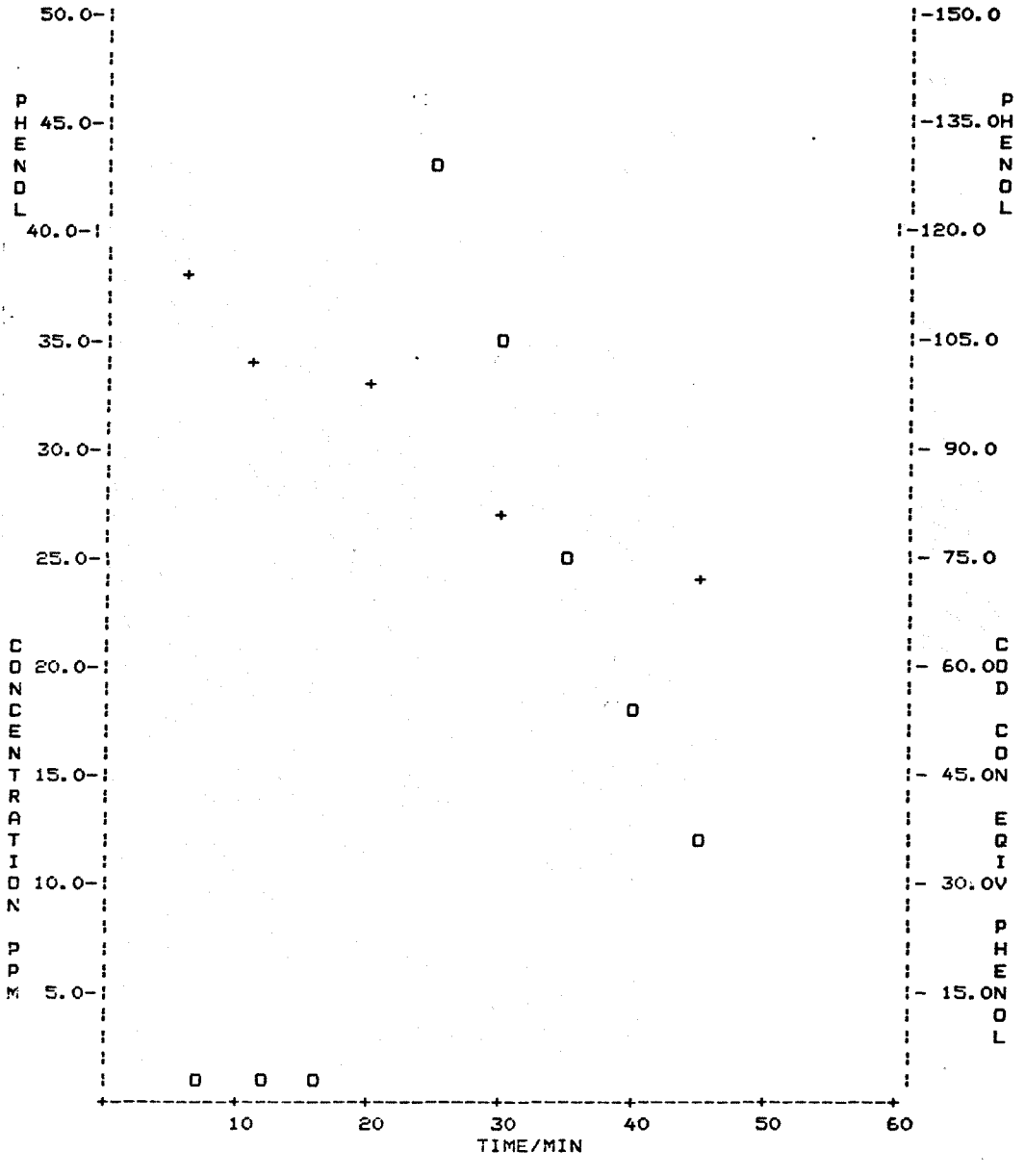


Figure 20
A Plot of Substrate and COD Concentration vs. Time for the Degradation of Phenol in the Media Livingston/LLMO Run II

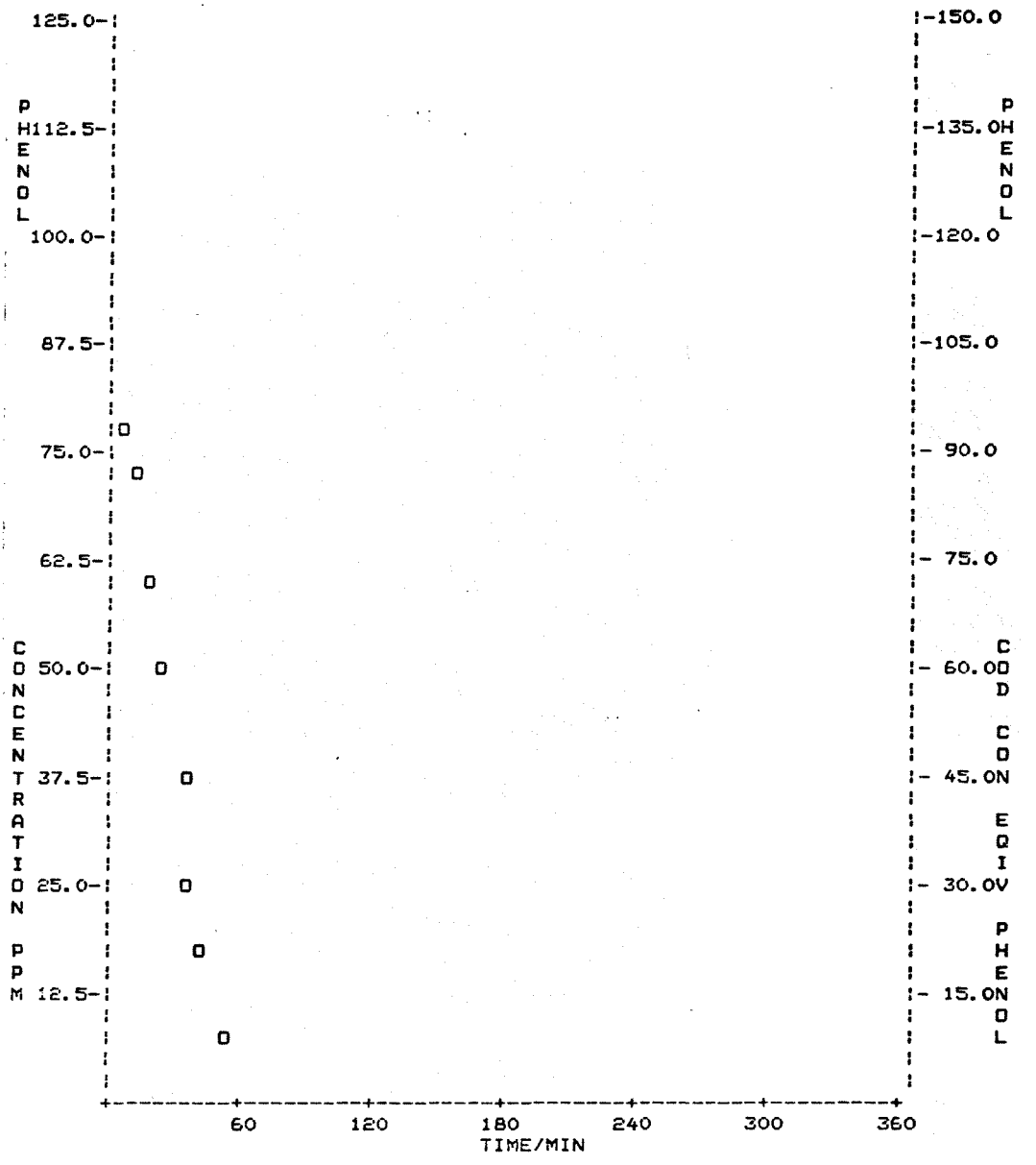


Figure 21
A Plot of Substrate and COD Concentration vs. Time for the Degradation of Phenol in the Media Livingston/LLMO Run III

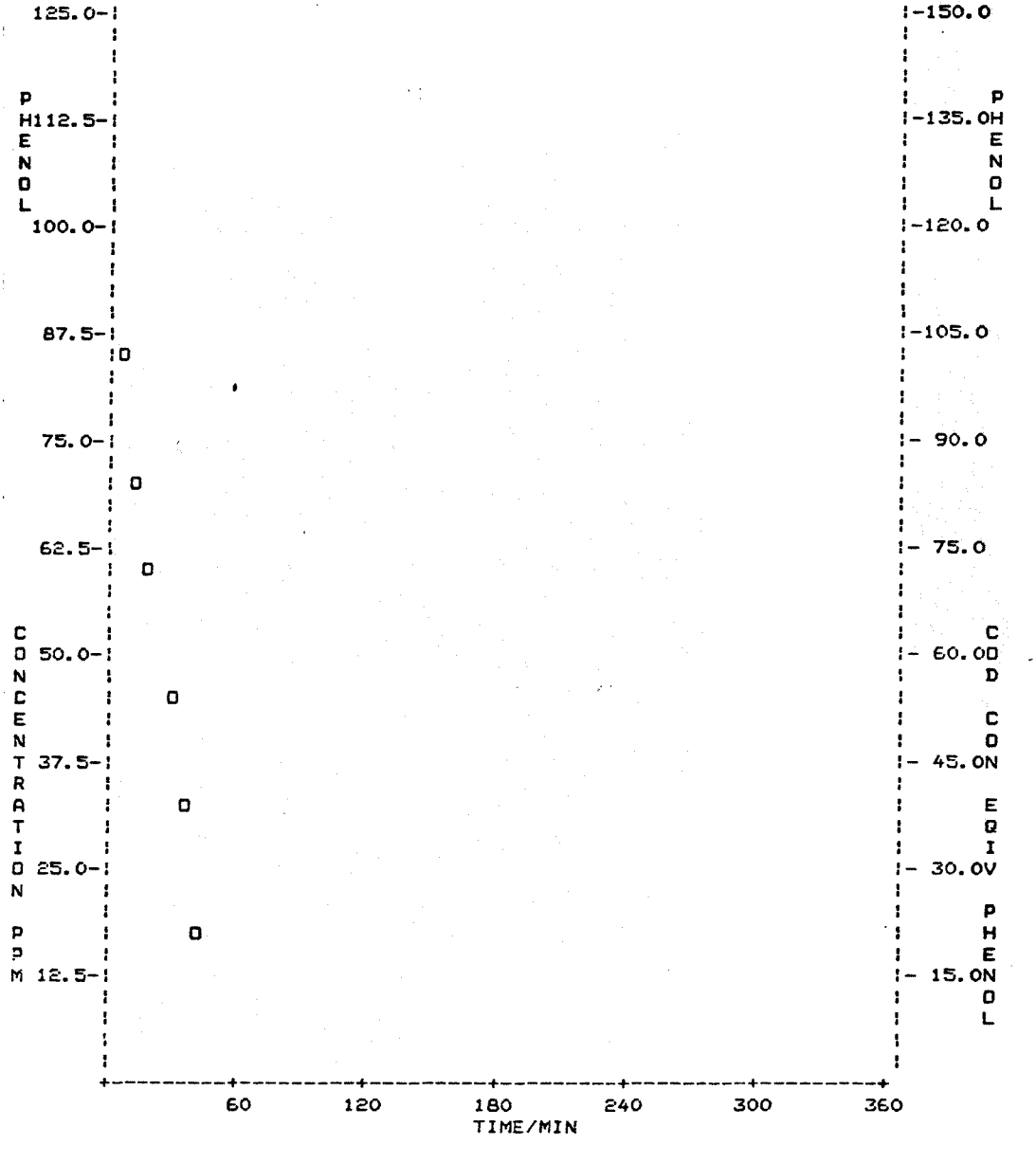


Figure 22
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media Hydrobac Run I

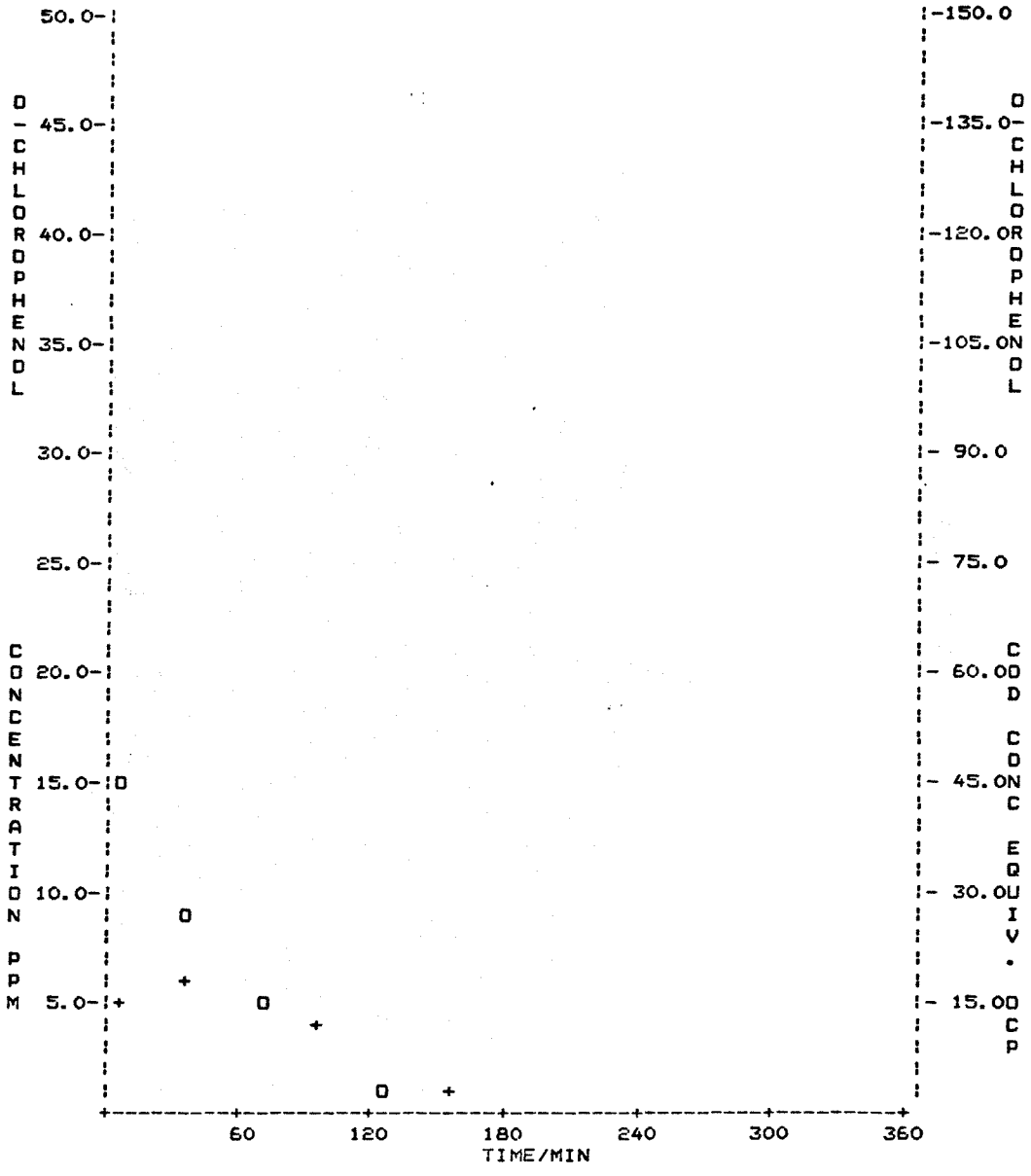


Figure 23
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media Hydrobac Run II

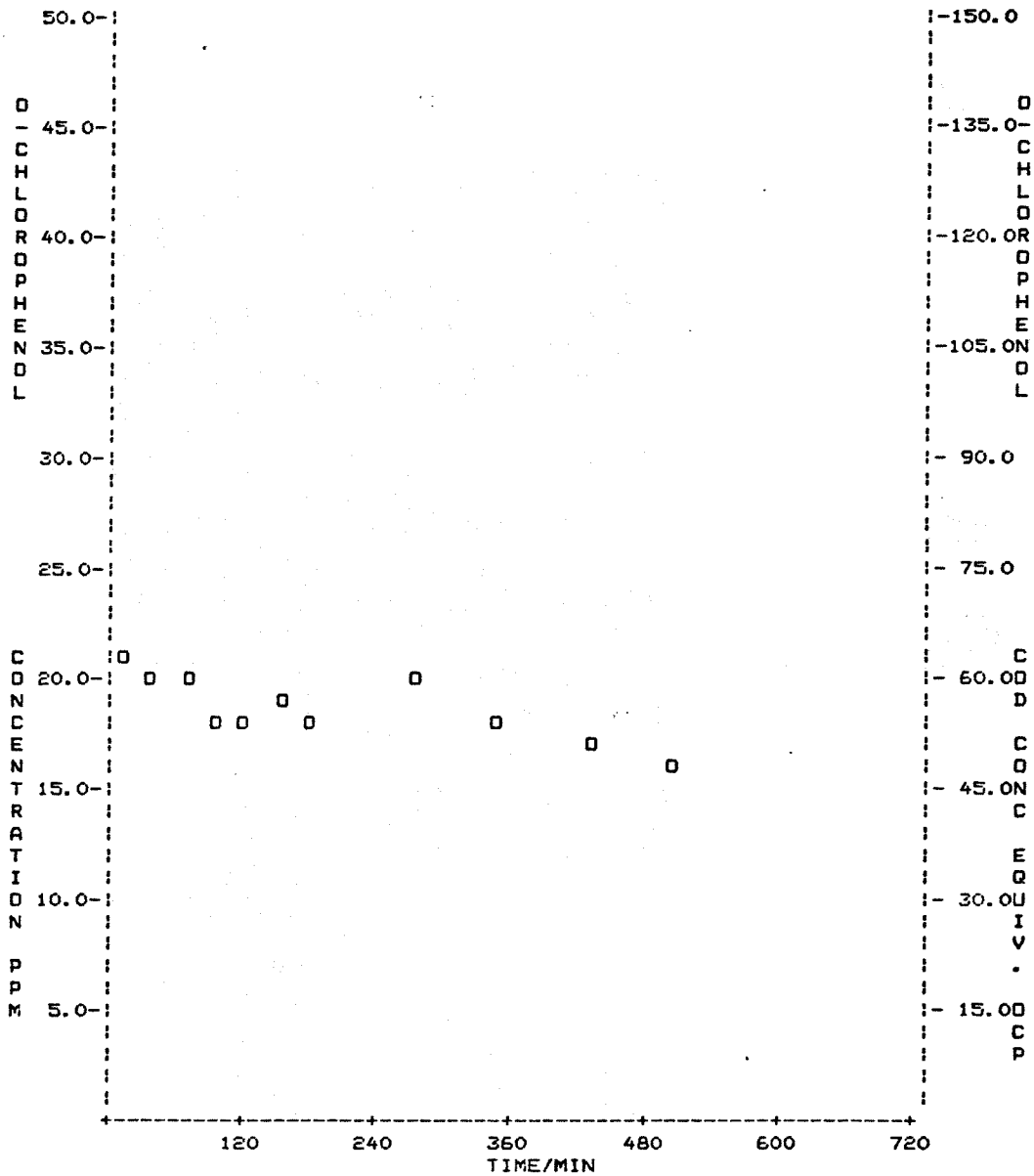


Figure 24
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media Hydrobac Run III

