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DOI: <https://doi.org/10.31979/etd.rspu-gjh4>
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**BIODEGRADATION OF 1,2 DIBROMO-3-CHLOROPROPANE USING
CULTURES ISOLATED FROM MARINE ALGAE**

A Thesis

Presented to

The Faculty of the Department of Chemical Engineering

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

Inmar Zuhair Munir

December, 1995

UMI Number: 1377258

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ABSTRACT

Biodegradation of 1,2 Dibromo-3-chloropropane Using Cultures Isolated From Marine Algae

by Inmar Zuhair Munir

This study evaluates the potential for the microbial degradation of the nematocide 1,2 dibromo-3-chloropropane(DBCP) using microbes isolated from the red marine algae *Plocamium cartilagineum* and an undetermined species from genera *Laurencia*. Investigations included the degradation of DBCP both as the sole source of carbon and as a co-substrate with the additions of L-camphor and 3-chloro-1-propanol in artificial seawater solutions. Degradation of DBCP was not observed in any of the reactor systems during the experimental period within the margins of experimental uncertainty. The viability of the cell cultures was found to be greatly inhibited by high levels of DBCP in the aqueous solutions. An apparent decrease in the aqueous camphor concentrations was noted in inoculated systems containing 2 mg/L DBCP, over the three week period. Increases in microbial populations were only noted in the systems containing chloropropanol implying metabolic activity.

ACKNOWLEDGMENTS

The author wishes to thank the advising professor Dr. Melanie A. McNeil for her guidance and supervision from the inception of this project. Her support, insight and understanding was greatly appreciated. The author would also like to thank the committee members, Dr. Patricia Grilione and Dr. Roy Okuda, whose expertise in the areas of microbiology and natural products chemistry played a pivotal role in the development and execution of this project.

The author also wishes to extend a special thanks to his colleague and friend, Kevin B. Wallace, who provided a foundation on which to base a substantial portion of this research. In addition, the author is grateful for the efforts of Colleen Hallen for her time and care in the isolation and culturing of the microbial cultures used in this research.

Finally, but most importantly, the author would like to extend his appreciation to his family and close friends. Their patience, emotional and financial support enabled the completion of this project. I will always be grateful for that which they have given me.

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Chapter 1. Introduction

1.1 Background

The widespread development and use of man-made halogenated organic biocides in the early twentieth century has recently been the focus of much attention. These compounds were originally favored as being efficient and economical pesticides and herbicides for the agricultural industry in the early 1940s (Lal and Saxena, 1982; Neilson, 1990). Since then, there has been a heightened awareness to detrimental characteristics that these compounds possess. Studies have shown that many of these halogenated species have a slow rate of degradation both physically and biologically. Therefore, they tend to accumulate in soils and lower organisms and, hence, have the capability to biomagnify in higher animals, leading to concerns regarding the toxicity and carcinogenic effects to humans.

Due to the recalcitrant and toxic nature of these anthropogenic compounds, many countries have since restricted or suspended their production and use. However, widespread contamination still exists. Entry into the environment has, and continues to take place through the use, spillage and disposal of these chemicals. In many cases, this has led to a high degree of contamination in ground water supplies. In a 1984 survey of water supplies in the United States, halogenated hydrocarbons such as trichloroethylene (TCE) were the most frequently identified contaminants (Westrick *et al.*, 1984). The

Environmental Protection Agency now mandates cleanup of many of these sites. This has catalyzed research in this area in hopes that a safe, efficient and economical solution can be found for the degradation of these halogenated organics.

One such anthropogenic compound of great concern is the nematocide 1,2 dibromo-3-chloropropane (DBCP). DBCP was used as a soil fumigant beginning in 1955 in the form of emulsifiable concentrates and fertilizer additives in the range of 0.6 to 87.7% (Babich *et al.*, 1981). In 1956 the Shell Chemical Company, once a principal producer of DBCP containing fumigants under the trade names of Nemagon® and Nemaforme®, was one of the first sources to report on adverse health effects due to exposure (Babich *et al.*, 1981). Despite this information, DBCP production continued and attained a level of 25,000,000 lbs produced in 1975 alone (Interagency Regulatory Liaison Group, 1978). Finally in 1977, the Occupational Safety and Health Administration (OSHA) suspended the production and use of DBCP as a result of studies showing increased infertility in men and possible carcinogenicity to those exposed to it. In 1979 the United States Environmental Protection Agency (USEPA) prohibited the use of all pesticide and fertilizer products which contained DBCP in the United States (Litton and Guyman, 1993). However large scale contamination in some areas still remains both within and outside the United States

Due to the recalcitrance of DBCP, significant concentrations still exist in many irrigation and domestic wells. Holden (1986) found that more than 25% of wells monitored in California alone had detectable amounts of DBCP present. Similar levels of contamination ranging from 0.02 to 20 µg/l have been found in groundwaters in Hawaii, Arizona, South Carolina and Maryland (Cohen *et al.*, 1984). This has catalyzed efforts to find efficient and economical methods for the removal and degradation of DBCP in affected regions.

Various methods have been studied for the decomposition of DBCP, including hydrolysis, photolysis and biological degradation. Burlinson *et al.* (1982) and Milano *et al.* (1990), respectively, have studied the hydrolysis and photolysis of DBCP. While both investigations showed an effective and efficient degradation of DBCP under extreme temperature, pH and energy input conditions, minimal decomposition was noted under moderate environments. In addition, many of the primary and secondary products were highly toxic, therefore requiring long residence to degrade DBCP to benign forms. Thus, these methods appear too tedious and expensive for large scale remedial applications.

The effective and economical degradation of DBCP using microbial cultures has been known for over 25 years, since the work of Castro and Belser (1968). However, the main difficulty associated with the use of biodegradation lies in the isolation of cultures capable of degrading the target compound as either a sole carbon source or as a co-

substrate. Often the most effective method for isolating such cultures is to culture microbes which have been found to grow in the vicinity of contaminated sites. In many cases, microbes which have been continually exposed to the target substrate have been able to adapt them into their metabolic pathways as carbon sources or redox agents.

A rather new approach for the isolation of suitable microorganisms for the degradation of anthropogenic halogenated organics is through the isolation of cultures which grow in the presence of naturally produced chlorinated and brominated compounds having similar size and structure. The work of Higa and Sakemi (1983) studied a species of marine acorn worm which was estimated to produce 43 kg/day of chlorinated phenolic compounds over a square kilometer of ocean sediments. There did not, however, appear to be any significant buildup of these compounds within this vicinity, leading to the belief that some degradative action, perhaps microbial, was taking place in this region.