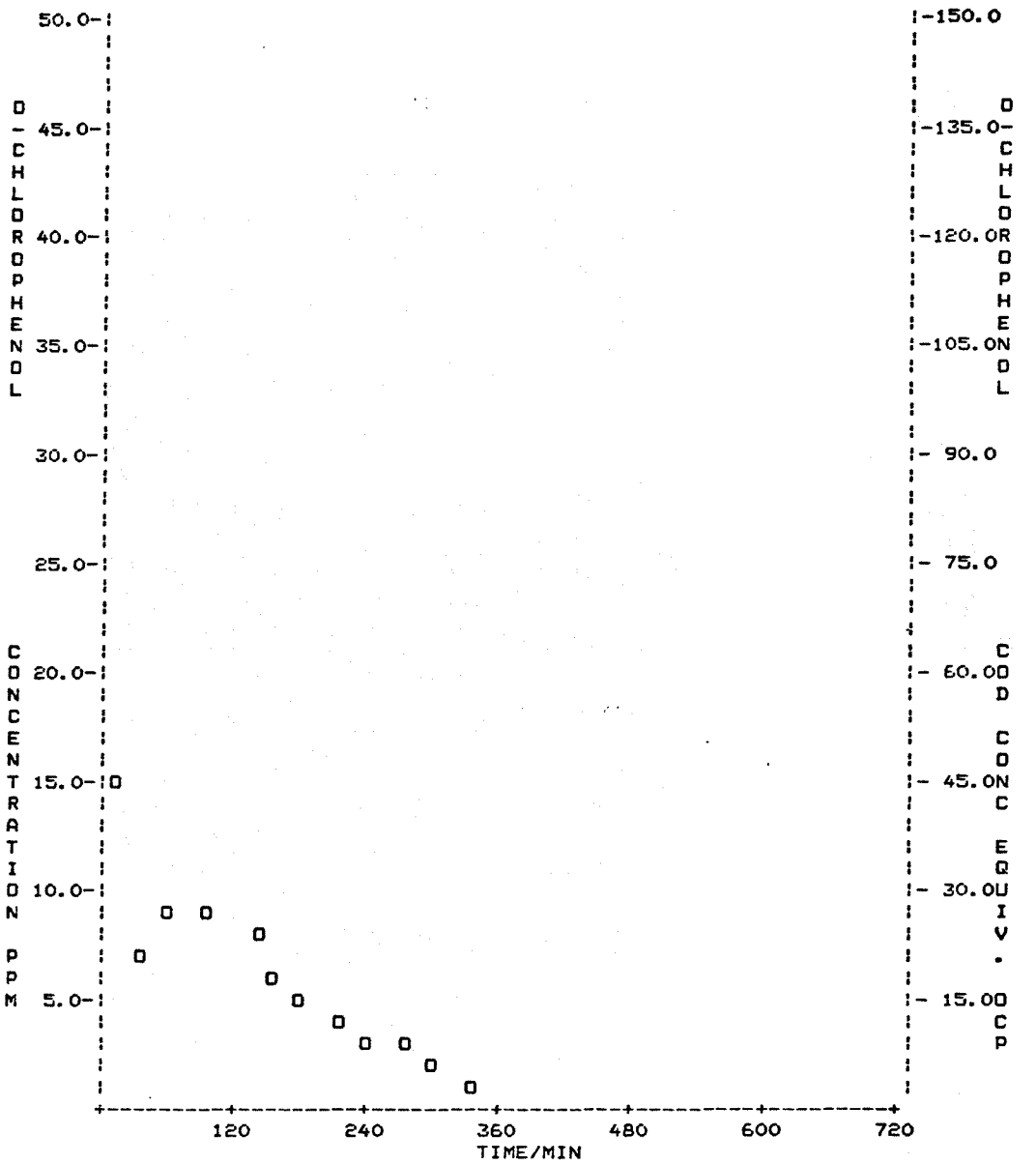


Figure 25
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media Hydrobac Run IV

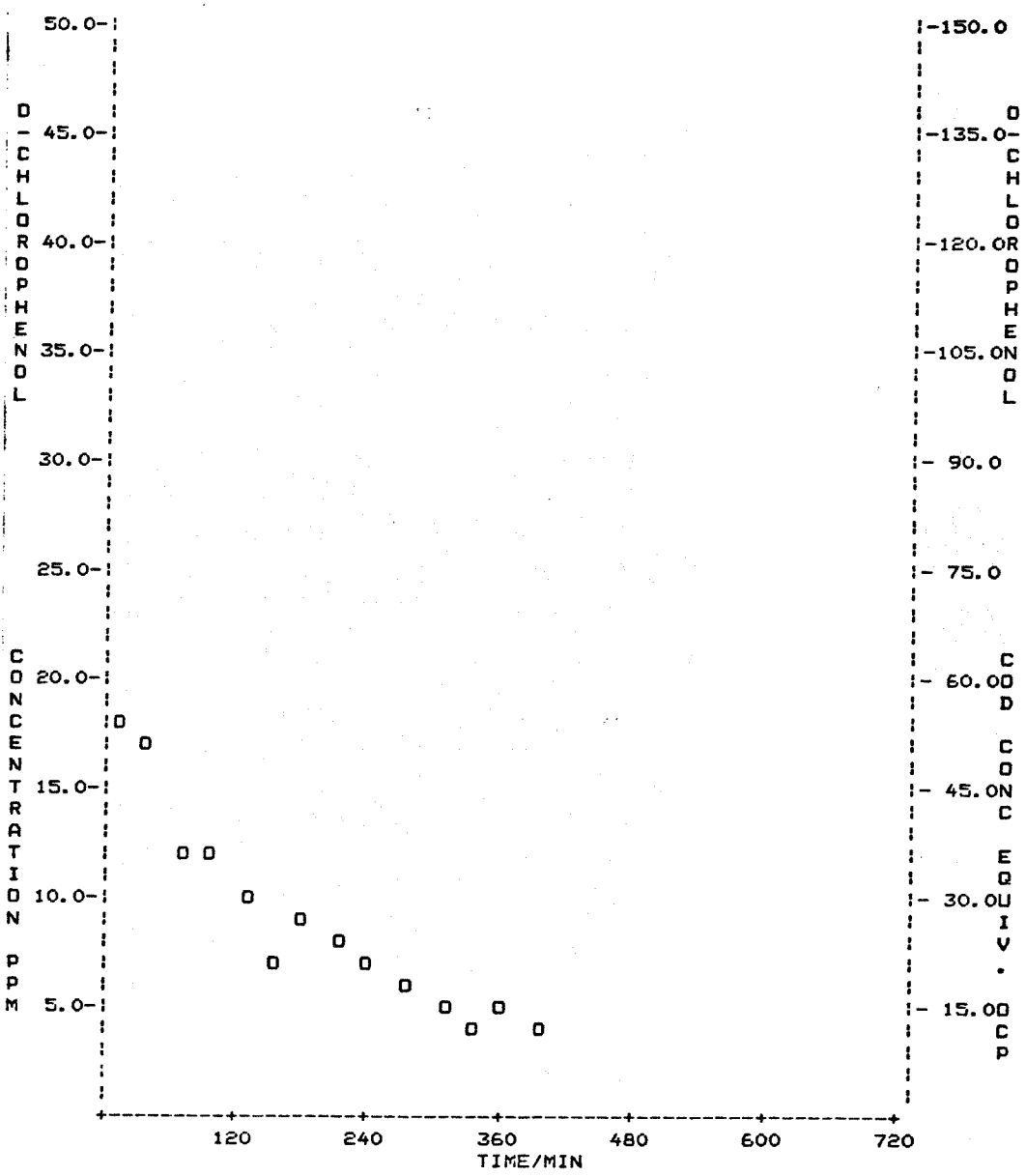


Figure 26
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media BI-CHEM Run I

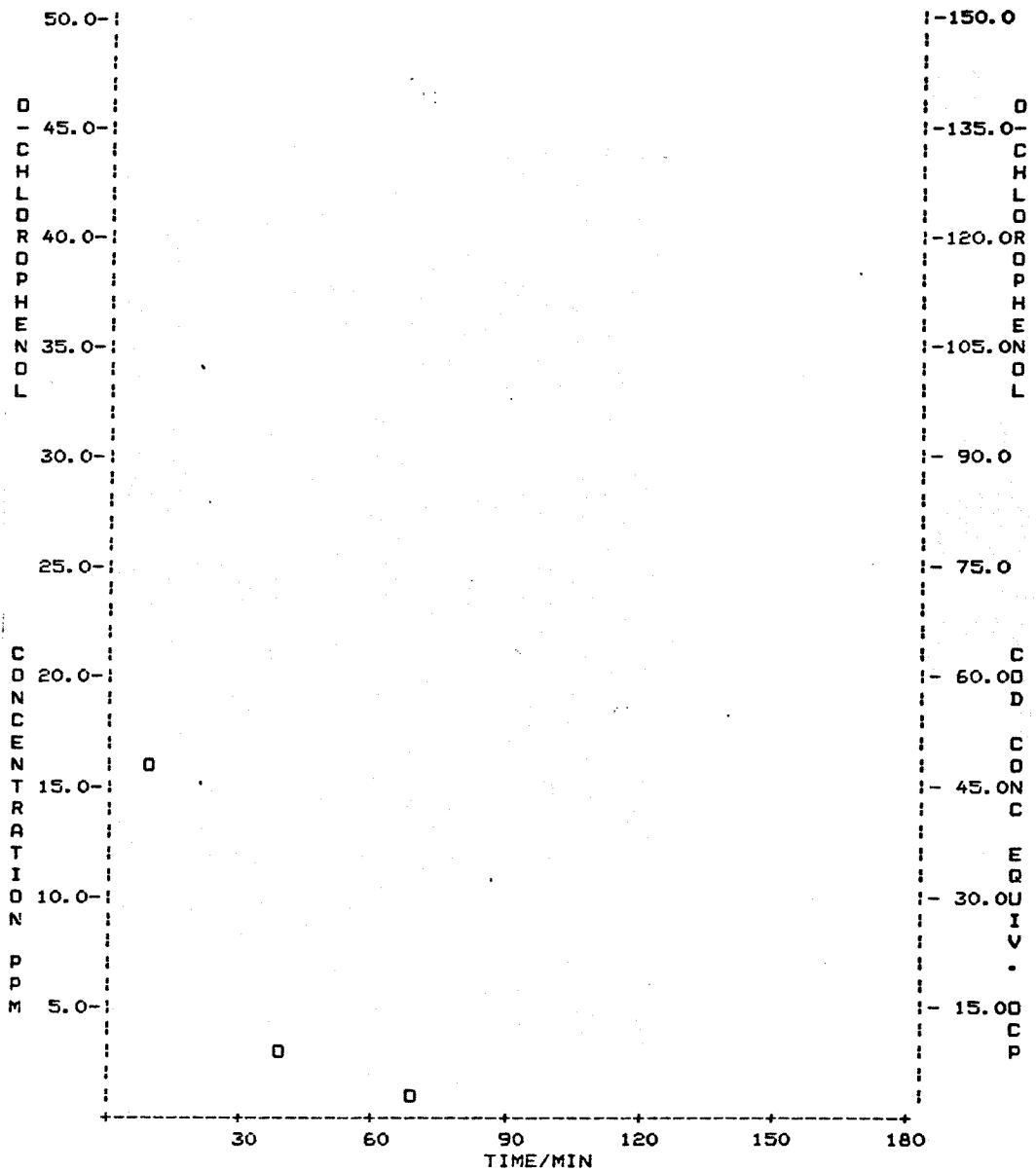


Figure 27
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media BI-CHEM Run II

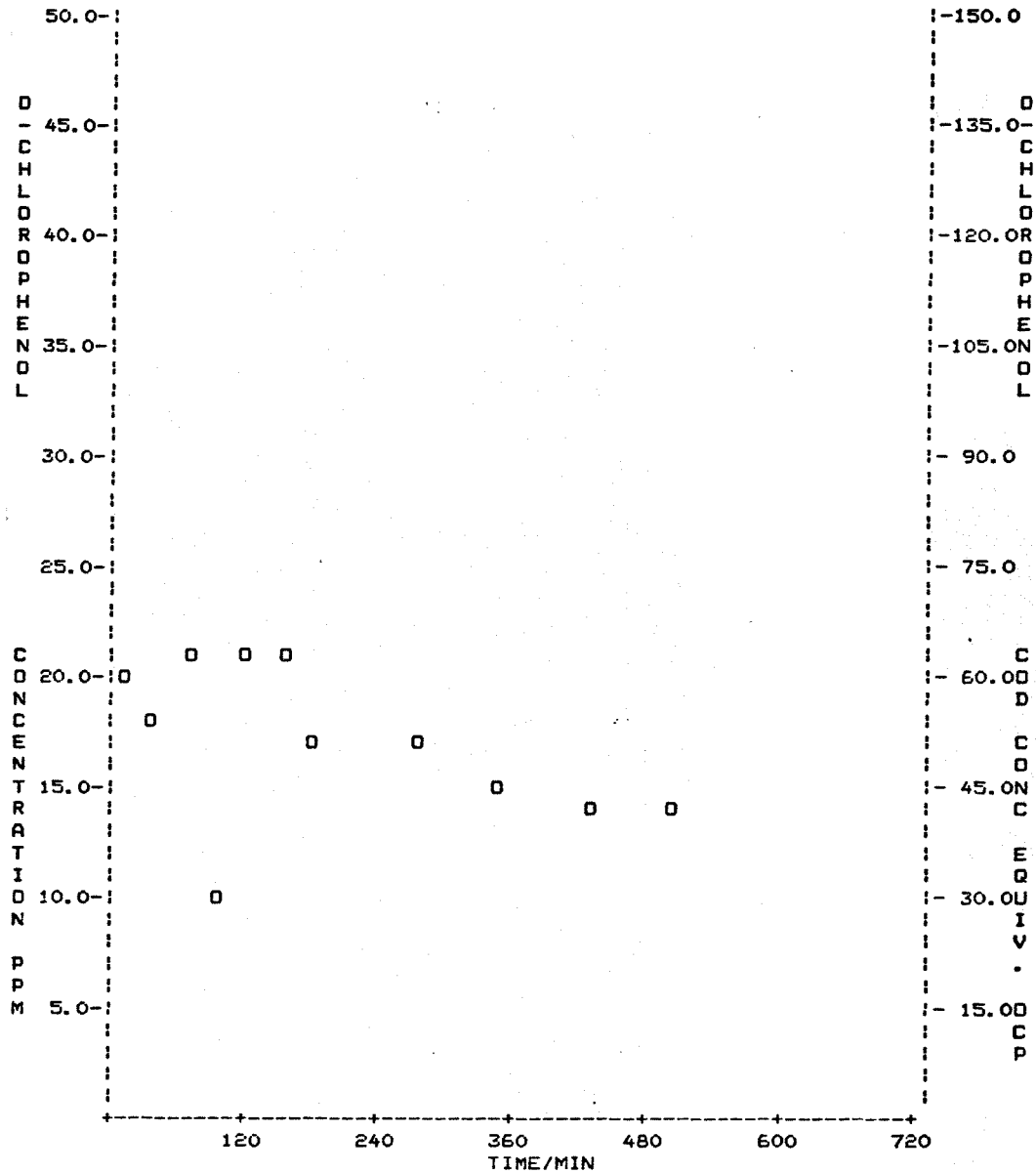


Figure 28
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media BI-CHEM Run III

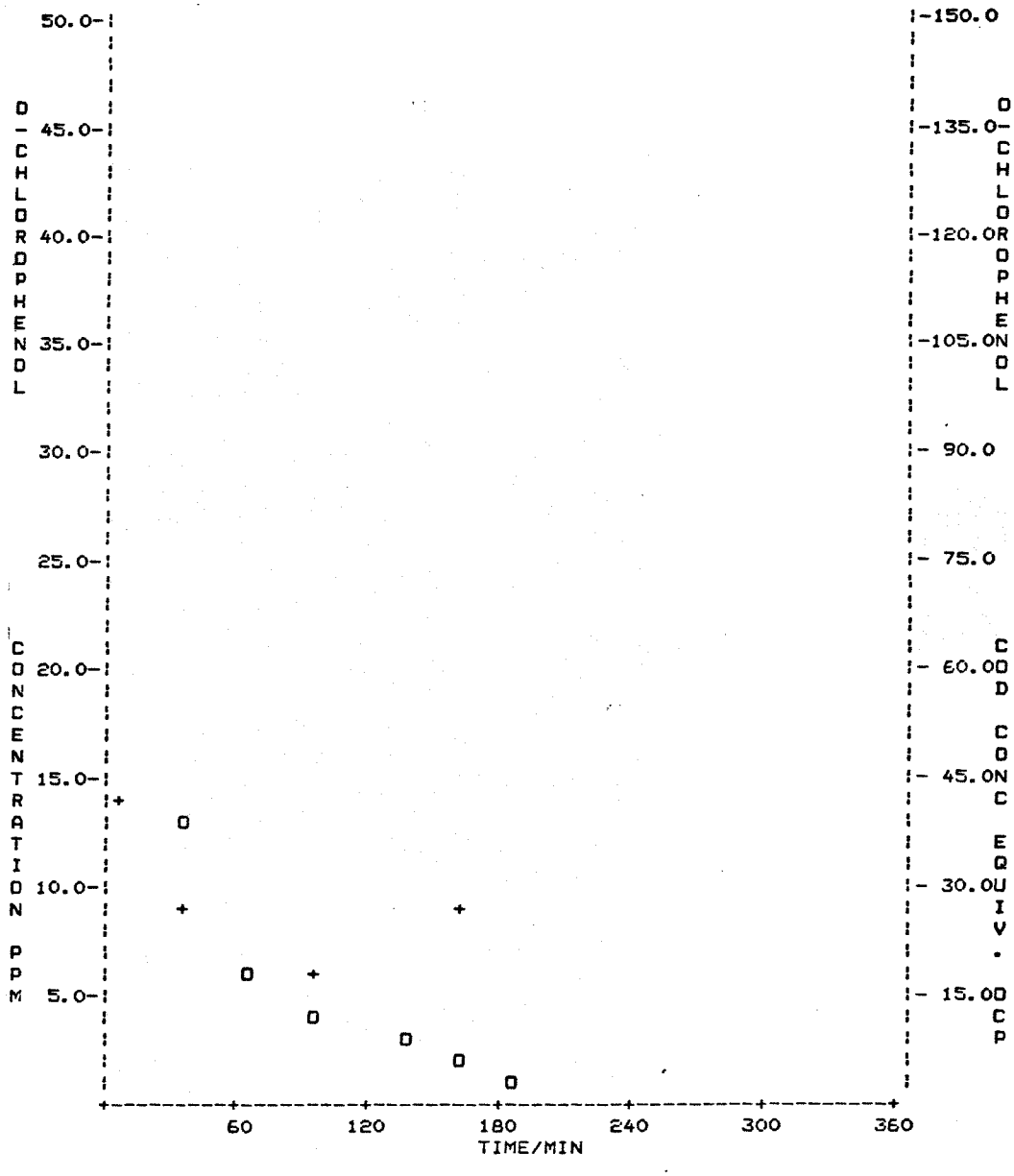


Figure 29
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media BI-CHEM Run IV

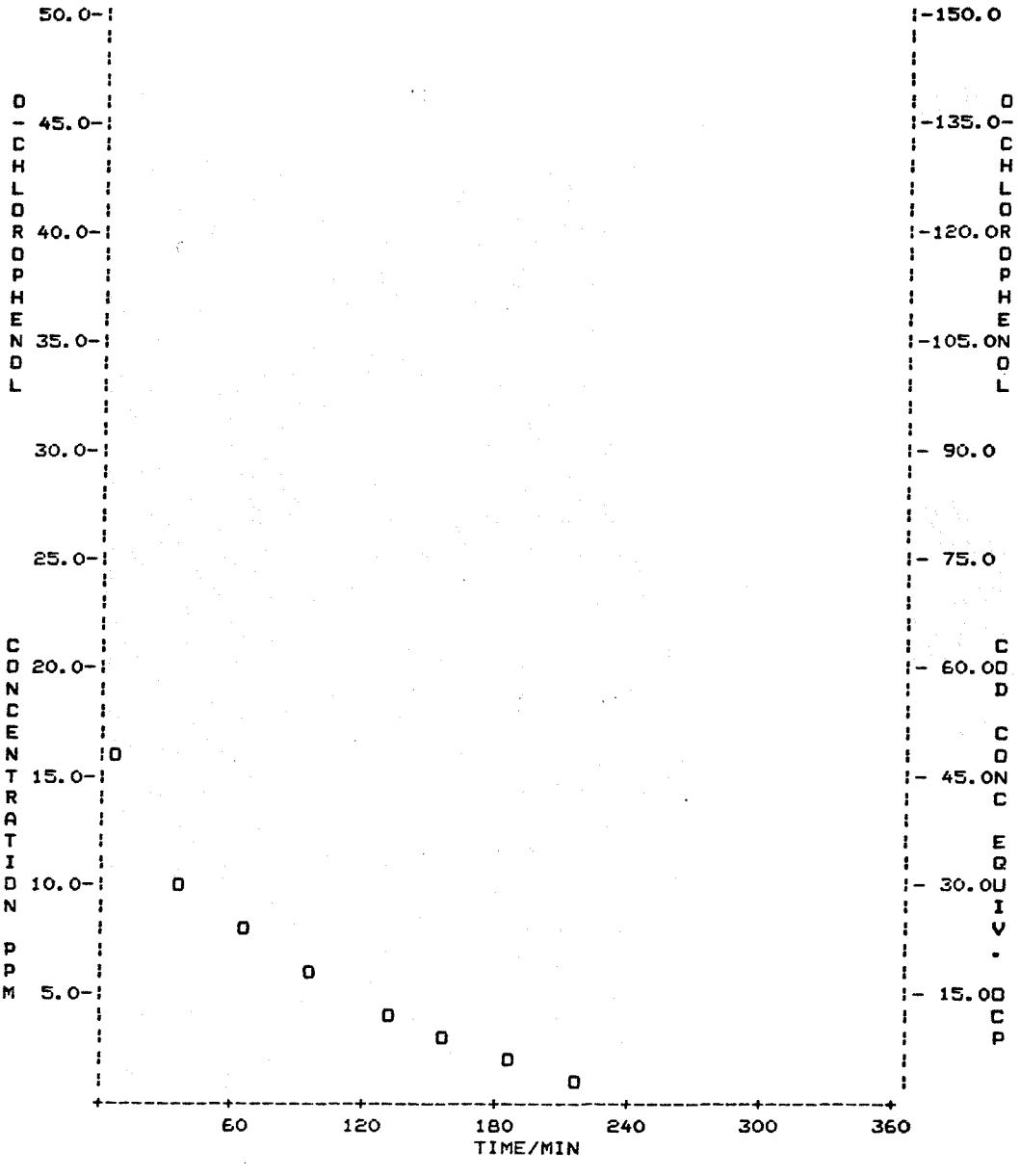


Figure 30
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media Livingston Run I

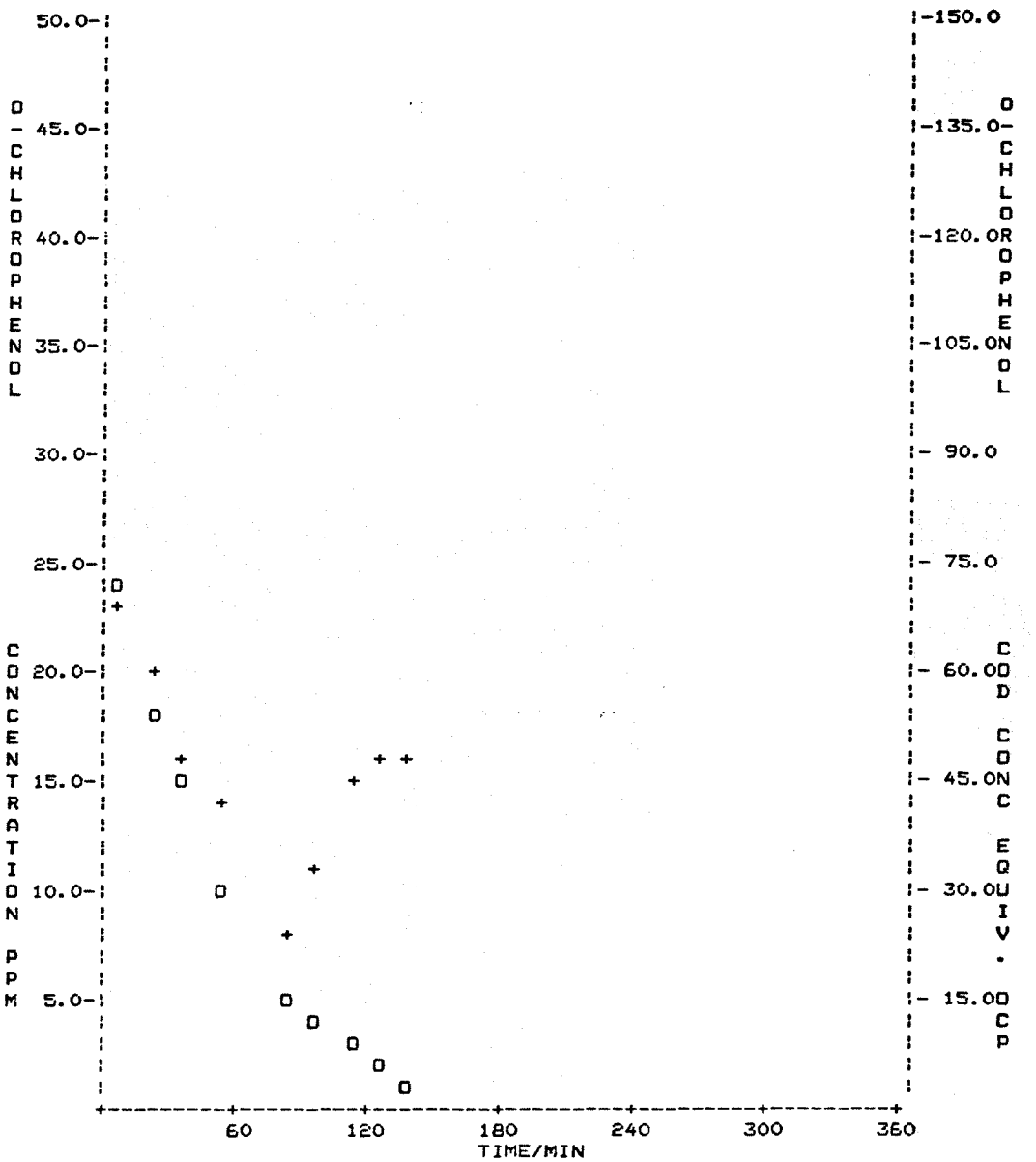


Figure 31
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media Livingston Run II

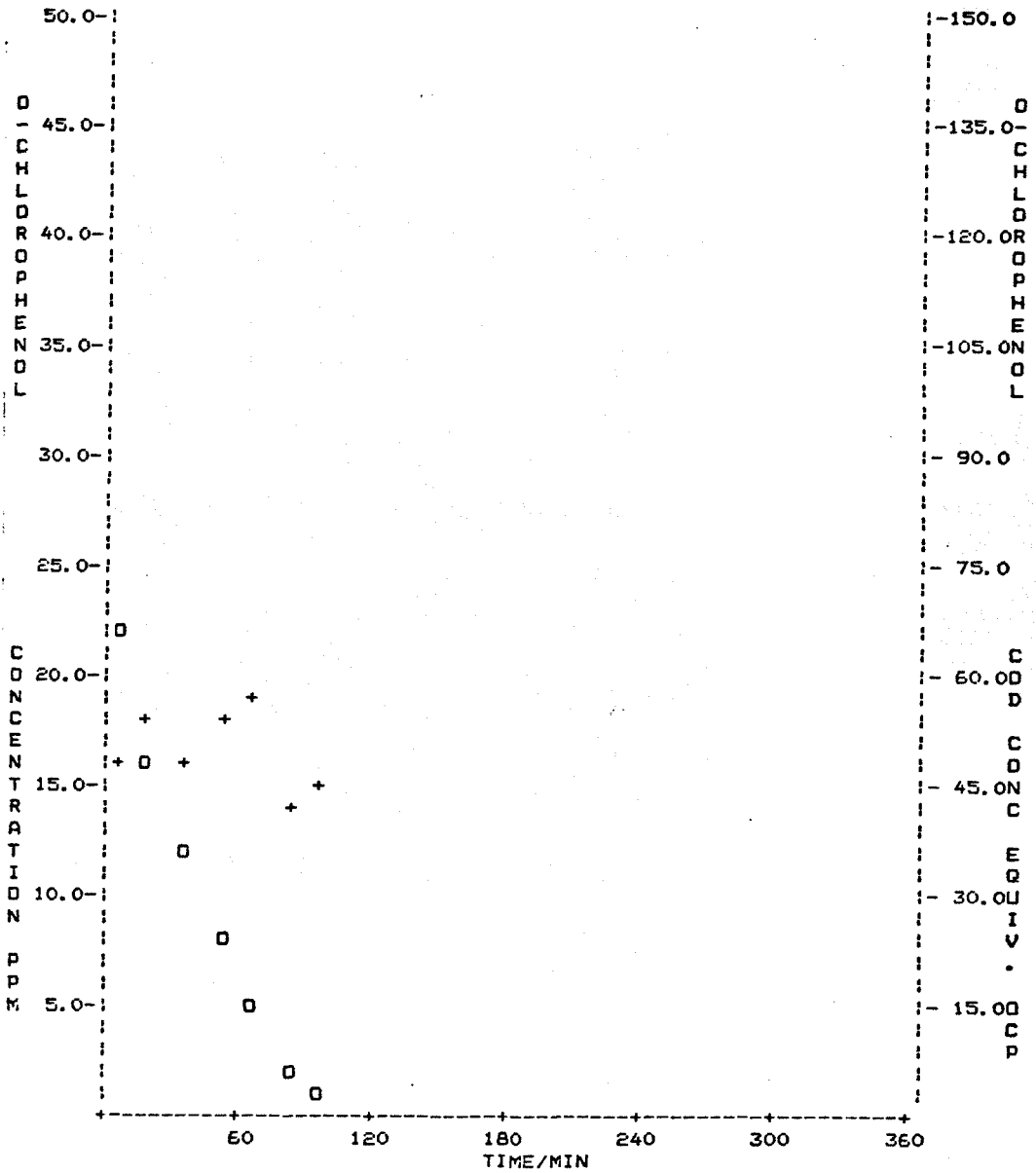


Figure 32
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media Livingston Run III