Various types of marine macroalgae have also been well characterized in their production of polybrominated and chlorinated compounds (Rivera *et al.*, 1987). More specifically, the red marine macroalgae species of *Laurencia* and *Plocamium* are rich in linear and cyclic halogenated organic compounds. It is reasonable to assume that some symbiotic/parasitic relationship could have developed with microbes growing on, or in the vicinity of many of these macroalgae, perhaps resulting in some which may have the ability to degrade halogenated organic compounds.

1.2 Proposed Study

This research will investigate the potential of microbial cultures isolated from the halogenated organic producing marine algae species of *Laurencia* and *Plocamium* as it pertains to the degradation of the nematocide 1,2-Dibromo-3-chloropropane (DBCP). DBCP was chosen based on its recalcitrance in the environment, its structural similarity to compounds produced by the aforementioned algae, and as a result of preliminary observations by Wallace (1994). This study focuses on the degradation of DBCP both as the sole carbon source, and with the addition of camphor and 3-chloro-1-propanol, as co-substrates, in aqueous systems.

Chapter 2. Literature Review

2.1 Introduction

Microbial degradation, or biodegradation, refers to the process where microorganisms metabolically or enzymatically decompose or transform organic compounds. In many cases these microbes can eliminate hazardous toxins by aerobically mineralizing them to water and carbon dioxide, or anaerobically decomposing them to methane (Kobayashi and Rittnerman, 1982). In anabolic and catabolic degradations, the hazardous compound serves as the primary carbon and energy source, respectively. However, degradation of toxins often occurs cometabolically as a result of incidental metabolism, where toxins are degraded by enzymes such as halogenases, reductases and oxidases found in high percentages of microorganisms. While complete mineralization of toxins to water, carbon dioxide and mineral salts is often desired, simple dehalogenation and decomposition of the original compound to more benign forms can sometimes be considered sufficient.

Low molecular-weight hydrocarbons often present some of the most difficult problems for biological degradation applications. The principal reason for this is that few microorganisms have been found which naturally produce enzymes necessary for transforming these hydrocarbons into intermediates that can participate in the cells metabolic pathways (Lam and Vilker, 1987). In addition, pesticides and herbicides often

contain copious amounts of chlorine and bromine in their structure, which further increases their resistance to microbial attack (Chaudry and Chapalamadugu, 1991). 1,2-dibromo-3-chloropropane possesses both of the aforementioned qualities, and has been characterized as being recalcitrant to biotic as well as abiotic degradation.

2.2 Metabolic Pathways

Previous studies have shown the existence of two basic mechanisms for the biodegradation of organohalogen compounds: elimination of hydrogen halides and nucleophilic substitution of halogens (Neilson, 1990). Elimination of hydrogen halides, often called dehydrohalogenation, involves the simultaneous removal of hydrogen and halogen ions on adjacent saturated carbons to form the corresponding acid (Lal and Saxena, 1982). Since this reaction is not dependent on oxygen, both anaerobic and aerobic degradations can occur through this pathway.

The other class of degradation reactions of saturated aliphatic compounds involves the nucleophilic substitution of halogens, often requiring the presence of various dehalogenating enzymes. Nucleophilic substitution of the halogen with an hydroxyl group from water, termed hydrolytic dehalogenation, is found to be more common among

single substrate aerobic metabolites, and hence has become a mechanism of key interest for the aerobic degradation of anthropogenic compounds (Van der Waarde *et al.*, 1992).

Substitutions of other nucleophiles such as hydride ions or thiol groups have also been observed to occur (Neilson, 1990). Substitution of hydride ions, termed reductive dehalogenation, is seen to occur primarily in anaerobic conditions.

In addition to the reaction enzymes which drive the dehalogenating reactions, there are other proteins which often act as oxidizing and reducing agents. Van den Wijngaard *et al.* (1993) show the presence of two of these proteins, nicotinamide adenine dinucleotide (NAD/NADH) and a quinoprotein (PQQ/PQQH₂). These act as coenzymes in many of the degradation reactions, which can ultimately lead to the formation of aldehydes, ketones and carboxylic acids after hydrolytic substitutions.

The formation of the carboxylic acid often forms stable resonance structures which enable further degradation reactions to occur.

2.3 Biodegradation of Halogenated Anthropogenic Compounds

Biodegradation of anthropogenic compounds has been recognized for over 45 years. Studies conducted on 2,4-dichlorophenoxyacetic acid (2,4-D), one of the first synthetic organic pesticides showed that significant loss in its pesticidal activity was “due almost entirely to the activity of microorganisms” (Audus, 1949). Since then, there has been a plethora of studies conducted on the biodegradation of halogenated pesticides, herbicides and solvents. According to Racke and Coats (1990), the metabolic adaptability of many microorganisms has often resulted in substantial pest control failures. These capabilities, once regarded as an obstacle to overcome, can now be used as tools in bioremediative applications. Many studies have shown microorganisms to degrade a wide variety of halogenated pesticides ranging from polychlorinated biphenyls (Shiaris and Sayler, 1980) to simpler halogenated alkanes (Janssen *et al.*, 1985). This section will focus on the latter types of compounds due to the size and structural similarity to that of DBCP.

Van den Wijngaard *et al.* (1993) investigated the kinetics of 1,2 dichloroethane (DCE) degradation using pure cultures of *Ancylobacter aquaticus* AD20, AD25 and *Xanthobacter autotrophicus* GJ10. Substrate utilization rates up to 67 nM DCE / min (mg dry cell weight) were observed for AD25 cultures growing in a 279 μ M solution.

This system exhibited a 97% elimination efficiency in the degradation of DCE to glycolic acid. The degradation pathways in this metabolism have been elucidated by Janssen *et al.* (1985) and have been found to possess multiple enzymes. Similar hydrolytic dehalogenating enzymes were found to be active in the degradation of 2-chloroallyl alcohol (2CAA) studied by Van der Waarde *et al.* (1992). Three *Pseudomonas* cultures were found to utilize 2CAA as the sole source of carbon for growth. Both mono- and di-chloroallyl alcohols were found to be degraded, but no metabolism of tri-chlorinated compounds was observed. These cultures were found to be quite active up to substrate concentrations of 15 mM, above which 2CAA became toxic and inhibitory to cell growth.

Degradation of brominated compounds has also been shown to occur. Schochat *et al.* (1993) investigated the degradation of brominated alkanes using two *Pseudomonas* isolates ES-1 and ES-2. The degradation pathway was found to occur through hydrolytic dehalogenation followed by catabolism of the residual carbon skeleton. Maximum growth rates were observed for 1-bromoalkanes with a 10 carbon chain, however the maximum bromide release rate was observed for carbon chain lengths of 6. Lag times exhibited by the cultures increased with increasing carbon chain length, showing a strong dependence on substrate size.

2.4 Biodegradation of Anthropogenic Compounds with Bacteria Isolated from Marine Environments.

Many studies have shown that bacteria isolated from marine environments have been able to degrade a wide range of anthropogenic compounds. While most studies focus on the biodegradation of phenolic compounds, such research can provide information regarding the metabolic adaptability of such marine organisms.