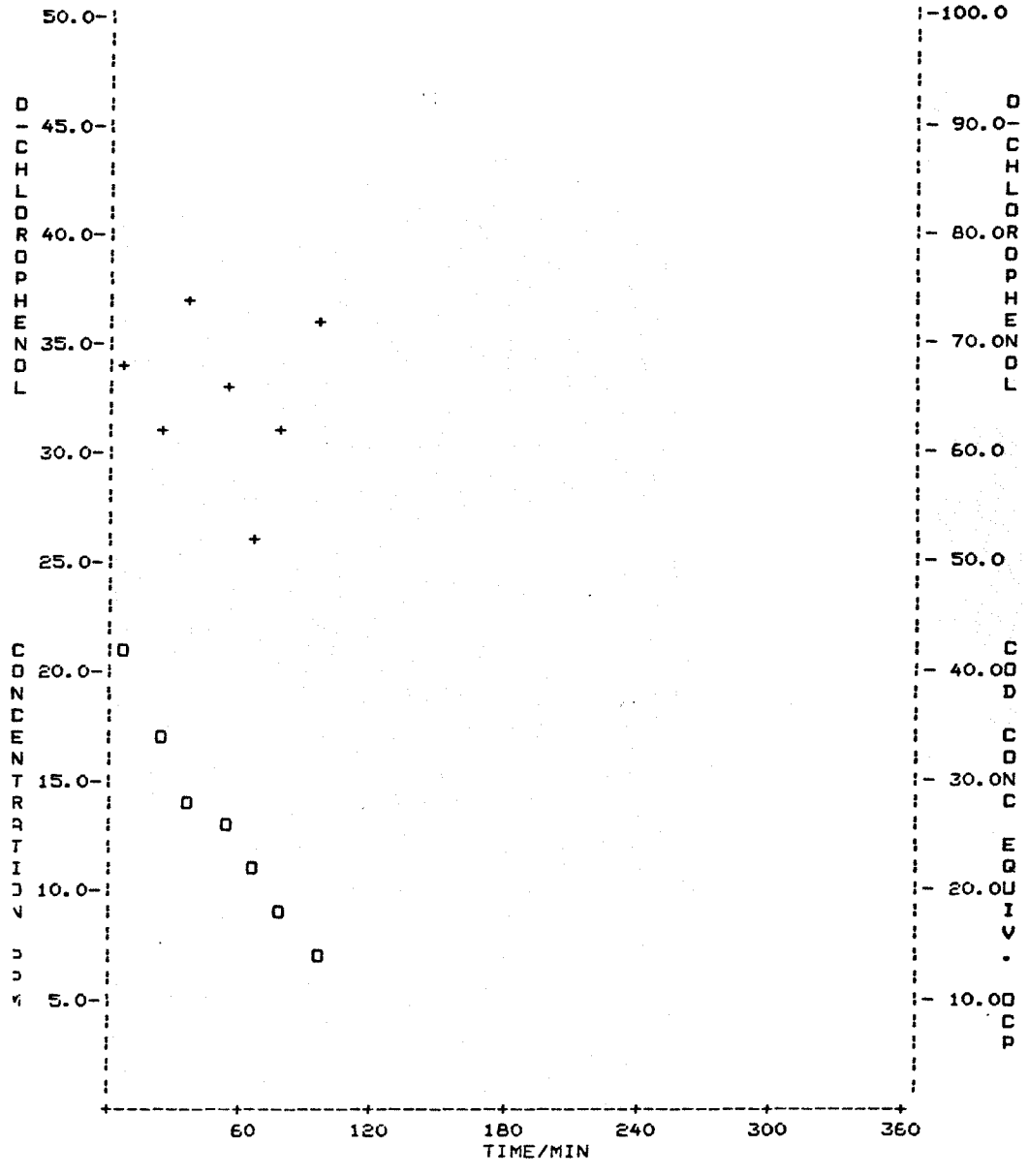


Figure 33
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media LLMD Run I

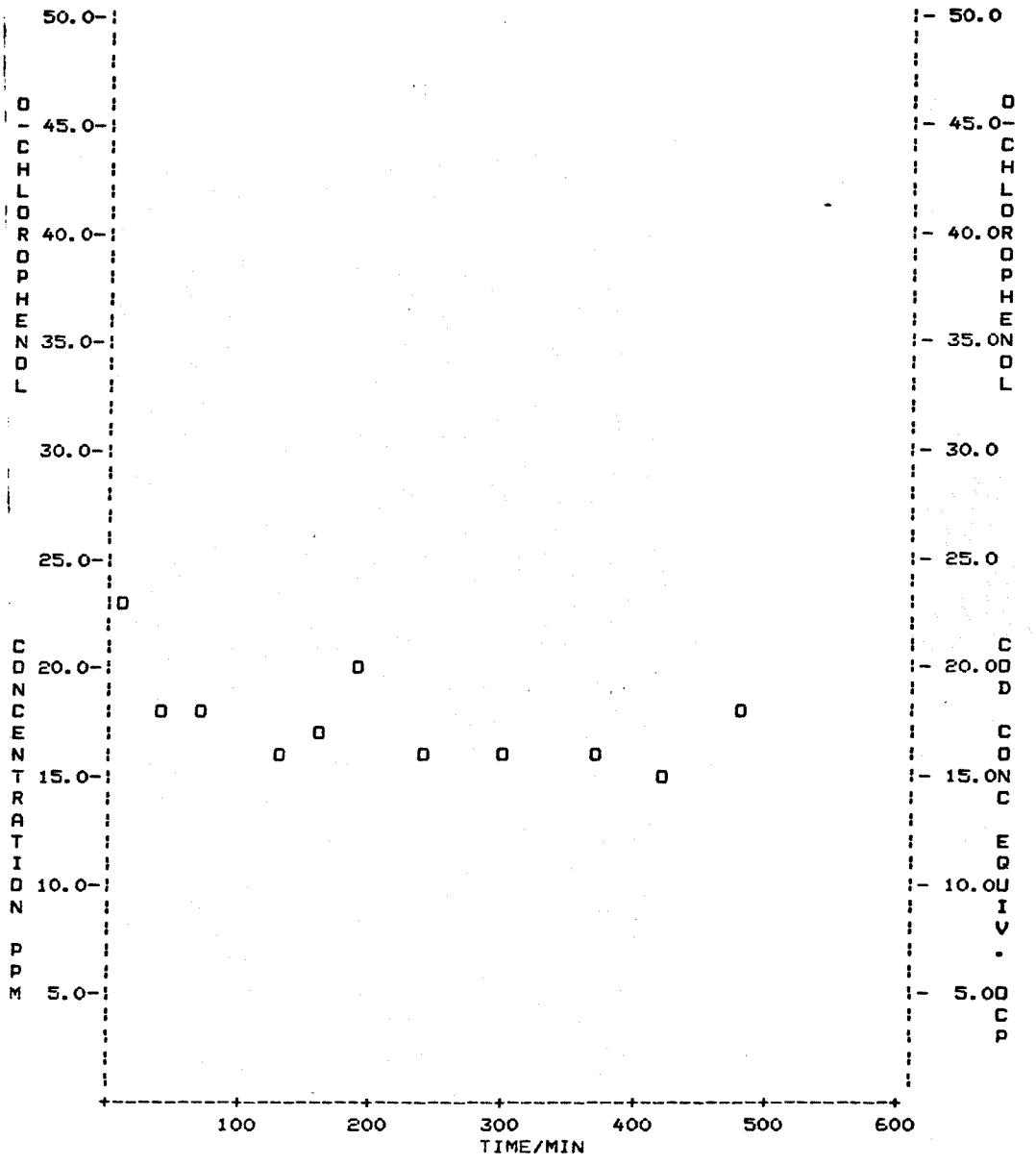


Figure 34
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media LLMD Run II

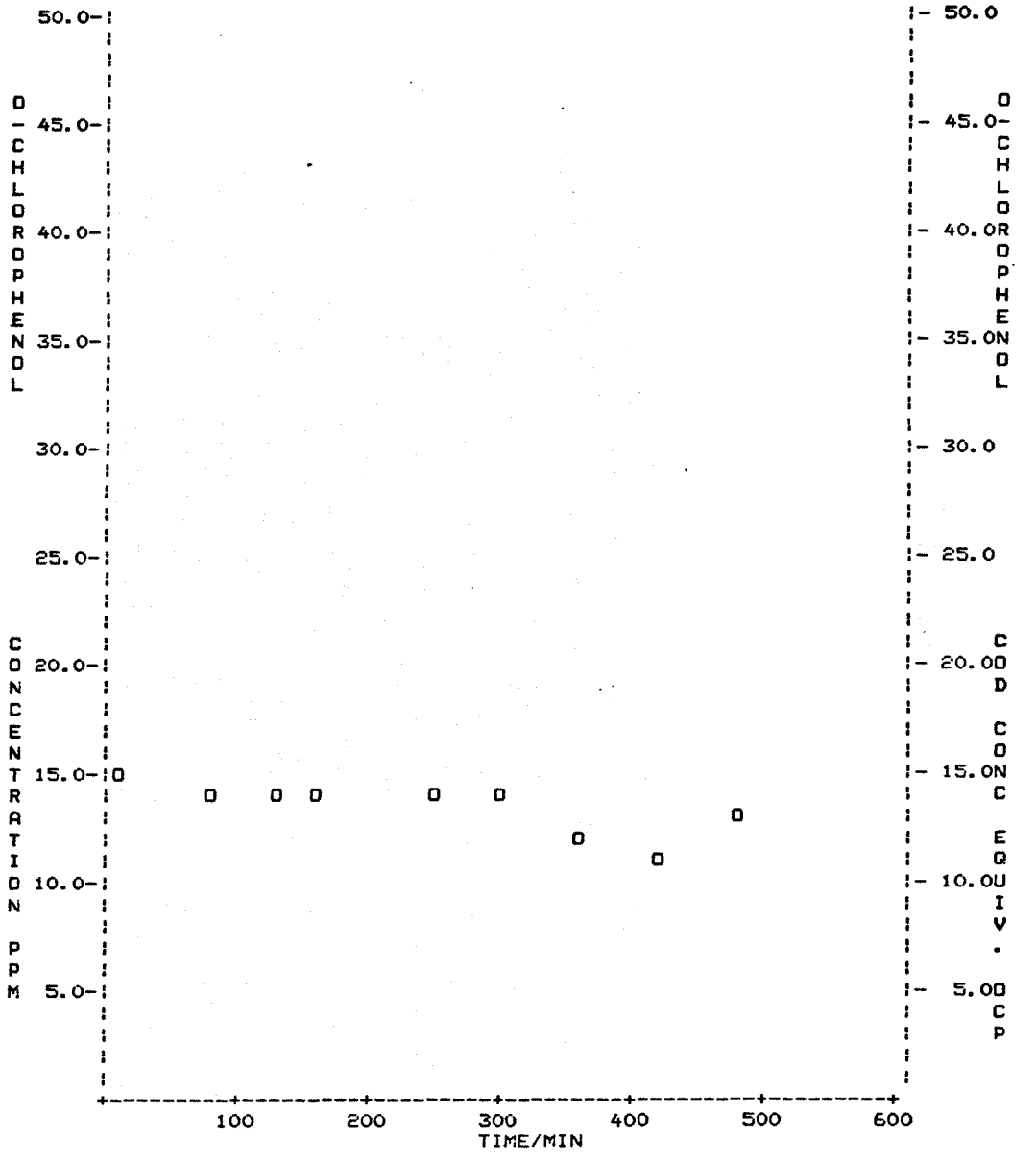


Figure 35
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media LLMO

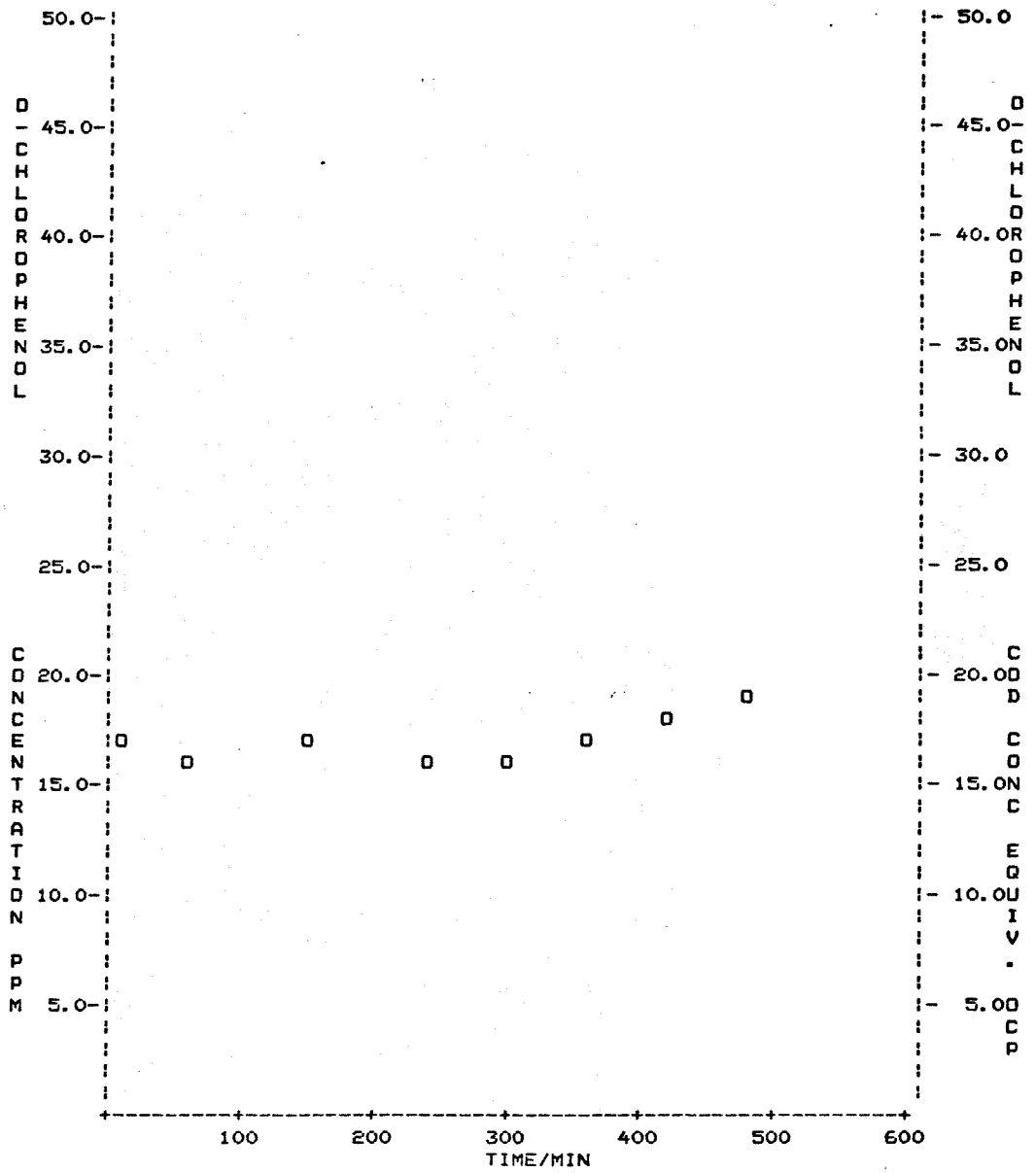


Figure 36
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media Livingston/BI-CHEM Run I

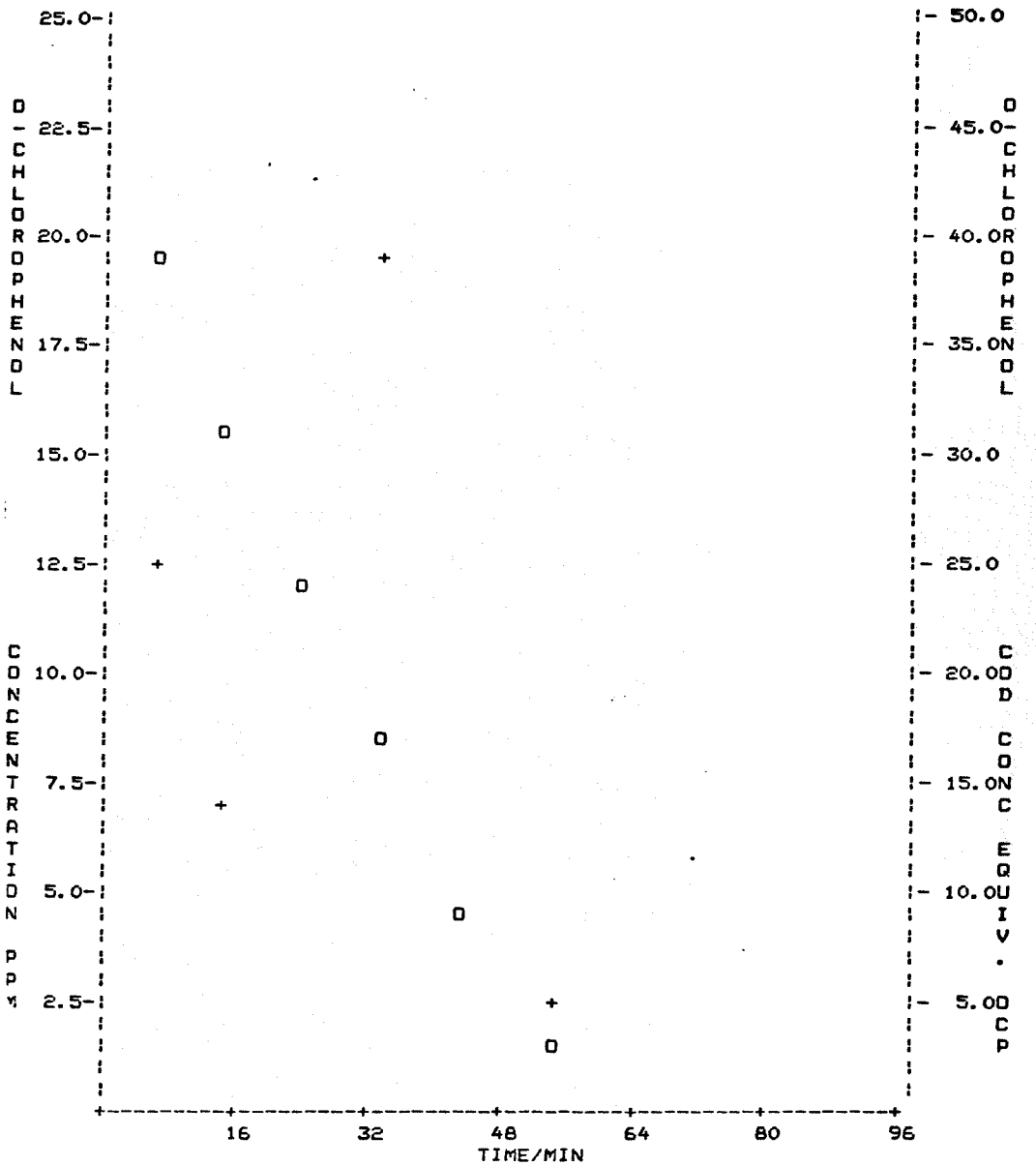


Figure 37
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media Livingston/BIII-CHEM Run I

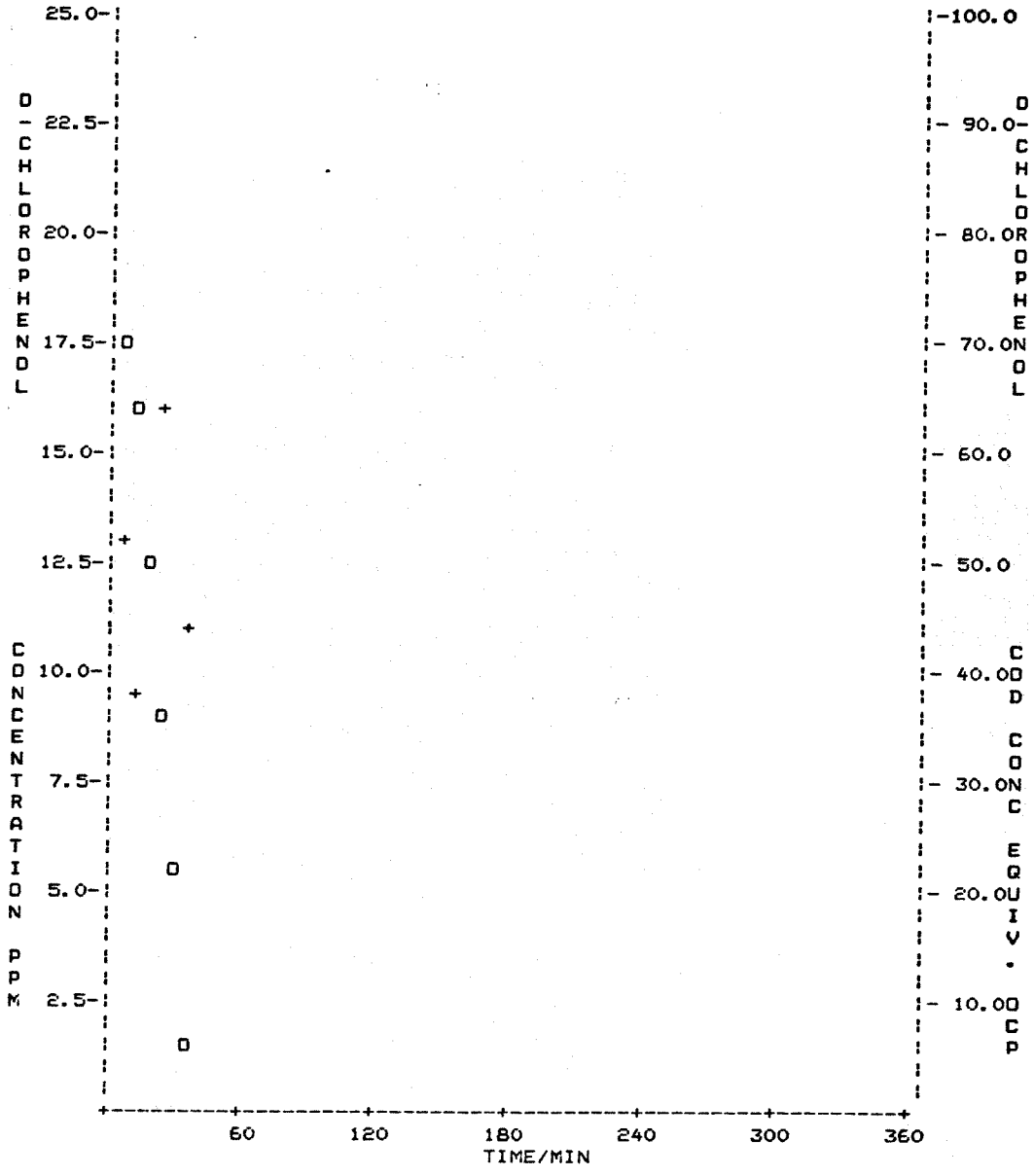


Figure 38
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media Livingston/BI-CHEM Run IV

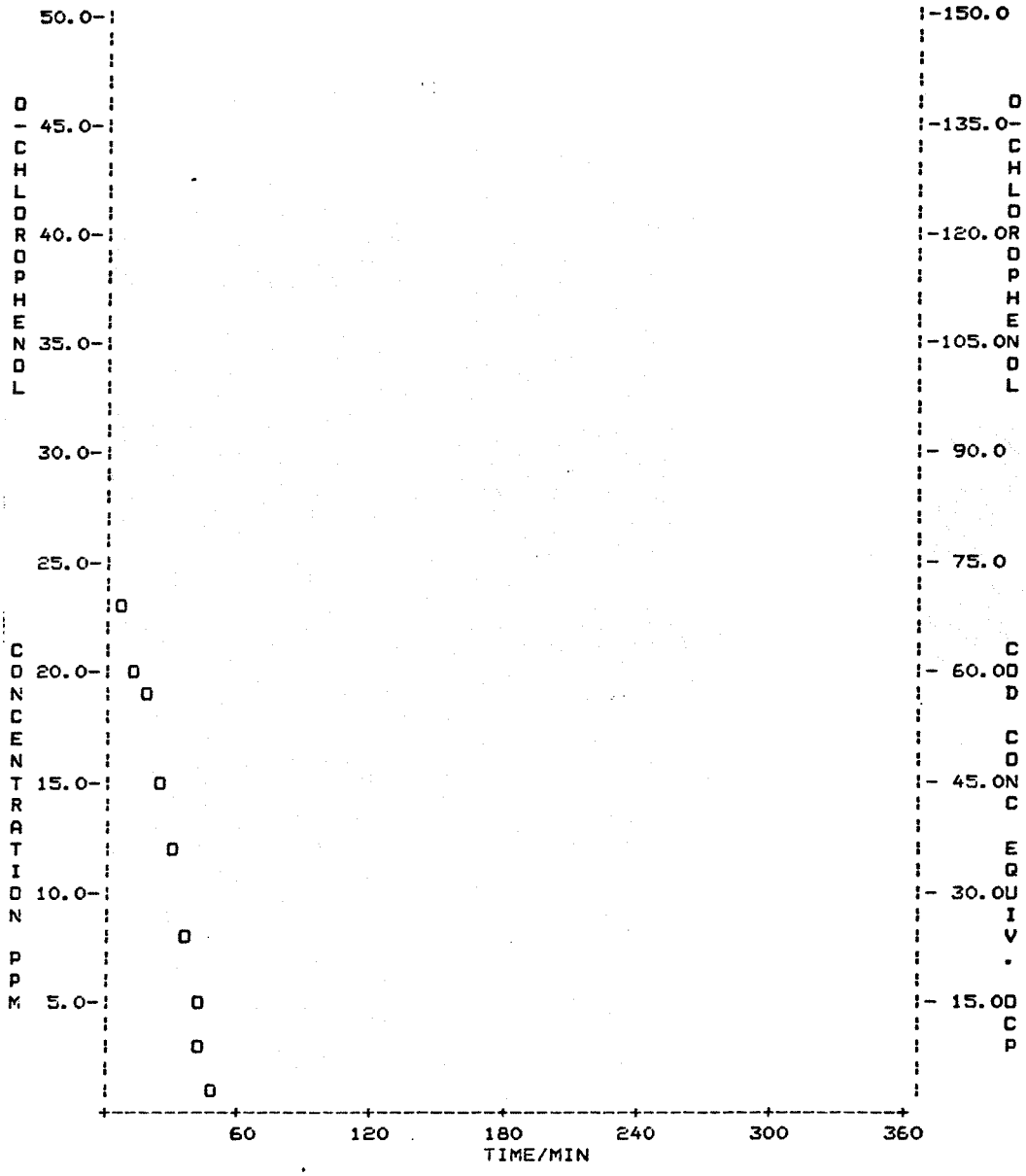


Figure 39
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media Livingston/Hydrobac Run I

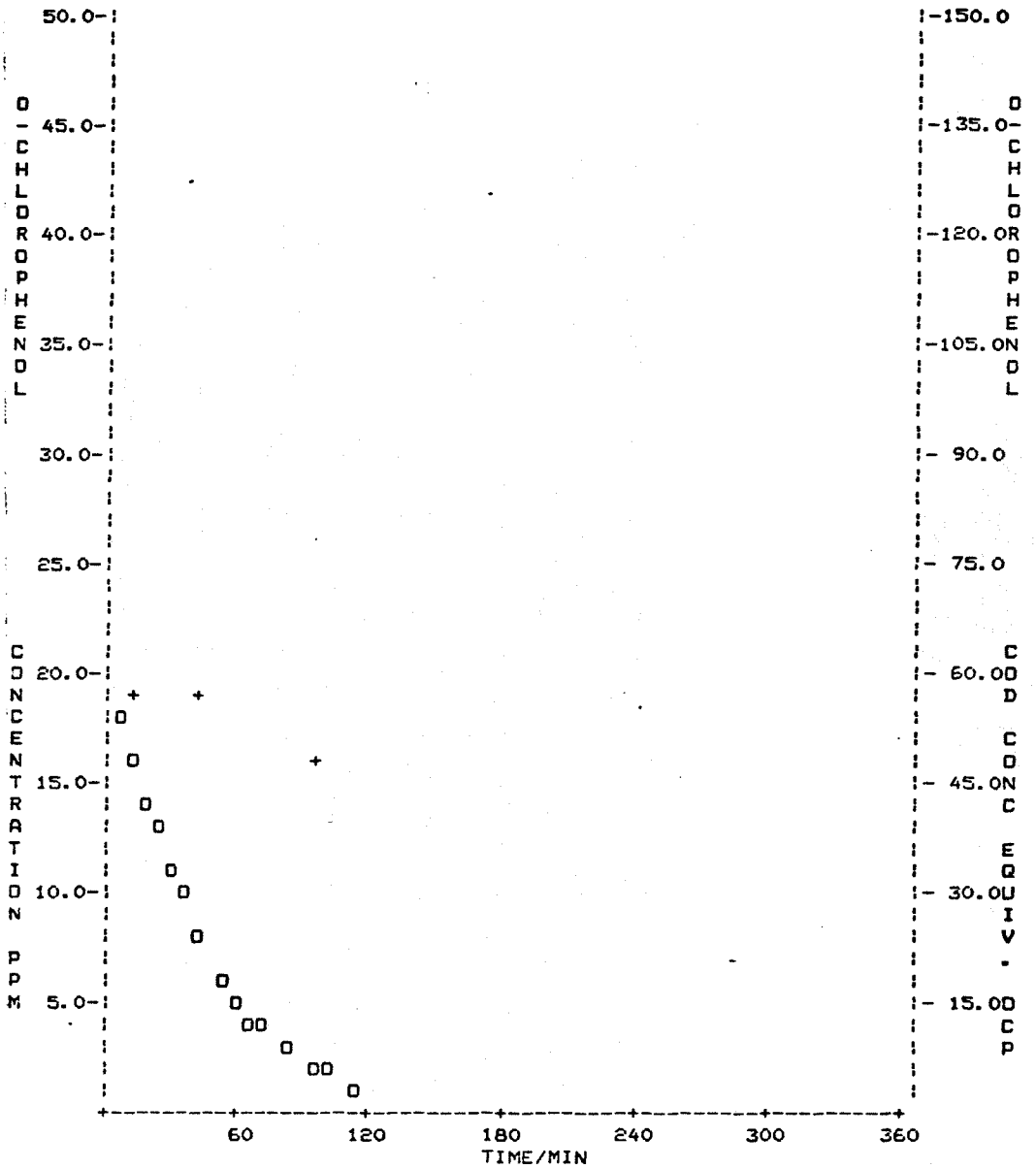


Figure 40
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media Livingston/Hydrobac Run I A

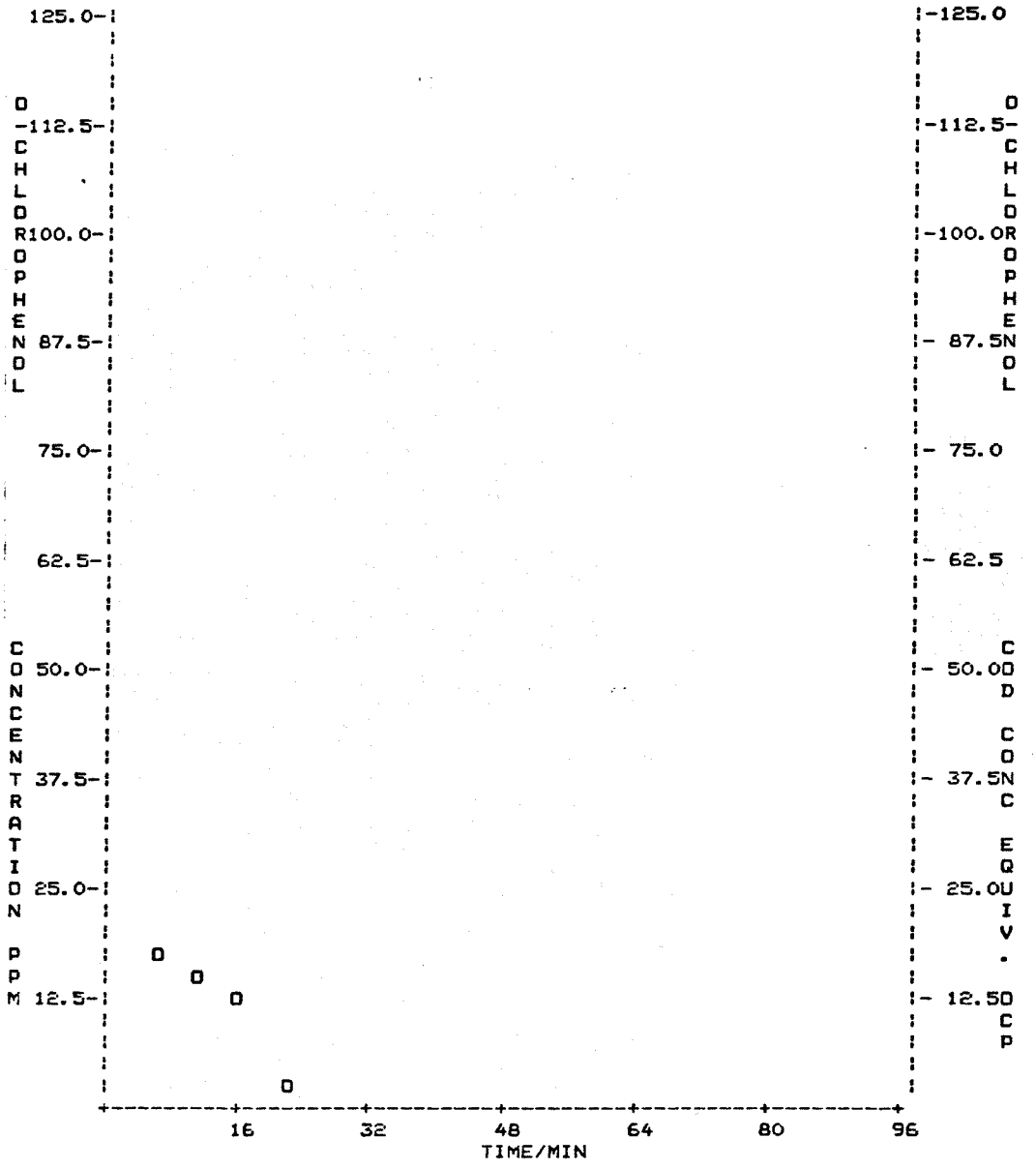


Figure 41
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media Livingston/Hydrobac Run II A

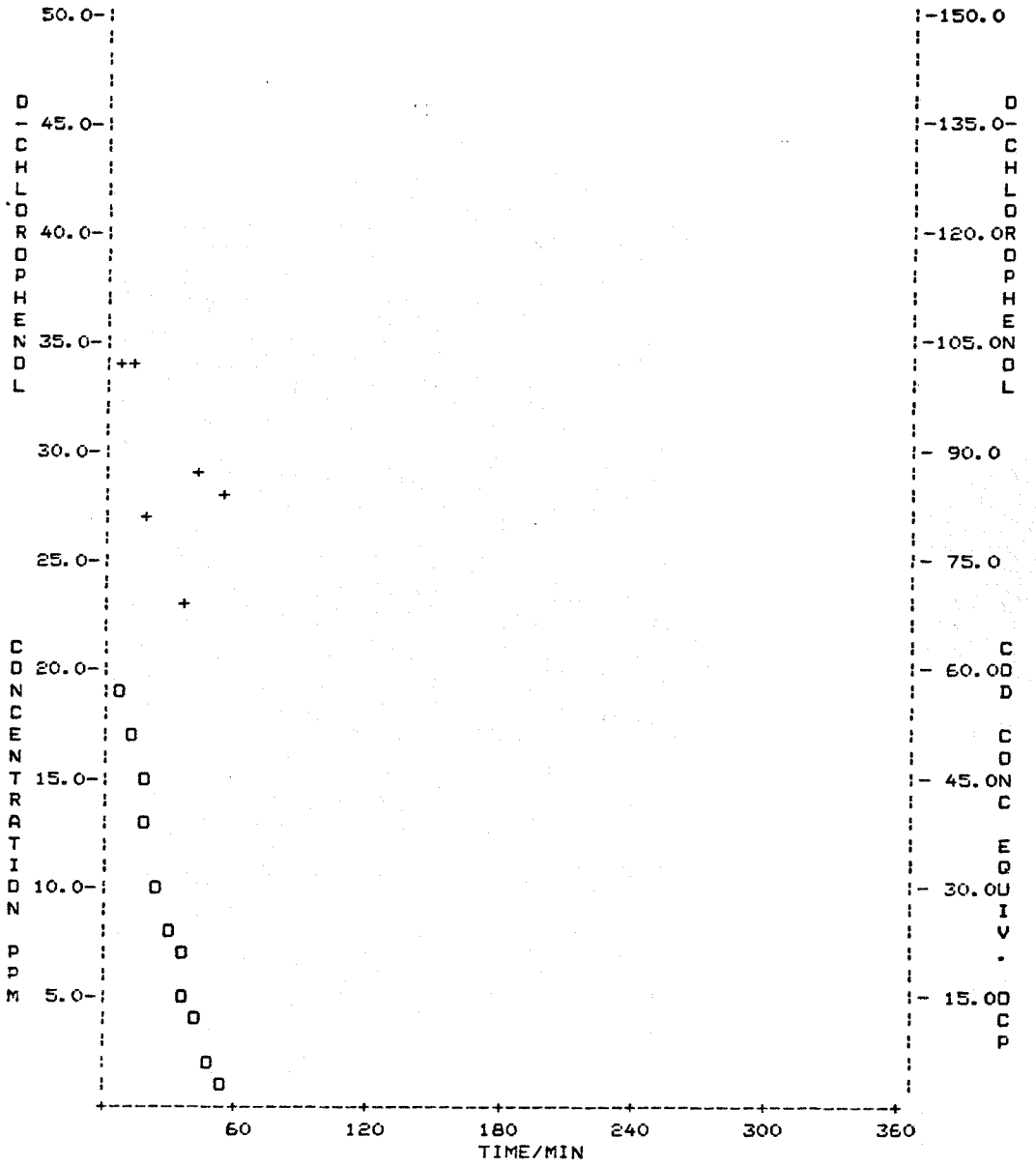


Figure 42
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media Livingston/Hydrobac Run III A

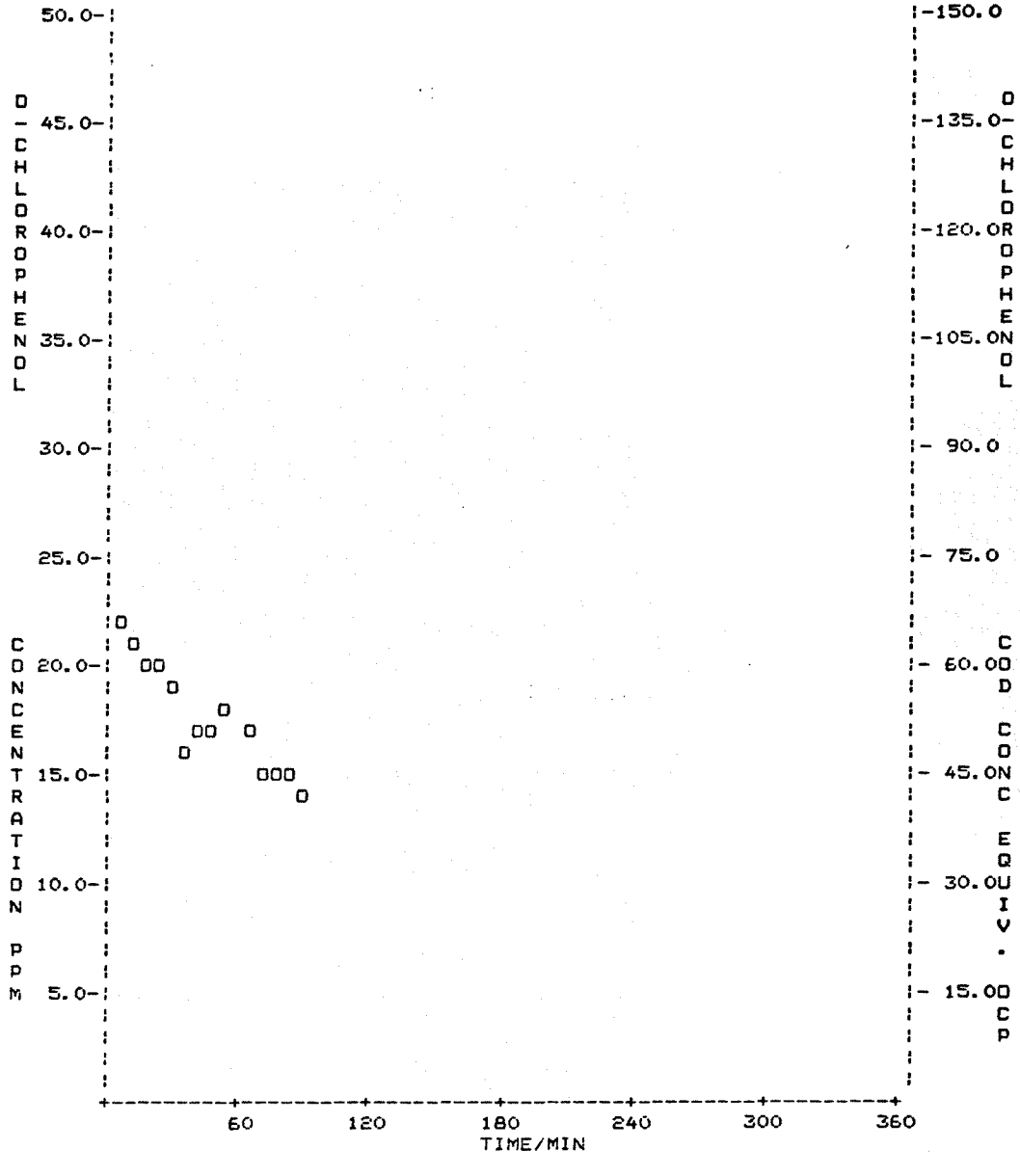


Figure 43
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media Livingston/LLMO Run I

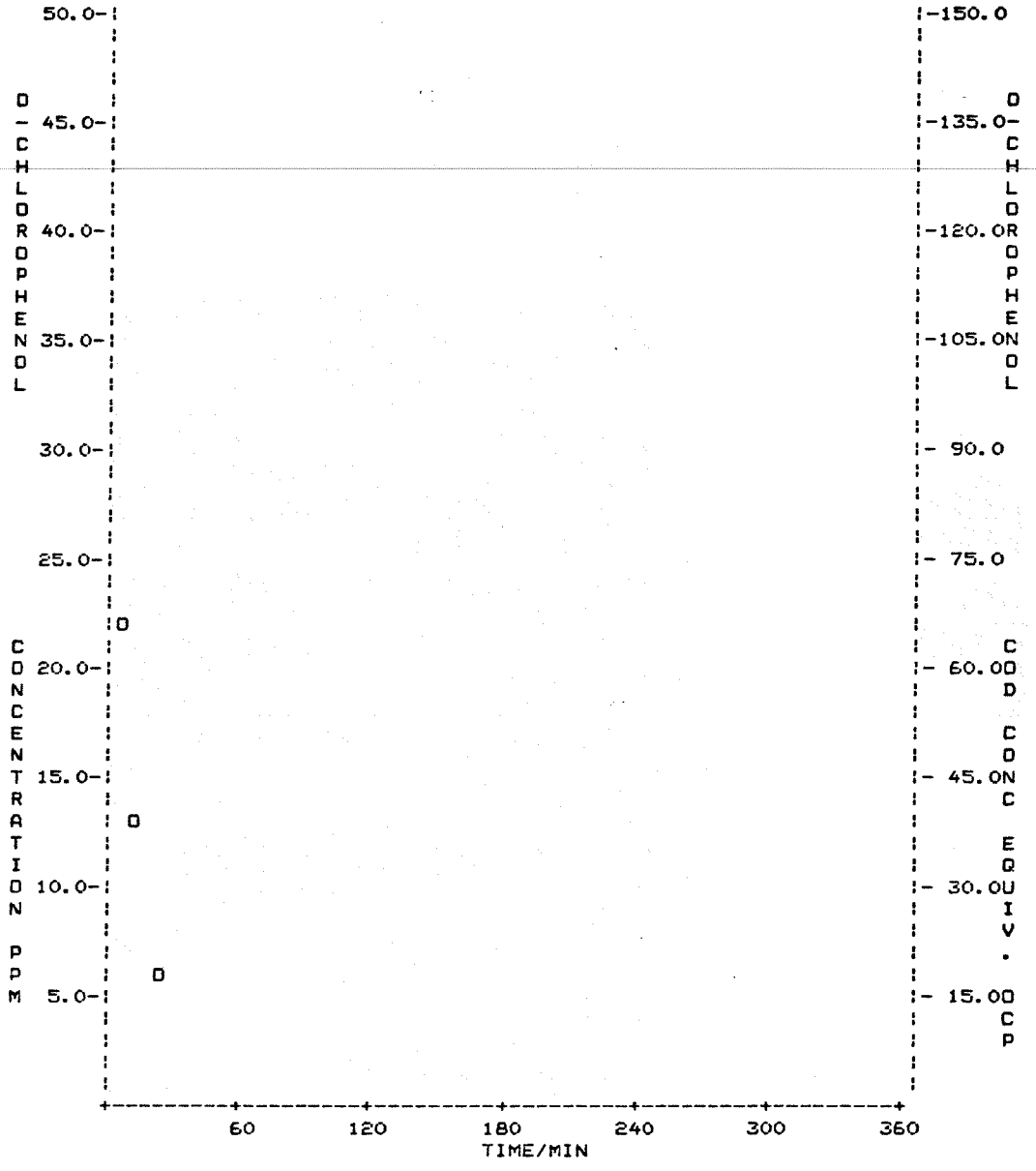


Figure 44
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media Livingston/LLMO Run II

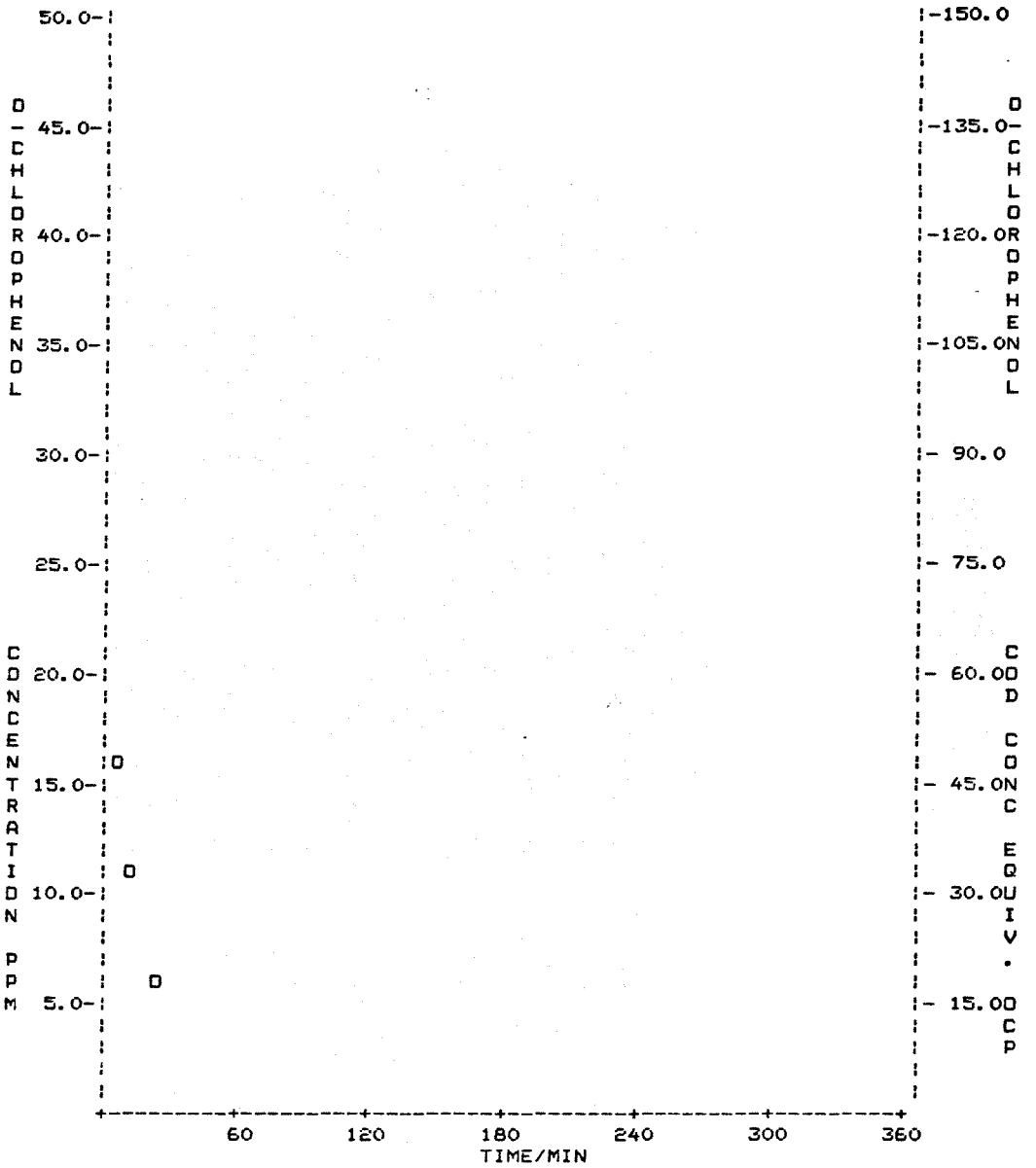
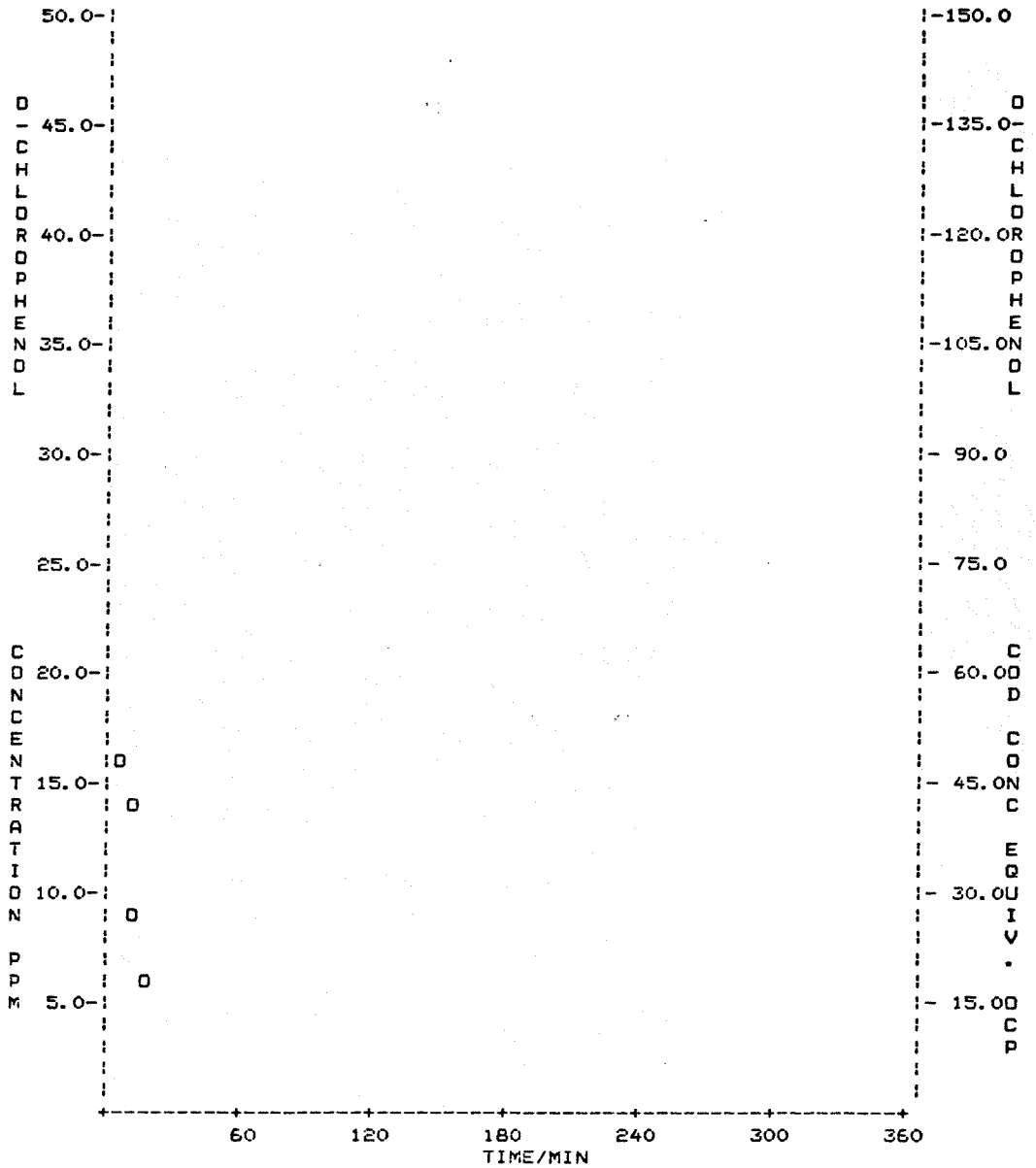