Yanase *et al.* (1992) investigated the degradation of chloro-, bromo- and fluoro-substituted phenols in aqueous artificial seawater systems. Two thermophilic cultures were isolated from marine brine surrounding a natural gas well, and were identified as *Bacillus stearothermophilus* and an unknown species of the family *Rhizobiaceae*. Degradation efficiencies as high as 98.7% were observed for *Bacillus* cultures growing on 0.1 mM *o*-chlorophenol after 30 minutes of incubation at 50 °C. Strong effects of salinity were observed for this particular culture. Degradation efficiencies were reduced over 80% in some cases when systems were cultured in 10% artificial seawater, as compared to those incubated in the 100% ASW systems.

The degradation of halogenated phenols was studied by Abrahamsson and Klick (1991) using cultures present in three anoxic marine sediment samples. Several anthropogenic phenols were investigated including pentachlorophenol (PCP) 2,4,6-trichlorophenol and 2,4,6-tribromophenol. Initial concentrations of 0.8 µg PCP/g sediment were no longer

detectable after incubation at 30 °C for 15 days. In, addition degradation studies conducted on analogous brominated and chlorinated substituted phenols showed that the brominated compounds were degraded much more rapidly than their chlorinated counterparts.

Patil *et al.* (1972) investigated the microbial transformation of insecticides, namely DDT, Dieldrin, Aldrin and Endrin. Cell cultures were obtained from a variety of marine environments including surface films, algae and marine plankton. Dehalogenation of DDT was found to occur with microbes associated with the algae and plankton. However, no degradation occurred with cultures isolated from the open sea, and only limited transformations were noted from microbes isolated from marine sediments.

2.5 Biodegradation of Naturally Occurring Halogenated Organic Compounds

Certain marine organisms are known to produce a wide variety of halogenated organics including substituted aromatic, aliphatic and terpenoid compounds. While significant quantities have been found to be incorporated into the living systems (Wright *et al.* 1991), often large amounts are released as secondary metabolites or possible defense mechanisms. Higa and Sakemi (1983) reported on copious amounts of halogenated metabolites released by a species of Acorn worm, *Ptychodera flava*. A 1 km² habitat containing on the order of 6×10^7 individuals was investigated off the coast of Kohama

Island, Okinawa, Japan. While an estimated 43 kg of halogenated compounds were produced daily by this population, no apparent build up in this vicinity was observed. This may suggest that some sort of degradation, possibly biological, may occur in surrounding sediments. However, no studies were conducted to determine the fate of these compounds.

A similar study conducted by King (1988) investigated the production and fate of 2,4-dibromophenol (DBP) observed in the burrow microenvironment of the hemichordate, *Saccoglossus kowalewskii*. The degradation of DBP was investigated using slurry phase reactor systems of surrounding sediments in both oxic and anoxic conditions. More than 90% of the original compounds were degraded within 48 hours in anaerobic conditions. Studies conducted with 2,4-dichlorophenol in anoxic systems showed similar decompositions, however degradation rates were slower than the brominated counterparts. A significant decrease in the dehalogenation efficiency was observed for aerobic decompositions.

Various types of Red marine algae and kelp contain significant quantities of halogenated organic compounds incorporated into their structure (Gribble, 1992; Wright *et al.*, 1991). In particular the species of *Plocamium* and *Laurencia* have been found to be rich sources of halogenated alkenes, ketones and terpenes. Figure 2.5.1 shows some of the compounds which have been identified.

Figure 2.5.1 Identified compounds produced by *Plocamium* red algae.

Many of these resemble anthropogenic compounds frequently used as pesticides and herbicides. In the natural death and decay of living systems, microbial activity often facilitates the decomposition of plants and animals to usable nutrients (Reiper-Kirchner, 1989; and Hollohan *et al.*, 1986). Therefore, it is highly probable that microbes living on or within the vicinity of such organisms can partially or fully degrade these halogenated organics.

2.6 Biodegradation of 1,2-Dibromo-3-chloropropane

The capability of microorganisms to degrade DBCP has been known since the late 1960s. Early work of Castro and Belser (1968) studied the biodegradation of DBCP using

cultures present in contaminated soils. Experiments conducted in glycerol amended slurry phase systems showed up to 63% efficient degradations of DBCP to n-propanol over a 4 week period. Based on similar studies with di-bromobutanes, degradation pathways were assumed to follow both reductive dehalogenation reactions and hydrolytic substitutions. From these data and information regarding the presence of the allyl chloride as an intermediate, the following degradation pathway was proposed.

Similar studies conducted by Litton and Guyman (1993) have shown that microbial populations previously exposed to pesticide contaminated soil had the capability of degrading DBCP in soil systems. Initial concentrations of 0.12 µg DBCP/kg. soil were degraded to 0.03 µg DBCP/kg soil in inorganic nutrient amended systems, and to below 0.008 in natural (unamended) soils after 42 days of incubation. No attempt was made to identify degradation products in these experiments.

Bloom and Alexander (1990) were unable to isolate organisms capable of degrading DBCP as a sole source of carbon from DBCP amended soils obtained from various locations previously exposed to DBCP. However, microbial populations grown on 3-chloro-1-propanol amended soils were able to adapt and degrade DBCP as a single and co-substrate. Cometabolic studies using 50 mg/l DBCP and 10 mg/l chloropropanol were found to dehalogenate DBCP after 36 hours. In addition, these isolated cultures were also able to degrade DBCP as a sole source of carbon but at reduced rates.

Cultures of *Pseudomonas putida* PpG-786 have been shown to effectively degrade DBCP in aerobic conditions (Lam and Vilker, 1986). Cultures were grown in the presence of camphor, which is known to induce the cytochrome P-450_{cam} monooxygenase that participates in the reductive and oxidative dehalogenation reactions. Initial DBCP concentrations of $1 \times 10^{-5} \text{M}$ were degraded over 90% within 40 minutes. Later studies conducted by Koe and Vilker (1993) found that the nature of the degradation products was highly dependent on the dissolved oxygen level. Oxygen rich conditions led to the formation of 1-bromo-3-chloro acetone (BCA), while O₂ lean conditions produced 3-chloro-1-propene. Based on the dehalogenation reactions by cytochrome P-450_{cam}, mechanisms were proposed for both the O₂ rich and lean conditions, shown in Figure 2.6.1. However, it is noted that the proposed mechanism does not produce the observed product BCA under the oxygen rich conditions. This may be a result of an invalid mechanism or an inaccurate identification of reaction products.

Figure 2.6.1 Dehalogenation mechanism for cytochrome P-450 in both oxygen rich and oxygen lean conditions (Koe and Vilker, 1993).