Figure 45
A Plot of Substrate and COD Concentration vs. Time for the Degradation of O-Chlorophenol in the Media Livingston/LLMO Run III



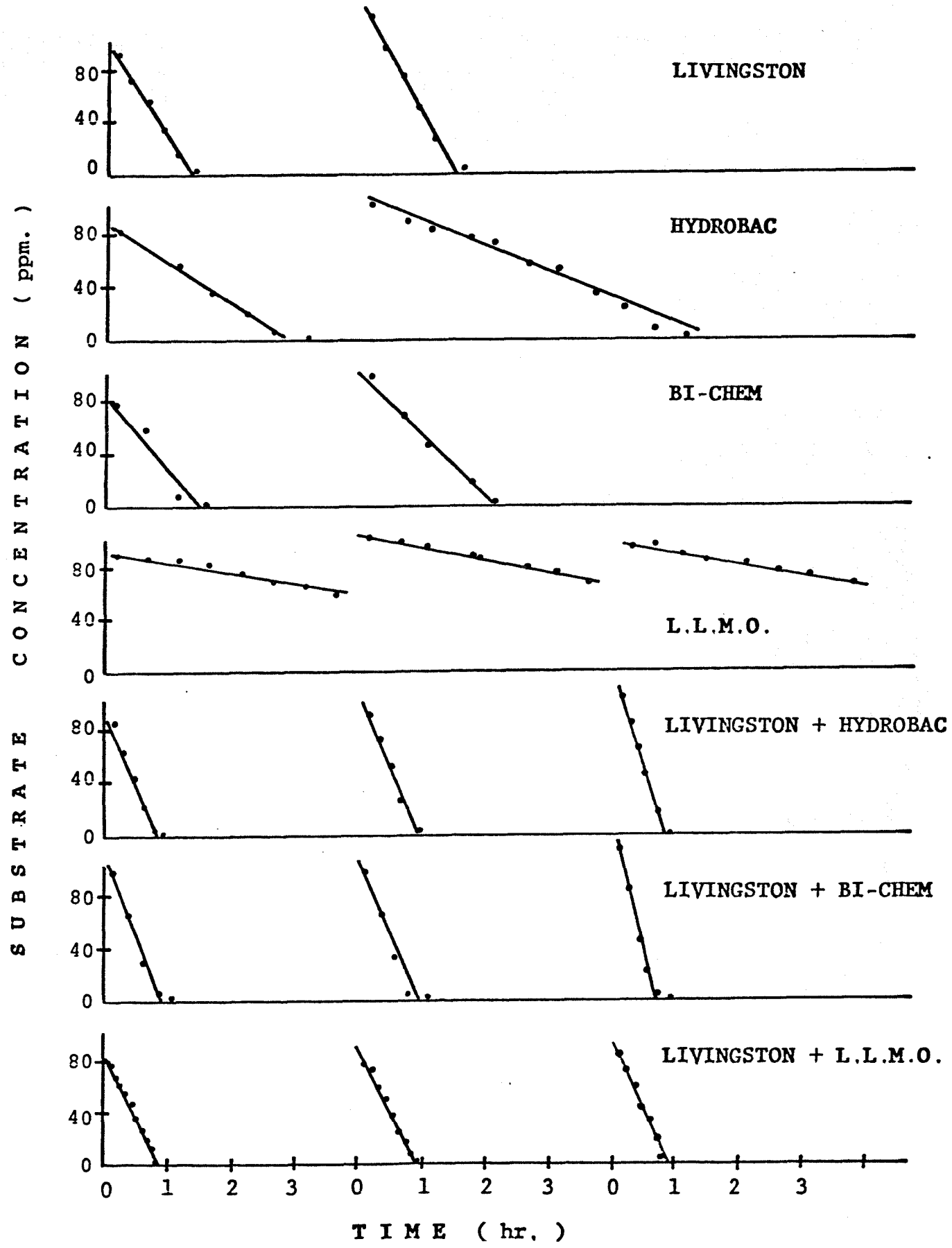


FIGURE 46 PHENOL

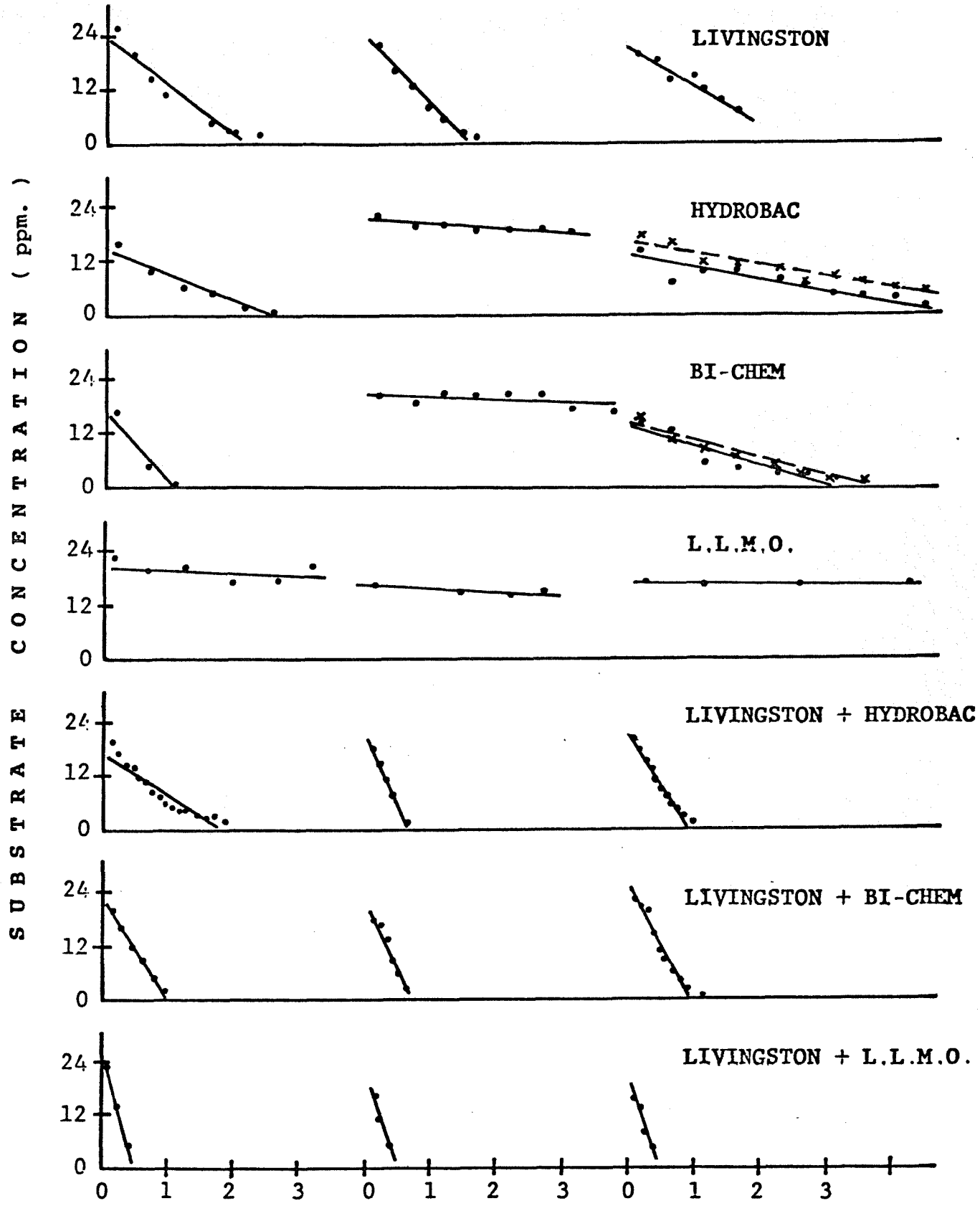


FIGURE 47 O-CHLOROPHENOL

APPENDIX 1. COMPUTER PROGRAM

```
C C ******************************************************* C * * C * Program
FIT written by Nigel McMullen 1983-84 * C * * C * Purpose: To fit sets of
kinetic degradation data * C * to the zero order, Monod, and Haldane * C *
models, and to plot and summarize the * C * data. * C * * C
******************************************************* C
      COMMON TEMP(23,8),CONC(23,8),DATE(23,8),SUBST(23,25)
      DIMENSION Y(23),X(23),TITLE(23,20),A(23,7,7),R(23,7),
     %XLABEL(23,20),YLABEL(23,20),RUN(23,15),IPICT(51,65),
     %YCAL(23),TIME(23),PPM(23),COD(23),PH(23),MLSS(23),
     %G(2,3),NH(23),F(23,50),S(50),B(23,7,7),RLABEL(23,20)
     %,CL(23),DELTAY(23) C X - INDEPENDENT VARIABLE C Y - DEPENDENT VARAIABLE C
NP - # OF POINTS C NOL - # OF LAG POINTS AT START OF RUN C TEMP - TEMPERATURE
(CELCIUS) C CONC - CONCENTRATION OF SUBSTRATE (PPM) C COD - COD CONCENTRATION
(PPM) C DATE - DATE THAT RUN WAS PERFORMED C SUBST - SUBSTRATE NAME C TITLE -
MEDIA NAME C A - CONSTANTS OF INTERGRATION C R - REGRESSION COEFFICIENT C TIME -
TIME OF BIOCIDE ADDED TO SAMPLE (MIN) C PH - pH (-log10[H+]) C NH - AMMONIA
CONCENTRATION (PPM) C MLSS - MIXED LIQUOR SUSPENDED SOLIDS (PPM) C CL - CHLORINE
CONCENTRATION (PPM) C C
      IC=0 1 LC=1
      IC=IC+1
      CALL INPUT(NP,TIME,PPM,COD,PH,NH,MLSS,TITLE,RUN,MAXORD,
     %CL,XS,RS,YS,NOL,XLABEL,YLABEL,RLABEL,IC)
      MODE=-1
      ID=1
      NPT=NP
      DO 11 ISW=1,2
      CALL ZERO(NP,TITLE,RUN,MAXORD,IC,LC,NOL,ISW,
     %TIME,PPM,COD,XS,RS,YS,MODE,XLABEL,RLABEL,YLABEL
     %,A,B,R,DELTAY,YCAL,ERROR) 11 CONTINUE
      NP=NPT
      K1=2
      CALL REPORT(ID,K1,NP,TIME,PPM,COD,PH,NH,MLSS,TITLE,RUN,
     %CL,A,B,R,YCAL,DELTAY,IC,LC,ERROR)
      LC=LC+1
      NP=NPT
      K1=2
      CALL MONOD(TIME,PPM,NP,IC,LC,A,B,R,YCAL,DELTAY,ERROR)
      CALL REPORT(ID,K1,NP,TIME,PPM,COD,PH,NH,MLSS,TITLE,RUN,
     %CL,A,B,R,YCAL,DELTAY,IC,LC,ERROR)
      LC=LC+1
      K1=3
      CALL HALDAN(TIME,PPM,NP,IC,LC,A,B,R,YCAL,DELTAY,ERROR)
      CALL REPORT(ID,K1,NP,TIME,PPM,COD,PH,NH,MLSS,TITLE,RUN,
     %CL,A,B,R,YCAL,DELTAY,IC,LC,ERROR)
      READ(1,*)MORE
      IF(MORE) 17,17,1 17 CALL RESULT(A,R,TITLE,RUN,IC,LC)
      WRITE(2,9090) 9090 FORMAT('1',5X,'TOP OF PAGE')
      WRITE(2,4010) 4010 FORMAT('0','.page')
      WRITE(2,4017) 4017 FORMAT('0','.asis')
       STOP
       END
```

```
      SUBROUTINE INPUT(NP,TIME,PPM,COD,PH,NH,MLSS,TITLE,RUN,
C
C ******************************************************
C *                                                    *
C *     Subroutine INPUT                               *
C *                                                    *
C *     Purpose: To read into the program the data from  *
C *              one run, along with the scales for the  *
C *              the plot and the number of lag points   *
C *              at the start of each run.               *
C *                                                    *
C ******************************************************
C
     %MAXORD,CL,XS,RS,YS,NOL,XLABEL,YLABEL,RLABEL,IC)
      COMMON TEMP(23,8),CONC(23,8),DATE(23,8),SUBST(23,25)
      DIMENSION TITLE(23,20),TIME(23),PPM(23),RUN(23,15),
     %XLABEL(23,20),YLABEL(23,20),COD(23),PH(23),MLSS(23),
     %CL(23),NH(23),RLABEL(23,20)
      IF(IC.GT.1) GO TO 9093
      READ(1,9099)(XLABEL(IC,I),I=1,20)
9099  FORMAT(23A1)
      WRITE(2,9098)(XLABEL(IC,I),I=1,20)
9098  FORMAT('0',5X,20A1)
      READ(1,9095)(RLABEL(IC,I),I=1,20)
9095  FORMAT(23A1)
      WRITE(2,9094)(RLABEL(IC,I),I=1,20)
9094  FORMAT('0',5X,20A1)
      READ(1,9097)(YLABEL(IC,I),I=1,20)
9097  FORMAT(23A1)
      WRITE(2,9096)(YLABEL(IC,I),I=1,20)
9096  FORMAT('0',5X,20A1)
9093  READ(1,9002)(SUBST(IC,I),I=1,25)
9002  FORMAT(25A1)
      WRITE(2,9018)(SUBST(IC,I),I=1,25)
9018  FORMAT('0',5X,25A1)
      READ(1,9004)(TITLE(IC,I),I=1,20)
9004  FORMAT(23A1)
      WRITE(2,9005)(TITLE(IC,I),I=1,20)
9005  FORMAT('0',5X,20A1)
      READ(1,9003)(CONC(IC,I),I=1,8)
9003  FORMAT(8A1)
      WRITE(2,9012)(CONC(IC,I),I=1,8)
9012  FORMAT('0',5X,8A1)
      READ(1,9013)(DATE(IC,I),I=1,8)
9013  FORMAT(8A1)
      WRITE(2,9014)(DATE(IC,I),I=1,8)
9014  FORMAT('0',5X,8A1)
      READ(1,9007)(RUN(IC,I),I=1,15)
9007  FORMAT(15A1)
      WRITE(2,9008)(RUN(IC,I),I=1,15)
9008  FORMAT('0',5X,15A1)
      READ(1,9016)(TEMP(IC,I),I=1,8)
9016  FORMAT(8A1)
      WRITE(2,9017)(TEMP(IC,I),I=1,8)
9017  FORMAT('0',5X,8A1)
      READ(1,*)NP
      WRITE(2,9000)NP
9000  FORMAT('A',5X,'NUMBER OF PTS = ',I3)
      WRITE(2,9001)
```

```
9001  FORMAT('0',5X,'TIME(I)',10X,'PPM(I)',10X,'COD(I)')
      DO 10 I=1,NP
      READ(1,*)TIME(I),PPM(I),COD(I),PH(I),MLSS(I),NH(I),CL(I)
      WRITE(2,*)TIME(I),PPM(I),COD(I)
10    CONTINUE
      READ(1,*)MAXORD
      READ(1,*)XS,RS,YS,NOL
      RETURN
      END
```

```
      SUBROUTINE ZERO(NP,TITLE,RUN,MAXORD,IC,LC,NOL,ISW,
C
C ******************************************************
C *                                                    *
C *     Subroutine ZERO                                *
C *                                                    *
C *     PURPOSE: To execute first substrate concentration*
C *              followed by COD concentration in to a  *
C *              series of subroutines to determine the *
C *              constants of intergration by the method *
C *              of least-squares for the zero order    *
C *              model.                                 *
C *                                                    *
C ******************************************************
C
     %TIME,PPM,COD,XS,RS,YS,MODE,XLABEL,RLABEL,YLABEL
     %,A,B,R,DELTAY,YCAL,ERROR)
      COMMON TEMP(23,8),CONC(23,8),DATE(23,8),SUBST(23,25)
      DIMENSION Y(23),X(23),TITLE(23,20),A(23,7,7),R(23,7),
     %XLABEL(23,20),YLABEL(23,20),RUN(23,15),IPICT(51,65),
     %YCAL(23),TIME(23),PPM(23),COD(23),PH(23),MLSS(23),
     %B(23,7,7),DELTAY(23),NH(23),RLABEL(23,20)
      IF(ISW.GT.1) GO TO 4500
      DO 4030 I=1,NP
      X(I)=TIME(I)
      Y(I)=PPM(I)
4030  CONTINUE
      GO TO 4070
4500  DO 4050 I=1,NP
      Y(I)=COD(I)
      X(I)=TIME(I)
4050  CONTINUE
      MODE=-1
C     IF MODE ) 0 DO NOT PLOT DATA
C     IF MODE  0 PLOT COD AND SUBSTRATE VS TIME DATA
4070  CALL EXECUT(NP,TIME,PPM,X,Y,TITLE,RUN,MAXORD,IC,LC,NOL,ISW,
     %A,B,YCAL,DELTAY,R,XS,RS,YS,MODE,XLABEL,RLABEL,YLABEL,ERROR)
      RETURN
      END
```

```
      SUBROUTINE EXECUT(NP,TIME,PPM,X,Y,TITLE,RUN,MAXORD,IC,LC,NOL,ISW,
     %A,B,YCAL,DELTAY,R,XS,RS,YS,MODE,XLABEL,RLABEL,YLABEL,ERROR)
C
C ******************************************************
C *                                                    *
C *       SUBROUTINE EXECUT                            *
C *                                                    *
C *       Purpose: To sort the input data so that if any *
C *                lag points are included at the start  *
C *                of a data set they are not used in any*
C *                calculations for the kinetic constants*
C *                                                    *
C ******************************************************
C
      COMMON TEMP(23,8),CONC(23,8),DATE(23,8),SUBST(23,25)
      DIMENSION Y(23),X(23),TITLE(23,20),A(23,7,7),R(23,7),
     %XLABEL(23,20),YLABEL(23,20),RUN(23,15),IPICT(51,65),
     %YCAL(23),TIME(23),PPM(23),COD(23),PH(23),MLSS(23),
     %NH(23),B(23,7,7),DELTAY(23),RLABEL(23,20)
      IF(ISW.EQ.1) GO TO 19
      DO 15 I=1,NP
      IF(Y(I).GE.0) GO TO 15
      L=I+1
      DO 12 J=L,NP
      K=J-1
      X(K)=X(J)
      Y(K)=Y(J)
12    CONTINUE
      NP=NP-1
15    CONTINUE
19    DO 18 LAG=1,NOL
      IF(ISW.GT.1) GO TO 98
      CALL FITIT(K1,NP,LAG,X,Y,MAXORD,YCAL,DELTAY,IC,LC,
     %A,B,R,ERROR)
98    CALL PLOT(TITLE,ISW,XS,YS,NP,IC,LAG,MODE,X,Y,XLABEL,
     %RS,RLABEL,YLABEL)
18    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE FITIT(K1,NP,LAG,X,Y,MAXORD,YCAL,DELTAY,IC,LC,
     %A,B,R,ERROR)
C
C       THIS PROGRAM FITS A POLYNOMIAL OF ORDER 6
C
        DIMENSION SIGMAY(23),X(23),Y(23),DELTAY(23),YCAL(23)
     %,A(23,7,7),B(23,10,10),R(23,7)
        IF(NP.LT.3) GO TO 99
C
        DO 2 I=LAG,NP
        SIGMAY(I)=0.
2       CONTINUE
        NCODE=0
C       MAXORD=NP/2
C       IF(NP.LE.4) MAXORD=2
C       IF(MAXORD.GT.6) MAXORD=6
        NNK=MAXORD
        DO 3 K=1,NNK
        K1=K+1
C
        CALL POLIFI(X,Y,SIGMAY,NP,K1,0,A,B,CHISQR,IC,LC,LAG)
C
        ERROR=0.0
       L=0.0
       NLAG=LAG-1
        DO 4 J=LAG,NP
        SUM=A(IC,LC,1)
        DO 5 I=2,K1
        SUM=SUM+A(IC,LC,I)*X(J)**(I-1)
5       CONTINUE
        YCAL(J)=SUM
        DELTAY(J)=YCAL(J)-Y(J)
       IF((NLAG.EQ.0).OR.(L.EQ.NLAG)) GO TO 4
       DO 125 L=1,NLAG
       DELTAY(L)=0.0
       YCAL(L)=Y(L)
125    CONTINUE
       L=NLAG
4       ERROR=ERROR+DELTAY(J)**2
        ERROR=ERROR/NP-LAG+1
       CALL CORR(Y,ERROR,R,IC,LC,NP)
C
3       CONTINUE
C
99      RETURN
        END
```

```
      SUBROUTINE POLIFI(X,Y,SIGMAY,NPTS,NTERMS,MODE,A,B,
     %CHISQR,IC,LC,LAG)
C
C     EXTRACTED FROM: BEVINGTON,P. R., "DATA REDUCTION AND
C     ERROR ANALYSIS FOR THE PHYSICAL SCIENCES", MCGRAW HILL,1969
C
C     SUBROUTINE POLIFIT PURPOSE
C
C     MAKE A LEAST-SQUARES FIT TO DATA WITH A POLYNOMIAL CURVE
C     Y = A(1) + A(2)*X + A(3)*X**2 + A(4)*X**3 + ...
C
C     DESCRIPTION OF PARAMETERS
C     X   -ARRAY OF DATA POINTS FOR INDEPENDENT VARIABLE
C     Y   -ARRAY OF DATA POINTS FOR DEPENDENT VARIABLE
C     SIGMAY - ARRAY OF STANDARD DEVIATIONS FOR Y DATA POINTS
C     NPTS   -NUMBER OF PAIRS OF DATA POINTS
C     NTERMS -NUMBER OF COEFFICIENTS(DEGREE OF POLYNOMIAL + 1)
C     MODE  -DETERMINANTS METHOD OF WEIGHTING LEAST-SQUARES FIT
C              +1 (INSTRUMENTAL) WEIGHT(I)=1./SIGMAY(I)**2
C              0 (NO WEIGHTING) WEIGHT =1.
C             -1 (STATISTICAL) WEIGHT(I) = 1./Y(I)
C     A  - ARRAY OF COEFFICIENTS OF POLYNOMIAL
C     CHISQR - REDUCED CHI SQUARE FOR FIT
C
C       DELTERM (ARRAY,NORDER)
C       EVALUATES THE DETERMINANTS OF A SYMMETRIC TWO-DIMENSIONAL
C       MATRIX OF NORDER
C
      DOUBLE PRECISION SUMX,SUMY,XTERM,YTERM,ARRAY,CHISQ
      DIMENSION X(23),Y(23),A(23,7,7),B(23,10,10),
     % SIGMAY(23),SUMX(23),SUMY(23),ARRAY(8,8)
C
C     ACCUMULATE WEIGHTING SUMS
C
11    NMAX = 2*NTERMS - 1
      DO 13 N=1, NMAX
13    SUMX(N) = 0.
      DO 15 J=1, NTERMS
15    SUMY(J)= 0.
      CHISQ =0.
21    DO 50 I=LAG, NPTS
      XI=X(I)
      YI= Y(I)
31    IF (MODE) 32,37,39
32    IF(YI) 35,37,33
33    WEIGHT = 1./YI
      GO TO 41
35    WEIGHT = 1./(-YI)
      GO TO 41
37    WEIGHT = 1.
      GO TO 41
39    WEIGHT = 1. / SIGMAY(I)**2
41    XTERM=WEIGHT
      DO 44 N=1,NMAX
      SUMX(N) = SUMX(N) + XTERM
44    XTERM = XTERM * XI
45    YTERM = WEIGHT*YI
      DO 48 N=1, NTERMS
      SUMY(N)=SUMY(N) + YTERM
```

```
48      YTERM = YTERM *XI
49      CHISQ = CHISQ + WEIGHT*YI**2
50      CONTINUE
C
C       CONSTRUCT MATRICES AND CALCULATE COEFFICIENTS
C
51      DO 54 J=1, NTERMS
        DO 54 K=1, NTERMS
        N = J + K - 1
54      ARRAY(J,K) = SUMX(N)
        DELTA = DETERM (ARRAY, NTERMS)
        IF(DELTA) 61,57,61
57      CHISQR = 0.
        DO 59 J=1, NTERMS
59      A(IC,LC,J) = 0.
        GO TO 80
61      DO 70 L=1, NTERMS
62      DO 66 J=1, NTERMS
        DO 65 K=1,NTERMS
        N = J+K-1
65      ARRAY(J,K)=SUMX(N)
66      ARRAY(J,L)=SUMY(J)
70      A(IC,LC,L)=DETERM(ARRAY,NTERMS)/DELTA