Rasche *et al.* (1990) investigated the degradation of DBCP using both marine and terrestrial nitrifying bacteria in aqueous systems. It has been shown, previously, that autotrophic nitrifying bacteria have been able to co-oxidize several aliphatic, cyclic and halogenated organic compounds (Hyman and Wood, 1984). While the terrestrial cultures of *Nitrosomonas europaea* and *Nitrosolobus multiformis* were able to degrade DBCP, no reactions were facilitated by the marine nitrifier *Nitrosococcus oceanus*.

Previous work conducted by Wallace (1994) showed the possible degradative capability of microorganisms isolated from the marine algae *Plocamium cartilogenean* and an unidentified species of *Laurencia*. A consortium of 15 cultures, 7 from *P. cartilogenean*

and eight from the *Laurencia sp.*, were cultured in aqueous artificial seawater systems for a period of 3 weeks, exposed to DBCP concentrations of 10 and 100 mg/l. Degradation of DBCP was thought to have been observed within 1 week of incubation at 12.5 °C through analyses using gas chromatography. This was supposed due to the reduction of the parent DBCP peaks and the formation of intermediate compounds, not observed in control systems. Chromatograms showing control systems and possible degradation of DBCP in the inoculated systems can be seen in Figures 2.6.2 and 2.6.3. While attempts were made to reproduce these sets of experiments, no apparent degradation was observed. However, results from his first set of experiments show strong possibilities of the degradation potential of these microorganisms toward DBCP exhibited by the overall reduction of the parent compound, and the formation of intermediate peaks.

Figure 2.6.3 Gas Chromatograph for inoculated reactor systems after 3 week incubation (Wallace, 1994).

2.7 Literature Trends

The metabolic adaptability of micro-organisms to anthropogenic compounds has been known for well over 40 years. Even though most of the studies focus on the biodegradation and adaptation to polyaromatic hydrocarbons, significant research exhibits strong activity of some microbes to low molecular weight halogenated hydrocarbons (LMHs). These cultures often possess enzymes both for the dehalogenation and the transformation of LMHs into intermediates capable of being metabolized. There has also been considerable work elucidating the activity of microbes for the degradation of DBCP.

Various studies have shown red marine macro-algae, such as *Plocamium*, to possess and excrete copious amounts of halo-organic compounds of similar size and structure to DBCP. Based on other systems studied, it is possible that micro-organisms associated with the natural decay process of these macro-algae are capable of transforming these compounds to useful nutrients. Previous work by Wallace (1994) has shown signs of such activity with consortia similar to those being used in this research. It is therefore likely that some of the cultures to be used will be capable of degrading DBCP.

Chapter 3. Materials and Methods

3.1 Introduction

The following chapter describes the materials, equipment and procedures used to evaluate the degradation potential of two consortia of marine microorganisms for the aerobic degradation of the anthropogenic nematocide 1,2-dibromochloropropane in aqueous phase. A series of eight separate studies were conducted with microbes isolated from two species of marine algae, *Laurencia* and *Plocamium*. Cultures were subjected to DBCP levels ranging from 10 to 100 mg/l as a sole carbon source, and ranges of 2 to 10 mg/l in the presence of 3-chloro-1-propanol and camphor. Experiments were conducted over a 21 day period with weekly sampling of reactors for viable colonies and substrate composition.

3.2 Materials

All experiments were conducted in an artificial seawater (ASW) aqueous phase as described by Gerhardt *et al.* (1981), the composition of which is described in Table 3.2.1.

Table 3.2.1 Composition of the artificial seawater solution on a 1 Liter basis.

27.5 g NaCl	1.0 g KCl
5.0 g MgCl ₂	0.001 FeSO ₄
2.0 g MgSO ₄	1.0 g NH ₄ H ₂ PO ₄
0.5 g CaCl ₂	1.0 g K ₂ HPO ₄

All salts used to make the artificial seawater solution were obtained from Aldrich (Milwaukee, WI) and were of reagent grade. After addition of the salts in 1 liter of deionized water, the mixture was sterilized at 121°C for 15 minutes using a Hirayama HA-300MII (Japan) autoclave. The pH of the solution was adjusted to 7.5 by the addition of sterilized NaOH (Fisher Scientific, Fairlawn N.J.) when needed.

The complete agar medium used in the culturing and colony counts was formulated by the addition of 20 grams agar, 1 gram tryptone, 1 gram yeast extract (Difco Laboratories, Detroit, MI) and 0.5 grams D-glucose (Fisher Scientific, Fairlawn N.J.) to one liter of artificial seawater solution, described previously. The agar was only autoclaved for 5 minutes at 121°C to prevent the degradation of glucose due to thermal decomposition. Because of the shortened sterilization time, all agar plates and slants were incubated at 25°C for a period of at least 5 days prior to use to monitor any possible contamination.

For the quantitative analysis of DBCP and camphor in the reactor systems, an extractant solution was prepared. This solution consisted of 50 ppm and 50 ppm 1,3,5-trichlorobenzene dissolved in 1 liter of HPLC grade pentane all obtained from Fisher Scientific (Fairlawn N.J.). The trichlorobenzene served as the internal standard for all quantitative calculations. The benzene, due to its retention time and elution

characteristics served only as a time standard and was not used in the quantitative analysis.

The 1,2-dibromo-3-chloropropane used in these experiments was supplied by Pfaltz and Bauer (Aurora, CT) with a technical grade purity greater than 97%. The camphor and 3-chloro-1-propanol were supplied by Aldrich (Milwaukee, WI) as reagent grade with an associated purity of at least 98%. The densities and the aqueous solubilities of the organic compounds utilized in these studies are summarized in Table 3.2.2.

Table 3.2.2 Physical characteristics of the employed organic compounds.

<u>COMPOUND</u>	<u>Sp. Grav.</u>	<u>Sol. (%wt)</u>
Benzene	0.877	0.18
Camphor	solid	0.12
3-Chloro-1-propanol	1.131	> 1.0
1,2-Dibromo-3-chloropropane	1.198	0.10
Pentane	0.626	0.04
1,3,5-Tri-chlorobenzene	solid	< 0.1

3.3 Isolation of Microbial Cultures

Two sets of microbial consortia were used in this study, one consisting of nine cultures and the other containing 3. The three culture consortium, used in Experiments 1 through 7, was comprised of cultures gathered by Colleen Hallen in November 1994 from *Plocamium cartilagineum* growing in the tidepools at Davenport Beach, approximately 15 miles north of Santa Cruz, California.. One square centimeter portions of the algae

were collected and placed directly into 50 ml Erlenmeyer flasks containing 20 ml artificial seawater (described previously) supplemented with 10 mg/l DBCP. The systems were sealed with plastic push-on caps and allowed to incubate for 14 days at 19 ± 2 °C (Hallen, 1995). After incubation, 0.1 ml aliquots of this suspension were plated on complete agar medium and allowed to incubate for a period of 4 days at 18 °C. Through successive streaking and isolations, a total of three isolates were obtained. These cultures, designated C1-3, were then streaked onto complete medium agar slants, capped and stored for 6 months at 5°C prior to use.

The microbes which comprised the nine culture consortium (designated P1,3,5-7 L1-4) used in Experiment 8 were gathered between 5:45 and 7:00 a.m. June 24, 1994 from *Plocamium cartilagineum* and *Laurencia sp.* growing in tidepools at Davenport Beach. At the time of collection the temperature, pH and dissolved oxygen levels were recorded in the tidepools and surrounding sites. These are summarized in Table 3.3.1.

Table 3.3.1. Ambient marine conditions at time of microbe sampling.

Temperature	8.5-9.5 °C
pH	7.5 - 7.65 (ocean) 7.0 (tidepools)
DO	8.0 mg/l (ocean) 4.5 mg/l (tidepools)

Microbial cultures were obtained by streaking small portions of the aforementioned algae directly onto the complete agar medium, described earlier. These systems were allowed

to incubate at 17 °C for a period of 5 days, after which distinct colonies were restreaked to obtain pure isolates. Through successive streaking and isolations, a total of nine isolates were obtained by Colleen Hallen (1995), five from *Plocamium cartilogeneum* (P1,P3,P5-7) and four from *Laurencia sp.* (L1-4). These nine cultures were then streaked onto complete medium agar slants, capped and stored for nine months at 5 °C prior to use. The morphology of any of these cultures has not yet been determined for either of the consortia. However, through gram stains, all three isolates C1, C2 and C3 (from the three culture consortium) are supposed gram negative.

3.4 Culturing of Microbial Cultures

The following describes procedures used for the culturing and preparation of the inoculant suspensions for both the three and nine culture consortium experiments.

In order to obtain a sufficient population of microbes for the inoculum, each culture was streaked onto three complete medium agar slants and allowed to incubate at 20 °C for 5 days. Using these slants, a total of six petri dishes were inoculated for each culture used in the three culture consortium, while only two plates were used for each culture in the nine culture consortium, to give the same approximate biomass and viable colony population for all sets of experiments. These cultures were then incubated for 4 days at 20 °C.

In order to remove the cell growth from the agar surface, 2 ml of sterile artificial seawater was added to each plate and allowed to set for 15 to 20 minutes. After this period, the cells were carefully removed from the surface to the aqueous phase using a sterile inoculating loop. The contents of each dish was then poured into sterile centrifuge tubes and spun at 100 RPM for 10 minutes and the supernatant was removed. The cell pellets were washed by adding 15 ml of sterile ASW to each tube, and the microbes were resuspended and centrifuged once again. Each cell culture was washed four times, to remove any trace amounts of the complete medium components, and finally resuspended in 10 ml of artificial seawater.

Due to the varying cellular concentrations in the pure culture suspensions, described in the previous paragraph, it was necessary to dilute some of the cultures with the addition of the sterile artificial seawater solution. Following this dilution, small amounts of the suspensions were removed from the more prolific cultures and were centrifuged once again. This was done until each culture had a pellet volume of approximately 0.2 to 0.3 ml. Once this was achieved, the cultures were resuspended in 5 ml ASW to be transferred to the cell inoculum. The consortia were formed by transferring the appropriate cell suspensions (P1,3,5-7 , L1-4 and C1-3) into a sterile 100 ml volumetric flask, whereby the appropriate volume of ASW was added to make 100 ml of the inoculant solution. The cell cultures were then stirred moderately to provide a homogeneous mixture during inoculation into the appropriate reactors, described later in

this section. It is necessary to note that cell concentrations were estimated by the volume of the cell pellet dissolved in 5 ml ASW, no individual colony counts were performed on the individual cultures to obtain their viability.

The biomass concentrations for each of the consortia were conducted by measuring the dry cell weights. This was done by suction filtering 10 ml of the inoculum onto dried and pre-weighed 0.2 μm filter paper. This paper was then dried for 5 days at 50 °C with weight measurements taken on the 3rd, 4th and 5th days to ensure that the samples were completely dry (noted by no apparent reduction in mass). An average of three samples for each consortium was used in estimating the biomass concentration.

3.5 Preparation of Batch Reactor Systems

Experiments 1 through 3 investigated the degradation potential of the three culture consortium to three concentrations of DBCP (10, 50 and 100 mg/l) as the sole carbon source. In order to minimize error, the lower concentrations were prepared from a 100 mg/L stock solution. In addition care was taken to avoid any loss of DBCP to volatilization during the preparation of the substrate solution. This was done by chilling the artificial seawater solution and the DBCP for 4 hours at 0 °C before the stock solution was prepared. This solution was capped and thoroughly mixed and allowed to chill before aliquots were removed to form the 10 and 50 mg/l solutions.

Because no apparent degradation had been observed in the first set of experiments, the capabilities of the three culture consortium to cometabolic degradation were investigated. Experiments 4 and 5 studied the degradation of DBCP at concentrations of 2 and 10 mg/l with the addition of 10 mg/l camphor in the reactor substrate. While the exact morphology of the employed microbial cultures was not known, camphor was added to these systems both as a possible carbon source, redox agent or to possibly induce similar dehalogenating enzymes as observed by Lam and Vilker (1986). A 10 mg/l camphor solution was prepared by weighing the appropriate amount of camphor and dissolving it into artificial seawater. The solution was then chilled and the 10 mg/l and 2 mg/l DBCP solutions were prepared using similar methods employed in Experiments 1 through 3.

Experiments 6 and 7 evaluated the degradation of DBCP at concentrations of 2 and 10 mg/l with the addition of 3-chloro-1-propanol (CPL) using the three culture consortium. The addition of CPL was done to evaluate whether or not the microbes had the capability to degrade DBCP cometabolically as seen by Bloom and Alexander (1990). Because chloropropanol is a volatile liquid at room temperature, similar procedures to that of DBCP were utilized in preparing the stock substrate and subsequent dilutions.

Experiment 8 was the only study conducted with the nine culture consortium, and only investigated the degradation of DBCP as a sole carbon source at a concentration of 10 mg/l. This study was done to reproduce, as closely as possible, the work of Wallace

(1994) where the degradation of DBCP was thought to have been observed with a similar consortium.