C
C       CALCULATES CHI SQUARE
C
71      DO 75 J=1, NTERMS
        CHISQ = CHISQ - 2.*A(IC,LC,J)*SUMY(J)
        DO 75 K=1, NTERMS
        N=J+K-1
75      CHISQ=CHISQ+A(IC,LC,J)*A(IC,LC,K)*SUMX(N)
76      FREE=NPTS-NTERMS
77      CHISQR=CHISQ/FREE
        CALL TTEST(A,B,LAG,IC,LC,FREE,NPTS,X,Y)
80      RETURN
        END
```

```
      FUNCTION DETERM(ARRAY,NORDER)
C
C     EXTRACTED FROM: BEVINGTON,P. R., "DATA REDUCTION AND
C     ERROR ANALYSIS FOR THE PHYSICAL SCIEINCES",MCGRAW HILL,1969
C
C     FUNCTION DETERM
C
C     PURPOSE
C     CALCULATES THE DETERMINANT OF A SQUARE MATRIX
C
C     USAGE
C     DET = DETERM(ARRAY,NORDER)
C
C     DESCRIPTION OF PARAMETERS
C       ARRAY  -MATRIX
C       NORDER -ORDER OF DETERMINANT (DEGREE OF MATRIX)
C
C     SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED
C     NONE
C
C     COMMENTS
C     THIS SUBPROGRAM DESTROYS THE INPUT MATRIX ARRAY
C
      DOUBLE PRECISION ARRAY,SAVE
      DIMENSION ARRAY(8,8)
10    DETERM =1.
11    DO 50 K=1, NORDER
C
C      INTERCHANGE COLUMNS IF DIAGNOL ELEMENT IS ZERO
C
      IF(ARRAY(K,K)) 41,21,41
21    DO 23 J=K, NORDER
      IF(ARRAY(K,J)) 31,23,31
23    CONTINUE
      DETERM = 0.
      GO TO 60
31    DO 34 I=K, NRODER
      SAVE = ARRAY(I,J)
      ARRAY(I,J)=ARRAY(I,K)
34    ARRAY(I,K)=SAVE
      DETERM = -DETERM
C
C     SUBTRACT ROW K FROM LOWER ROWS TO GET DIAGONAL MATRIX
C
41    DETERM = DETERM*ARRAY(K,K)
      IF(K - NORDER) 43,50,50
43    K1=K+1
      DO 46 I=K1, NORDER
      DO 46 J=K1,NORDER
46    ARRAY(I,J)=ARRAY(I,J)-ARRAY(I,K)*ARRAY(K,J)/ARRAY(K,K)
50    CONTINUE
60    RETURN
      END
```

```
      SUBROUTINE CORR(Y,ERROR,R,IC,LC,NP)
C
C ********************************************************
C *                                                      *
C *       Subroutine CORR                                *
C *       Purpose: To determin the quality of the fit of *
C *                the data to the model for the zero    *
C *                order constants.                      *
C *                                                      *
C ********************************************************
C
      DIMENSION Y(23),R(23,7)
      YT=0.0
      YS=0.0
      DO 10 I=1,NP
      YS=YS+Y(I)
      YT=YT+Y(I)**2
10    CONTINUE
      YMEAN=YS/NP
      DUM1=(YT/NP)-(YMEAN**2)
      R2=((DUM1-ERROR)/DUM1)
      R(IC,LC)=R2
      RETURN
      END
```

```
      SUBROUTINE PLOT(TITLE,ISW,XS,YS,NP,IC,LAG,MODE,X,Y,XLABEL,
     %RS,RLABEL,YLABEL)
C
C ********************************************************
C *                                                      *
C *         Subroutine PLOT                              *
C *                                                      *
C *         Purpose: To scale all the time an            *
C *                  concentration data so that it will  *
C *                  fit within a 51x60 matrix           *
C *                                                      *
C ********************************************************
C
      COMMON TEMP(23,8),CONC(23,8),DATE(23,8),SUBST(23,25)
      DIMENSION TITLE(23,20),X(23),Y(23),YLABEL(23,20),
     %XLABEL(23,20),RLABEL(23,20),IPICT(51,60)
      IF(ISW.GT.1) GO TO 9012
      CALL CLEAR(IPICT)
9012  IF(MODE)9011,17,9011
9011  IF(ISW.GT.1) GO TO 9010
      SCALE=YS/50.0
      GO TO 9040
9010  SCALE=RS/50.0
9040  DO 16 I=1,NP
      YT=Y(I)/SCALE
      IY=Y(I)/SCALE
      IF(IY.LE.SCALE) IY=0
      IF(Y(I).GT.(SCALE*50.0)) IY=51.0
      IF(YT-IY.GT.0.5) GO TO 9050
      GO TO 9015
9050  IY=IY+1
9015  XSCALE=XS/60.0
9060  XT=X(I)/XSCALE
      N=2
      NS=1
      IX=X(I)/XSCALE
      IF(X(I).LT.XSCALE) IX=1
      IF(X(I).GT.60*XSCALE) IX=60
      IF(XT-IX.GT.0.5) GO TO 9070
      GO TO 9080
9070  IX=IX+1
9080  IY=IY+1
      CALL POINT(IY,IX,IPICT,ISW)
16    CONTINUE
      IF(ISW.EQ.1) GO TO 17
      CALL DRAW(TITLE,IC,YS,XS,IPICT,XLABEL,YLABEL,RLABEL,RS)
17    RETURN
      END
```

```
      SUBROUTINE CLEAR(IPICT)
C
C       THIS SUBROUTINE CLEARS THE PICTURE SPACE
C
      DIMENSION IPICT(51,60)
      DATA NBLANK/' '/
      DO 2020 I=1,51
      DO 2010 J=1,60
      IPICT(I,J) = NBLANK
2010  CONTINUE
2020  CONTINUE
      RETURN
      END
```

```
      SUBROUTINE POINT(IY,IX,IPICT,ISW)
C
C ********************************************************
C *                                                      *
C *         Subroutine POINT                             *
C *                                                      *
C *         Purpose: To place the appropriate character  *
C *                  or blank in the matrix IPICT, in    *
C *                  order to set up the plot of data.   *
C *                                                      *
C ********************************************************
      DIMENSION IPICT(51,60)
      DATA NCHAR/'+'/
      DATA NAXIS/'O'/
      IF(ISW.GT.1) GO TO 2040
2030  IPICT(IY,IX) = NAXIS
      GO TO 2050
2040  IPICT(IY,IX) = NCHAR
2050  RETURN
      END
```

```
      SUBROUTINE DRAW(TITLE,IC,YS,XS,IPICT,XLABEL,YLABEL,RLABEL,RS)
C
C ******************************************************
C *                                                    *
C *          Subroutine DRAW                           *
C *                                                    *
C *          Purpose: To format the plot with labelled *
C *                   and scaled axis.                 *
C *                                                    *
C ******************************************************
C
      COMMON TEMP(23,8),CONC(23,8),DATE(23,8),SUBST(23,25)
      DIMENSION TITLE(23,20),IPICT(51,60),IXB(7),XLABEL(23,20),
     %YLABEL(23,20),RLABEL(23,20)
      DATA NBLANK/' '/
      WRITE(6,4014)
4014  FORMAT('0','.single')
      WRITE(6,4012)
4012  FORMAT('0','.page')
      WRITE(6,4019)
4019  FORMAT('0','.asis')
      WRITE(6,3013)
3013  FORMAT(//)
      IFIG=IC
      WRITE(6,3030)IFIG
3030  FORMAT('1',5X,'FIGURE #',I2,''
     %,1X,'PLOT OF CONCENTRATION'
     %' VS. TIME')
      WRITE(6,3333)
3333  FORMAT('0','.SKIP3')
      WRITE(6,4019)
      IS=0.0
      YSCALE=YS
      RSCALE=RS
      YINT=YS/10.0
      RINT=RS/10.0
3025  DO 3040 I=1,51
      IF(I.EQ.51) GO TO 3060
      II=52-I
      III=I-1
      IF(III/5.EQ.FLOAT(III)/5) GO TO 3080
      IF((I.LT.5).OR.(I.GE.30)) GO TO 3065
3045  WRITE(6,3050)SUBST(IC,I-4),(IPICT(II,J), J=1,60),SUBST(IC,I-4)
      GO TO 3040
3065  IF(I.GE.30) GO TO 3073
      WRITE(6,3050)NBLANK,(IPICT(II,J), J=1,60),NBLANK
      GO TO 3040
3073  IF(I-29.GT.20) GO TO 3075
      WRITE(6,3050)YLABEL(1,I-29),(IPICT(II,J), J=1,60),RLABEL(1,I-29)
      GO TO 3040
3075  WRITE(6,3050)NBLANK,(IPICT(II,J), J=1,60),NBLANK
3050  FORMAT(' ',A1,6X,'!',60A1,'!',6X,A1)
      GO TO 3040
3080  IF((I.LT.5).OR.(I.GE.30)) GO TO 3072
      WRITE(6,3090)SUBST(IC,I-4), YSCALE,(IPICT(II,J), J=1,60),
     %RSCALE,SUBST(IC,I-4)
      GO TO 3049
3072  IF(I.GE.30) GO TO 3074
      WRITE(6,3090)NBLANK, YSCALE,(IPICT(II,J), J=1,60),
```

```
     %RSCALE,NBLANK
      GO TO 3049
3074  IF(I-29.GT.20) GO TO 3076
      WRITE(6,3090)YLABEL(1,I-29),YSCALE,(IPICT(II,J),J=1,60),
     %RSCALE,RLABEL(1,I-29)
      GO TO 3049
3076  WRITE(6,3090)NBLANK,  YSCALE,(IPICT(II,J),  J=1,60),
     %RSCALE,NBLANK
3090  FORMAT(' ',A1,F5.1,'-:',60A1,'!-',F5.1,A1)
3049  YSCALE=YSCALE-YINT
      RSCALE=RSCALE-RINT
3040  CONTINUE
3060  WRITE(6,3070)
3070  FORMAT(' ',7X,'+---------+---------+---------+'
     %'---------+---------+---------+')
      SCALE=XS/60.0
3057  IXB(1)=0.0
      DO 3130 I=2,7
      J=I-1
      IXB(I)=IXB(J)+SCALE*10.0
3130  CONTINUE
      WRITE(6,3140)(IXB(I),I=2,7)
3140  FORMAT(' '9X,8(I10))
      WRITE(6,3150)
3150  FORMAT('0',36X,'TIME/MIN')
      RETURN
      END
```

```
      SUBROUTINE RESULT(A,R,TITLE,RUN,IC,LC)
C
C ***********************************************************
C *                                                         *
C *          Subroutine RESULT                              *
C *                                                         *
C *          Purpose: To give a summary of the              *
C *                   constants of intergration for each    *
C *                   model in each set of data.            *
C *                                                         *
C ***********************************************************
C
      COMMON TEMP(23,15),CONC(23,15),DATE(23,15),SUBST(23,25)
      DIMENSION A(23,7,7),R(23,7),TITLE(23,20),RUN(23,15)
      DO 7030 L=1,LC
      WRITE(6,4023)
4023  FORMAT('0','.double')
      WRITE(6,4013)
4013  FORMAT('0','.page')
      WRITE(6,4020)
4020  FORMAT('0','.asis')
      WRITE(6,7010)(SUBST(IC,I),I=1,25)
7010  FORMAT('1',5X,'SUMMARY OF RESULTS FOR THE SUBSTRATE ',25A1)
      WRITE(6,7020)
7020  FORMAT('0',10X,'MEDIA',12X,'RUN',15X,'INITIAL',
     %5X,'RATE',9X,'CORR')
      DO 7050 IR=1,IC,1
      IF(L.GT.1) GO TO 7031
      WRITE(6,7000)(TITLE(IR,I),I=1,20),(RUN(IR,J),J=1,15),A(IR,L,1),
     %A(IR,L,2),R(IR,L)
      GO TO 7050
7031  IF(L.GT.2) GO TO 7032
      WRITE(6,7001)(TITLE(IR,I),I=1,20),(RUN(IR,J),J=1,15),A(IR,L,1),
     %A(IR,L,2),R(IR,L)
      GO TO 7050
7032  WRITE(6,7002)(TITLE(IR,I),I=1,20),(RUN(IR,J),J=1,15),A(IR,L,1),
     %A(IR,L,2),A(IR,L,3),R(IR,L)
7050  CONTINUE
7030  CONTINUE
      RETURN
7000  FORMAT('0',5X,20A1,2X,15A1,2X,F9.4,2X,F9.4,2X,F9.4)
7001  FORMAT('0',5X,20A1,2X,15A1,2X,F9.4,2X,F9.4,2X,F9.4,2X,F9.4)
7002  FORMAT('0',5X,20A1,2X,15A1,2X,F9.4,2X,F9.4,2X,F9.4,2X,F9.4,
     %2X,F9.4)
      END
```

```
      SUBROUTINE TTEST(A,B,LAG,IC,LC,FREE,NP,X,Y)
C
C ******************************************************
C *                                                    *
C *         Subroutine TTEST                           *
C *         Purpose: To perform a student t-test on    *
C *                  the data used with the zero order *
C *                  model in order to estimate the error*
C *                  in the constants with 95% certainty *
C *                                                    *
C ******************************************************
C
      DIMENSION X(23),Y(23),SUMY(23),SUMX(23),SUMXY(23),
     #A(23,7,7),B(23,10,10),T95(23)
      DATA T95(1),T95(2),T95(3),T95(4)/12.706,4.303,3.182,2.776/
      DATA T95(5),T95(6),T95(7),T95(8)/2.565,2.447,2.365,2.306/
      DATA T95(9),T95(10),T95(11)/2.262,2.228,2.201/
      DATA T95(12),T95(13),T95(14)/2.179,2.160,2.145/
      DATA T95(15),T95(16),T95(17)/2.131,2.120,2.110/
      DATA T95(18),T95(19),T95(23)/2.101,2.093,2.086/
      DO 990 L=1,NP
      SUMX(L)=0.0
      SUMY(L)=0.0
      SUMXY(L)=0.0
990   CONTINUE
      NPT=NP+1
      LL=LAG+1
      DO 1000 L=LL,NPT,1
      J=L-1.0
      I=J
      SUMY(L)=SUMY(J)+(Y(I))
      SUMX(L)=SUMX(J)+(X(I))
      SUMY(J)=SUMY(L)
      SUMX(J)=SUMX(L)
1000  CONTINUE
      YSUM=SUMY(J)/NP
      XSUM=SUMX(J)/NP
      XS=0
      YT=0.0
      YS=0.0
      DO 1010 J=1,NP
      YS=YS+((YSUM-Y(J))**2)
      YT=YT+((YSUM-Y(J))*(XSUM-X(J)))
      XS=XS+((XSUM-X(J))**2)
1010  CONTINUE
      S=((YS-(A(IC,LC,2)*YT))/FREE)
      S2=S/XS
      S3=S/NP
      B(IC,LC,1)=T95(FREE)*(SQRT(((1.0/NP)+(XSUM/XS))*S))
      B(IC,LC,2)=T95(FREE)*(SQRT(S2))
      RETURN
      END
```

```
      SUBROUTINE MONOD(TIME,PPM,NP,IC,LC,A,B,R,YCAL,DELTAY,ERROR)
C
C ********************************************************
C *                                                      *
C *          Subroutine MONOD                            *
C *                                                      *
C *          Purpose: To set up an augmented matrix for  *
C *                   each data set to solve the Monod   *