Batch reactor systems were prepared in a similar manner for experiments 1 through 8. Prior to dispensing the substrate solutions into the 40 ml reactor vials, each was chilled for at least 12 hours at 0 °C to minimize any loss during transfer. Once chilled, 25 ml aliquots of the aforementioned solutions were pipetted into the appropriate vials. Inoculated reactor systems had 2 ml of the cell inoculum (described previously) added to the 25 ml of substrate. In order to equalize the total volumes of the reactors, 2 ml of sterile artificial seawater were added to each of the controls. In experiments 1 through 3, the reactor systems were placed vertically in a constant temperature shaker water bath at 18 °C and agitated at 75 RPM for the duration of the experiments. Due to problems with cell flocculation and sedimentation in the vertical reactor systems, it was necessary to manually shake the vials a minimum of six times daily to resuspend the cells. In experiments 4 through 8, the shaker bath was modified to allow horizontal placement of the glass vials, providing better mixing.

3.6 Analytical Procedures

For experiments 1 through 7, data were taken four times over a three week period; time equals 0 and once a week for the following three weeks. Experiment 8 only was analyzed twice, at week 0 and at week 3. For experiments 1 through 3, two control vials and three

inoculated systems were analyzed in each of the sampling periods. In experiments 4 through 8, only one control and two inoculated systems were analyzed. Table 3.6.1 lists the experimental matrices. The capital letters A, B and C indicate the reactor vials analyzed for substrate composition and concentration by gas chromatography. The label CFU (Colony Forming Units) indicates which systems were analyzed for viable colony counts using standard spread plate methods, discussed later in this section.

Table 3.6.1. Analytical Matrices for Experiments 1 through 8.

Experiment 1; 10 mg/L DBCP					
Time, Weeks	Control Vials		Inoculated Vials		
0	A	B	A	B	C
1	A	B/CFU	A	B/CFU	C/CFU
2	A	B/CFU	A	B/CFU	C/CFU
3	A	B/CFU	A	B/CFU	C/CFU

Experiment 2; 50 mg/L DBCP					
Time, Weeks	Control Vials		Inoculated Vials		
0	A	B	A	B	C
1	A	B/CFU	A	B/CFU	C/CFU
2	A	B/CFU	A	B/CFU	C/CFU
3	A	B/CFU	A	B/CFU	C/CFU

Experiment 3; 100 mg/L DBCP					
Time, Weeks	Control Vials		Inoculated Vials		
0	A	B	A	B	C
1	A	B/CFU	A	B/CFU	C/CFU
2	A	B/CFU	A	B/CFU	C/CFU
3	A	B/CFU	A	B/CFU	C/CFU

Experiment 4; 2 mg/L DBCP + 10 mg/L Camphor			
Time, Weeks	Control Vials	Inoculated Vials	
0	A/CFU	A/CFU	B/CFU
1	A/CFU	A/CFU	B/CFU
2	A/CFU	A/CFU	B/CFU
3	A/CFU	A/CFU	B/CFU

Experiment 5; 10 mg/L DBCP + 10 mg/L Camphor			
Time, Weeks	Control Vials	Inoculated Vials	
0	A/CFU	A/CFU	B/CFU
1	A/CFU	A/CFU	B/CFU
2	A/CFU	A/CFU	B/CFU
3	A/CFU	A/CFU	B/CFU

Experiment 6; 2 mg/L DBCP + 25 mg/L Chloropropanol			
Time, Weeks	Control Vials	Inoculated Vials	
0	A/CFU	A/CFU	B/CFU
1	A/CFU	A/CFU	B/CFU
2	A/CFU	A/CFU	B/CFU
3	A/CFU	A/CFU	B/CFU

Experiment 7; 10 mg/L DBCP + 25 mg/L Chloropropanol			
Time, Weeks	Control Vials	Inoculated Vials	
0	A/CFU	A/CFU	B/CFU
1	A/CFU	A/CFU	B/CFU
2	A/CFU	A/CFU	B/CFU
3	A/CFU	A/CFU	B/CFU

Experiment 8; 10 mg/L DBCP			
Time, Weeks	Control Vials	Inoculated Vials	
0	A/CFU	A/CFU	B/CFU
3	A/CFU	A/CFU	B/CFU

Since direct sampling and analysis of the aqueous solutions was not possible with the employed gas chromatography setup, extraction of the vials with an organic solvent was necessary to analyze substrate and degradation product concentrations. Preliminary studies showed pentane to be an effect extractant for DBCP and was used in all the experiments. A pentane extractant solution was prepared by the addition of two internal standards, 50 ppm benzene and 50 ppm 1,3,5-trichlorobenzene. One solution of the extractant solution was prepared for the formulation of calibration curves and experiments 1 through 3. However, due to an insufficient quantity, a second solution was prepared for the remaining experiments which exhibited slight deviations in the concentrations of the internal standards. Care was taken to avoid volatilization of pentane during transfer to avoid any changes in concentrations of the less volatile internal standards.

Prior to extraction, the reactor vials were chilled at 0 °C for a minimum of 24 hours. Two milliliters of the extractant pentane solution were added to the reactor systems with a 2.5 ml syringe. For this process, the vial caps were quickly opened, the extractant added and the vials quickly sealed. This was done to avoid piercing the septum prior to the extraction procedure, which would have resulted in significant volatilization due to the large hole left by this needle. After the addition of the pentane solution, the vials were placed horizontally on a shaker table and agitated at high speed for 45 minutes. During this period, significant emulsions formed. In control systems, the formed emulsions

quickly dissipated; however, removal of the emulsions in the inoculated systems required centrifugation of the entire reactor vials for 15 minutes. In order to remain consistent, control vials were also centrifuged for the same duration. This procedure provided excellent separation of the aqueous and organic layers. In addition, much of the cellular material was removed from the organic layer. After centrifugation, the vials were placed in a freezer for 30 minutes prior to analysis of the gas chromatograph.

A Hewlett Packard Model 5890A gas chromatograph was used for the analysis of substrate composition and concentrations for all eight experiments. The HP 5890A was equipped with a flame ionization detector (FID) and peak areas were recorded on a Hewlett Packard Model 3396A integrator. Chromatographic separations were done using an Alltech Econocap SE-54 capillary column (30 m X 0.53 mm.). A Cyclovie® direct injection liner was used as the inlet, supplied by Restech (Bellefonte, PA). Hydrogen was used as the carrier gas, supplied at 30 ml/minute, yielding an approximate linear velocity of 90 cm/sec. Nitrogen was used as a makeup gas for the FID at a flowrate of 20 ml/min. Hydrogen and air were supplied to the FID at 30 and 400 ml/min, respectively. Table 3.6.2 summarizes the GC parameters used.

Injections were made using a Hamilton 7101 1 µl syringe (Reno, NV). The vials were removed from the refrigerator and a 1 µl sample was removed from the 2 ml. organic layer above the aqueous substrate solution. Initial observations, prior to experimentation, showed small bubbles forming on the tip of the syringe needle due to temperature

differences between the room temperature syringe and the chilled solution. Therefore, the syringe was also chilled prior to sampling. A minimum of three injections were made for each system.