C *                   degradation equation for it's      *
C *                   constants by Gaussian reduction    *
C *                                                      *
C ********************************************************
C
      REAL*8 G
      DIMENSION TIME(23),PPM(23),Y(23),X(23),YCAL(23),S(100),
     %G(2,3),A(23,7,7),B(23,7,7),R(23,7),F(23,100),DELTAY(23)
      TLAG=TIME(1)
       DUM1=0.0
       DUM2=0.0
       DUM3=0.0
       DUM4=0.0
      DUM7=0.0
      TLAG=TIME(1)
       DO 10 I=1,NP
      TIME(I)=TIME(I)-TIME(1)
      Y(I)=ALOG(PPM(1)/PPM(I))
      X(I)=PPM(1)-PPM(I)
      DUM1=DUM1+(Y(I)*TIME(I))
      DUM2=DUM2+(TIME(I)**2)
      DUM3=DUM3+(X(I)*TIME(I))
      DUM4=DUM4+(X(I)**2)
      DUM7=DUM7+(X(I)*Y(I))
10    CONTINUE
      G(1,1)=DUM2*(-1.0)
      G(1,2)=DUM3
      G(1,3)=DUM1
      G(2,1)=DUM3*(-1.0)
      G(2,2)=DUM4
      G(2,3)=DUM7
      ND=2
      NCOL=3
      N=2
      NS=1
      CALL GAUSL(ND,NCOL,N,NS,G)
      G(1,3)=(G(1,3)*(-1.0))
      G(2,3)=(G(2,3)*(-1.0))
      C1=(G(1,3)/G(2,3))
      C2=(1.0/G(2,3))
      DO 20 I=1,NP
      S(1)=PPM(I)
      S(2)=PPM(I)+1.0
      L=1
30    F(I,L)=(C2*(ALOG(PPM(1)/S(L)))+(PPM(1)-S(L))-(C1*TIME(I)))
      IF (L.LT.2) GO TO 40
      GO TO 50
40    L=L+1
      GO TO 30
50    CALL SECANT(S,SNEW,F,I,L)
      DIFF=(S(L)-SNEW)
```

```
      IF((ABS(DIFF)).LT.0.0001) GO TO 25
      S(L+1)=SNEW
      L=L+1
      IF(L.GT.99) GO TO 25
      GO TO 30
25    DELTAY(I)=PPM(I)-SNEW
      YCAL(I)=SNEW
20    CONTINUE
      DO 60 I=1,NP
      TIME(I)=TIME(I)+TLAG
60    CONTINUE
      A(IC,LC,2)=C1
      A(IC,LC,1)=C2
      ERROR=0.0
      DO 21 I=1,NP
      ERROR=ERROR+(DELTAY(I)**2)
21    CONTINUE
      ERROR=ERROR/NP
      CALL CORR(Y,ERROR,R,IC,LC,NP)
      RETURN
      END
```

```
      SUBROUTINE SECANT(S,SNEW,F,I,L)
C
C ********************************************************
C *                                                      *
C *         Subroutine SECANT                            *
C *                                                      *
C *         Purpose: To perform abounded iterative       *
C *                  calculation to find a theoretical   *
C *                  substrate concentration knowing the *
C *                  kinetic constants of either the     *
C *                  Monod or Haldane equation at a      *
C *                  time t.                             *
C *                                                      *
C ********************************************************
C
      DIMENSION S(100),F(23,100)
      AMAX=5000.0
      AMIN=0.0001
      IF(F(I,L).NE.F(I,L-1)) GO TO 301
      SNEW=(S(L)+S(L-1))/2.0
      GO TO 310
301    SLOPE=(S(L-1)-S(L))/(F(I,L)-F(I,L-1))
      DELTAC=F(I,L)*SLOPE
305    SNEW=S(L)+DELTAC
      IF((SNEW.GE.AMIN).AND.(SNEW.LT.AMAX)) GO TO 310
      DELTAC=DELTAC*0.9
      GO TO 305
310   RETURN
      END
```

```
      SUBROUTINE REPORT(ID,K1,NP,TIME,PPM,COD,PH,NH,MLSS,TITLE,RUN,
     %CL,A,B,R,YCAL,DELTAY,IC,LC,ERROR)
C
C ******************************************************
C *                                                    *
C *           Subroutine REPORT                        *
C *                                                    *
C *           Purpose: To format each set of input and *
C *                    output data for use in the report *
C *                    of the regression results.      *
C *                                                    *
C ******************************************************
C
      COMMON TEMP(23,8),CONC(23,8),DATE(23,8),SUBST(23,25)
      DIMENSION RUN(23,15),NH(23),TITLE(23,20),A(23,7,7),R(23,7),
     %YCAL(23),TIME(23),PPM(23),COD(23),PH(23),MLSS(23),
     %CL(23),B(23,7,7),DELTAY(23)
1     WRITE(6,4015)
      WRITE(6,4011)
      WRITE(6,4100)
4100  FORMAT('0','.center')
      WRITE(6,4101)IC,ID
4101  FORMAT('0','TABLE ',I2,'-',I1)
      IF (ID.GT.1)GO TO 4105
      WRITE (6,4102)
4102  FORMAT('0','A SUMMARY OF THE EXPERIMENTAL DATA OBTAINED'
     %'FOR THE DEGRADATION OF')
      WRITE(6,4103)(SUBST(IC,I),I=1,25),(TITLE(IC,I),I=1,20)
4103  FORMAT('0',25A1,'IN THE MEDIA ',20A1)
      GO TO 4125
4105  IF(ID.GT.2) GO TO  4107
      WRITE(6,4311)(SUBST(IC,I),I=1,25)
4311  FORMAT('0','THE REGRESSION OF THE ',25A1,'CONCENTRATION'
     %' VERSUS TIME TO ')
      WRITE(6,4312)(TITLE(IC,I),I=1,20)
4312  FORMAT('0',' FIT THE ZERO ORDER MODEL IN THE MEDIA ',20A1)
      GO TO 4125
4107  IF(ID.GT.3) GO TO 4110
      WRITE(6,4211)(SUBST(IC,I),I=1,25)
4211  FORMAT('0','THE REGRESSION OF THE ',25A1,'CONCENTRATION'
     %' VERSUS TIME TO ')
      WRITE(6,4212)(TITLE(IC,I),I=1,20)
4212  FORMAT('0',' FIT THE MONOD MODEL IN THE MEDIA ',20A1)
      GO TO 4125
4110  WRITE(6,4111)(SUBST(IC,I),I=1,25)
4111  FORMAT('0','THE REGRESSION OF THE ',25A1,'CONCENTRATION'
     %' VERSUS TIME TO ')
      WRITE(6,4112)(TITLE(IC,I),I=1,20)
4112  FORMAT('0',' FIT THE HALDANE MODEL IN THE MEDIA ',20A1)
4125  WRITE(6,4027)
      WRITE(6,4018)
      WRITE(6,9021)(SUBST(IC,I),I=1,25)
9021  FORMAT('1',5X,'SUBSTRATE    :',25A1)
      WRITE(6,9005)(TITLE(IC,I),I=1,20)
9005  FORMAT('0',5X,'MEDIA        :',20A1)
      WRITE(6,9022)(CONC(IC,I),I=1,8)
9022  FORMAT('0',5X,'CONCENTRATION:',8A1,'NOMINAL')
      WRITE(6,9014)(DATE(IC,I),I=1,8)
9014  FORMAT('0',5X,'DATE         :',8A1)
```

```
      WRITE(6,9008)(RUN(IC,I),I=1,15)
9008  FORMAT('0',5X,'RUN              :',15A1)
      WRITE(6,9017)(TEMP(IC,I),I=1,8)
9017  FORMAT('0',5X,'TEMPERATURE   :',8A1)
      IF((LC.EQ.1).AND.(ID.EQ.1)) GO TO 101
      WRITE(6,4027)
      WRITE(6,4018)
      WRITE(6,100)
100   FORMAT('0',6X,'TIME (MIN)',3X,'PPMEXP',6X,'PPMCAL',8X,'DY')
      GO TO 149
101   WRITE(6,102)
102   FORMAT('0',8X,'TIME',5X,'CONC.',4X,'COD',4X,'pH'
     %,3X,'MLSS',3X,'NH4+',6X,'CL-')
      WRITE(6,103)
103   FORMAT('0',8X,'MINS',5X,' PPM ',4X,'PPM',4X,'  '
     %,3X,'mg/l',3X,'PPM ',6X,'PPM')
      WRITE(6,4027)
      DO 148 I=1,NP
      WRITE(6,4018)
      WRITE(6,104)TIME(I),PPM(I),COD(I),PH(I),MLSS(I),NH(I),CL(I)
104   FORMAT('0',5X,F7.1,2X,F7.1,2X,F7.1,2X,F4.1,2X,I4,2X,I4,5X,F5.1)
148   CONTINUE
      ID=ID+1
      GO TO 1
149   WRITE(6,4028)
4028  FORMAT('0','.skip1')
      WRITE(6,4014)
4014  FORMAT('0','.single')
      WRITE(6,4018)
      DO 201 J=1,NP
150   WRITE(6,200)TIME(J),PPM(J),YCAL(J),DELTAY(J)
200   FORMAT('0',5X,4G12.5)
201   CONTINUE
      WRITE(6,4027)
      WRITE(6,4024)
4024  FORMAT('0','.double')
      WRITE(6,500)
500   FORMAT(/,5X,'KINETIC CONSTANTS')
      A(IC,LC,2)=A(IC,LC,2)*60.0
      IF(LC.GT.0) GO TO 319
      B(IC,LC,2)=B(IC,LC,2)*60.0
319   GO TO (321,322,323),LC
321    WRITE(6,324)
324   FORMAT('0',5X,'ZERO ORDER MODEL')
      GO TO 331
322   WRITE(6,326)
326   FORMAT('0',5X,'MONOD MODEL')
      GO TO 331
323   WRITE(6,327)
327   FORMAT('0',5X,'HALDANE MODEL')
331   DO 20 I=1,K1
      IF(I.GT.1) GO TO 252
      WRITE(6,250)I,A(IC,LC,I),B(IC,LC,I)
250   FORMAT(/,5X,'K',I1,'=',F9.3,' +',F5.2,3X,'mg/l')
      GO TO 20
252   IF(I.GT.2) GO TO 253
      WRITE(6,251)I,A(IC,LC,I),B(IC,LC,I)
251   FORMAT(/,5X,'K',I1,'=',F9.3,' +',F5.2,3X,'mg/l.hr')
      GO TO 20
```

```
253   WRITE(6,254)I,A(IC,LC,I),B(IC,LC,I)
254   FORMAT(/,5X,'K',I1,'=',F9.3,' +',F5.2,3X,'1/mg')
20    CONTINUE
      WRITE(6,375) R(IC,LC)
375   FORMAT('0',5X,'THE CORRELATION COEFFICIENT = ',G12.5)
      RESID=(SQRT(ERROR*NP))/NP
      WRITE(6,300)RESID
300   FORMAT(/,6X,'THE ABSOLUTE AVERAGE RESIDUAL = ',G12.5)
      ID=ID+1
4015  FORMAT('0','.double')
4011  FORMAT('0','.page')
4018  FORMAT('0','.asis')
4027  FORMAT('0','.skip3')
      RETURN
      END
```

```
C     *       SUBROUTINE GAUSL(ND,NCOL,N,NS,G)
C     *
C     ************************************************************
C
C
C     SUBROUTINE GAUSL SOLVES N LINEAR EQUATIONS BY GAUSS
C     ELIMINATION WITH ROW PIVOTING.
C     TO SOLVE THE PROBLEM QX=U, WHERE Q IS A NXN MATRIX AND IS
C     NXNS, ONE PLACES Q IN THE FIRST N COLUMNS OF A ND U IS PLACED
C     IN THE FOLLOWING NS COLUMNS.
C     THE PROGRAM RETURNS X=Q**(-1)*U AT THE PREVIOS
C     POSITION OF U.
C     ************
C     ND IS THE ROW DIMENSION AND NCOL IN THE COLUMN DIMENSION OF A.
C     BOTH MUST BE TRANSFERRED TO THE SUBROUTINE.
C     **********************
C
      SUBROUTINE GAUSL(ND,NCOL,N,NS,G)
C
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION G(ND,NCOL)
      N1=N+1
      NT=N+NS
      IF(N .EQ. 1) GO TO 50
C
C     START ELIMINATION
C
      DO 10 I=2,N
      IP=I-1
      I1=IP
      X=DABS(G(I1,I1))
      DO 11 J=I,N
      IF(DABS(G(J,I1)) .LT. X) GO TO 11
      X=DABS(G(J,I1))
      IP=J
11    CONTINUE
      IF(IP .EQ. I1) GO TO 13
C
C     ROW INTERCHANGE
C
      DO 12 J=I1,NT
      X=G(I1,J)
      G(I1,J)=G(IP,J)
12    G(IP,J)=X
13    DO 10 J=I,N
      X=G(J,I1)/G(I1,I1)
      DO 10 K=I,NT
10    G(J,K)=G(J,K)-X*G(I1,K)
C
C
C     ELIMINATION FINISHED, NOW BACKSUBSTITION
C
50    DO 20 IP=1,N
      I=N1-IP
      DO 20 K=N1,NT
      G(I,K)=G(I,K)/G(I,I)
      IF(I .EQ. 1) GO TO 20
      I1=I-1
      DO 25 J=1,I1
```

```
25      G(J,K)=G(J,K)-G(I,K)*G(J,I)
20      CONTINUE
        RETURN
        END
```

```
      SUBROUTINE HALDAN(TIME,PPM,NP,IC,LC,A,B,R,YCAL,DELTAY,ERROR)
C
C ******************************************************
C *                                                    *
C *          Subroutine HALDAN                         *
C *                                                    *
C *          Purpose: To set up an augmented matrix for *
C *                   each data set to solve the Haldane *
C *                   degradation equation for it's    *
C *                   constants by Gaussian reduction  *
C *                                                    *
C ******************************************************
C
      REAL*8 G
      DIMENSION TIME(23),PPM(23),Y(23),X(23),YCAL(23),S(50),
     %G(3,4),A(23,7,7),B(23,7,7),R(23,7),F(23,50),DELTAY(23)
     %,Z(23)
      DUM1=0.0
      DUM2=0.0
      DUM3=0.0
      DUM4=0.0
      DUM5=0.0
      DUM6=0.0
      DUM7=0.0
      DUM8=0.0
      DUM9=0.0
      DUM10=0.0
       DO 10 I=1,NP
      Y(I)=PPM(I)
      X(I)=ALOG(PPM(I))
      Z(I)=(PPM(I)**2)
      DUM1=DUM1+(Y(I)*TIME(I))
      DUM2=DUM2+(TIME(I)**2)
      DUM3=DUM3+(X(I)*TIME(I))
      DUM4=DUM4+(X(I)**2)
      DUM5=DUM5+(Y(I)**2)
      DUM6=DUM6+X(I)
      DUM7=DUM7+(X(I)*Y(I))
      DUM8=DUM8+(Z(I)*X(I))
      DUM9=DUM9+(Y(I)*Z(I))
      DUM10=DUM10+(Z(I)**2)
10    CONTINUE
      G(1,1)=DUM2*(-1.0)
      G(1,2)=DUM3
      G(1,3)=DUM6
      G(1,4)=DUM1
      G(2,1)=DUM3*(-1.0)
      G(2,2)=DUM4
      G(2,3)=DUM8
      G(2,4)=DUM7
      G(3,1)=DUM6*(-1.0)
      G(3,2)=DUM8
      G(3,3)=DUM10
      G(3,4)=DUM9
      ND=3
      NCOL=4
      N=3
      NS=1
      CALL GAUSL(ND,NCOL,N,NS,G)
```

```
      G(1,4)=(G(1,4)*(-1.0))
      G(2,4)=(G(2,4)*(-1.0))
      G(3,4)=(G(3,4)*(-1.0))
      C1=G(1,4)
      C2=G(2,4)
      C3=G(3,4)
      DO 20 I=1,NP
      S(1)=PPM(I)
      S(2)=PPM(I)+1.0
      L=1
30    F(I,L)=((C1*TIME(I))-(C2*ALOG(S(L)))-S(L)-(C3*(S(L)**2)))
      IF (L.LT.2) GO TO 40
      GO TO 50
40    L=L+1
      GO TO 30
50    CALL SECANT(S,SNEW,F,I,L)
      DIFF=(S(L)-SNEW)
      IF((ABS(DIFF)).LT.0.0001) GO TO 25
      S(L+1)=SNEW
      L=L+1
      IF(L.GT.49) GO TO 25
      GO TO 30
25    DELTAY(I)=PPM(I)-SNEW
      YCAL(I)=SNEW
20    CONTINUE
      A(IC,LC,1)=G(2,4)*(-1.0)
      A(IC,LC,2)=G(1,4)*(-1.0)
      A(IC,LC,3)=G(3,4)*(-1.0)
      ERROR=0.0
      DO 21 I=1,NP
      ERROR=ERROR+(DELTAY(I)**2)
21    CONTINUE
      ERROR=ERROR/NP
      CALL CORR(Y,ERROR,R,IC,LC,NP)
      RETURN
      END
```