Table 3.6.2. Analytical parameters used for the HP 5890 GC.

Initial Temperature	35 °C
Initial Hold	2 minutes
Ramp A	8 °C/min.
Final Temp. A	135 °C
Final Time A	1 minute
Ramp B	25 °C/min.
Final Temp. B	225 °C
Final Time B	2 minutes
Injection Temp.	200 °C
Detector Temp.	250 °C

In addition to substrate concentration/composition analyses, viable colony counts were taken on appropriate reactor systems shown in Table 3.6.1. This was accomplished using a standard spread plate method for analysis. Colony counts for control reactors were done by removing 10 µl of the reactant broth (prior to extraction) from the glass vials and spreading it onto petri dishes containing complete agar medium. Only one test was conducted on control systems in order to minimize the aqueous volume removed from the reactor systems. For inoculated systems, 10 µl of the substrate solution was removed and diluted in 10 ml of sterile artificial seawater and agitated for a minimum of 5 minutes. One hundred microliters of this solution was then removed and diluted into another vial containing 10 ml of ASW. This process was repeated once again to obtain another cell dilution. Through experimentation, these dilutions provided an effective means to

monitor both cell growth and death during the course of the analytical period. One hundred microliters of each of these dilutions were plated onto petri dishes, in duplicate. All cultures were allowed to incubate at 20 °C for at least one day, until a sufficient microbial population had developed to permit colony counts.

3.7 Analytical Methods

Prior to experimentation, calibration curves were constructed for DBCP in the pentane extractant solution for concentrations ranging from 1 mg/l to 5500 mg/l. Using this information, and studies conducted on the organic/aqueous partitioning, it was possible to determine substrate concentrations of DBCP with the internal standard 1,3,5-trichlorobenzene. In order to standardize any fluctuations in the reactor systems, DBCP degradation analysis was conducted by plotting the ratio of inoculated substrate composition to that of the controls for each time interval. In cases where two control systems were sampled, the average control composition was used.

Calibration curves were not constructed for camphor, due to time constraints. However, possible degradation or metabolism was evaluated based on the peak area ratios of camphor with the internal standard TCB. Similarly to DBCP, the CAM/TCB area ratio of inoculated systems was normalized to that of the control for each time interval. Preliminary studies of 3-chloro-1-propanol showed that it eluted within the retention

times of the pentane solvent peak when added solely to pentane at levels of 10,000 mg/L. However, experiments showed that an efficient extraction of chloropropanol from the aqueous phase was not possible using pentane. Therefore quantitative analysis of this compound was not possible.

Chapter 4 Results and Discussion

4.1 Introduction

The eight experiments were conducted over two different time periods. Experiments 1 through 3, which investigated the biodegradation potential of DBCP as a sole carbon source using the three culture consortium, were performed between March 27 and April 26, 1995. The co-metabolic studies containing both camphor (Exp. 4 and 5) and 3-chloropropanol (Exp. 6 and 7) using the three culture consortium were carried out between June 6 and July 5, 1995. Experiment 8, in which the degradation potential of DBCP as a sole carbon source using the nine culture consortium was also studied between June 6 and July 5, 1995.

For quantitative analysis of the substrate concentrations, the ratio of the DBCP peak areas to those of the internal standard 1,3,5-trichlorobenzene were obtained for both the inoculated and control systems. The average DBCP concentrations of the inoculated systems were then normalized by dividing by those of the control systems. This method was also used for the analysis of camphor concentrations within the reactor vials in Experiments 4 and 5. Qualitative observations were also made to determine if the formation of any additional, possibly degradative product, peaks occurred. In addition to substrate concentration, data were taken on the biomass in each cell stock solution used, and counts of viable cell colonies were conducted for each reactor system shown in Table

3.6.1. The following chapter discusses these data and trends observed in the experimental systems.

4.2 DBCP Degradation as the Sole Source of Carbon; 3 Culture Consortium

The results of the 10, 50 and 100 mg/L DBCP degradation experiments as the sole source of carbon using the three culture consortium (Experiments 1, 2 and 3) are discussed in this section. Measurements of dry cell weights were made on the cell inoculum used for all of these systems, and found to be 2.76 ± 0.02 grams of cells per liter inoculum. This led to an approximate concentration of 0.20 g cells/L in each of the inoculated reactors.

4.2.1 Experiment 1; 10 mg/L DBCP

Figure 4.2.1-1 shows a typical chromatogram of a 10 mg/L DBCP inoculated reactor system after three weeks of incubation. The DBCP peak occurred at a retention time of 11.447 minutes and peaks areas of the two internal standards benzene and 1,3,5-trichlorobenzene are at 2.842 and 12.442 minutes, respectively. Chromatographic peaks resolving at higher retention times (>15 minutes) were ascribed to oils present in the injector septum. The magnitude of these peaks, due to septum bleed, were large after a new septum was installed and decreased significantly through successive injections. The peak occurring at 0.970 minutes is thought to be air, possibly introduced by the 1 μ L syringe used for GC injections. While there are no data to support this claim,

the occurrence of this peak is prevalent in all chromatograms attained during these experiments.

Figure 4.2.1-1 Gas Chromatogram for 10 mg/L DBCP System after Three Weeks of Incubation

A graphical representation of the average substrate concentrations for the 10 mg/L DBCP systems is shown in Figure 4.2.1-2. As stated previously, the concentrations of the inoculated systems are normalized by those of the control reactors. This figure shows the average of all three inoculated systems. Individual concentrations for each of the reactors and the associated error can be seen in Appendix A and plots of the non-normalized graphs can be found in Appendix E.

Figure 4.2.1-2. Experiment 1; DBCP Concentration versus Time

No definitive trends toward the degradation of DBCP can be noted. As a result of the fluctuations for each data point, it is possible to construct a straight line with the uncertainty of the system, showing that a constant composition can be assumed throughout the course of this study. In addition, qualitative observations of the chromatograms indicate that no formation of extraneous peaks occurred in the inoculated systems, when compared to the control reactors. Examples of chromatograms for both control and inoculated systems for all eight experiments can be found in Appendix D.

Counts of viable colonies for these systems are summarized in Table 4.2.1-1. The ranges given represent the results from duplicate samples of the same substrate solution. An asterisk is shown for systems in which only one valid colony count was obtained. Due to

difficulties in sampling, Week 0 counts were not obtained. As can be seen from these data, the number of viable microorganisms in the reactors steadily decreased over the three week period. Counts taken on control systems showed no contamination to exist throughout these sets of experiments. All colony count data are included in Appendix B.

Table 4.2.1-1. Counts of Viable Colonies for 10 mg/L DBCP Systems.

<u>Time (Weeks)</u>	<u>Viable Colonies (per ml broth)</u>	
	<u>INOC B</u>	<u>INOC C</u>
0	N/A	N/A
1	1.7×10^7 *	N/A
2	$1.3 - 1.7 \times 10^5$	$1.4 - 1.6 \times 10^5$
3	$2.1 - 2.5 \times 10^4$	$3.6 - 4.0 \times 10^4$

The persistence of some colonies after a period of three weeks is most likely due to the catabolism of dead biomass within the reactor systems, rather than any type of consumption of DBCP as noted by the previous observations.

4.2.2 Experiment 2; 50 mg/L DBCP

A typical chromatogram for a 50 mg/L DBCP inoculated vial after three weeks of incubation can be seen in Figure 4.2.2-1. The retention times for DBCP, benzene and TCB are 11.372, 2.782 and 12.360 minutes, respectively. Slight variations in retention times were observed as compared to the 10 mg/L DBCP chromatogram, most likely due to fluctuations in the carrier gas flow rates, which were often difficult to control.

Figure 4.2.2-1. Gas Chromatogram for 50 mg/L Inoculated Reactor after Three Weeks of Incubation

Figure 4.2.2-2. Experiment 2; DBCP Concentration versus Time

The average concentrations of the three inoculated systems as a function of time is depicted in Figure 4.2.2-2. As in the case of the 10 mg/L DBCP systems, no definitive trends can be based on this information. A constant composition in the inoculated systems can be supposed for the Week 0, 2 and 3 series. However, data for the first week falls outside this approximation, although fairly close in magnitude, suggesting no decomposition occurred. Similarly, visual observations of the chromatograms do not show the existence of any extraneous peaks, which could suggest degradation products.

Similar declines in the viable microbial populations were observed in the 50 mg/L DBCP experiments, as compared to the 10 mg/L reactors. Table 4.2.2-1 summarizes the number of colony forming units over the three week period.

Table 4.2.2-1. Counts of Viable Colonies for 50 mg/L DBCP Systems.

<u>Time (Weeks)</u>	<u>Viable Colonies (per ml broth)</u>	
	<u>INOC B</u>	<u>INOC C</u>
0	N/A	N/A
1	1.4×10^7 *	$1.0 - 1.8 \times 10^7$
2	$1.2 - 1.7 \times 10^5$	$5.4 - 7.9 \times 10^4$
3	$1.0 - 1.5 \times 10^4$	$2.2 - 4.0 \times 10^4$

As in the case of the 10 mg/L sets, Week 0 data were not available. In addition, no contamination was observed in the control systems. The data show that after three weeks,

microbial populations were found to exist in similar numbers as seen in analogous 10 mg/L systems.

4.2.3 Experiment 3; 100 mg/L DBCP

A typical gas chromatogram for a 100 mg/L DBCP inoculated vial after three weeks of incubation is shown by Figure 4.2.3-1. DBCP, benzene and tri-chlorobenzene elute at 11.395, 2.789 and 12.375 minutes, respectively. Small unintegrated peaks are seen to elute in the 5 to 8 minute region and were also noted in the control chromatograms. Preliminary work on the development of calibration curves showed similar peaks at higher DBCP concentrations, which increase with increasing amounts of DBCP. Therefore, it is reasonable to assume that these are contaminants in the DBCP reagent, being either by-products or a result of abiotic decomposition, only detectable at higher levels.

Figure 4.2.3-2 depicts the concentration of DBCP in the inoculated vials over the three week study. As in the previous systems, a constant DBCP concentration can be assumed within the experimental uncertainty. In addition to the constant composition, no extraneous peaks were observed in the inoculated systems when compared to the corresponding controls.

Figure 4.2.3-1. Gas Chromatogram for 100 mg/L Inoculated Reactor after Three Weeks of Incubation

Figure 4.2.3-2. Experiment 3; DBCP Concentration versus Time

Colony count studies showed a more rapid decrease in the number of viable microbes in the inoculated systems as compared to the 10 and 50 mg/L experiments. Table 4.2.3-1 lists the number of colony forming units at each interval during the three week investigation.

Table 4.2.3-1. Counts of Viable Colonies for 100 mg/L DBCP Systems.

<u>Time (Weeks)</u>	<u>Viable Colonies (per ml broth)</u>	
	<u>INOC B</u>	<u>INOC C</u>
0	N/A	N/A
1	4.0×10^5 *	7.9×10^4 *
2	$4.5 - 5.3 \times 10^4$	$1.5 - 4.6 \times 10^4$
3	$2.0 - 13.0 \times 10^3$	$0.9 - 1.7 \times 10^4$

Final cell concentrations were an order of magnitude lower than previously observed. At this high concentration, it is likely that DBCP became inhibitory to the metabolism of the dead biomass, while not as prevalent between DBCP concentrations of 10 and 50 mg/L. It was this concern that lead to the use of lower DBCP concentrations in all of the subsequent studies.

4.3 DBCP and Camphor Co-metabolic Studies

The following sections present and discuss the results of the 2 and 10 mg/L DBCP systems supplemented with 10 mg/L camphor (Experiments 4 and 5). Measurements of the dry cell weights were made on the cell inoculum used for these systems and were found to be 0.65 ± 0.02 g cells/L inoculum. This led to an approximate inoculated reactor

concentration of 0.05 g cells/L. Note that the initial concentration of biomass in these systems is an order of magnitude lower than those in experiments 1 through 3, although counts of viable colonies were on the same order, shown later in this chapter.

4.3.1 Experiment 4; 2 mg/L DBCP + 10 mg/L Camphor

A typical chromatogram for a 2 mg/L DBCP + 10 mg/L camphor inoculated reactor is shown in Figure 4.3.1-1. The retention times of DBCP, benzene, and TCB were 11.285, 2.725 and 12.276 minutes, respectively. Camphor eluted at a time of 12.524 minutes. As mentioned previously, the peak occurring at 0.919 is believed to be air and peaks due to septum bleed resolve after 15 minutes. Comparison of chromatograms for inoculated and control reactors showed no apparent degradative peaks for either DBCP or camphor. Additional chromatograms for the DBCP / camphor co-metabolic studies can be seen in Appendix D.

Figure 4.3.1-2 is a graphical representation of the DBCP concentration versus time. Data points for weeks 1 and 3 do not contain error bars because the associated uncertainty with these values was below 1.5%. No reasonable trends can be noted from these data, however a decrease in DBCP is portrayed between weeks 1, 2 and 3.

Figure 4.3.1-1. Gas Chromatogram for 2 mg/L DBCP + 10 mg/L Camphor Inoculated Reactor after Three Weeks of Incubation

Figure 4.3.1-2. Experiment 4; DBCP Concentration versus Time

A definitive trend is observed in the plot of camphor concentration versus time shown in Figure 4.3.1-3. Within the margins of uncertainty, it is evident that the camphor concentration decreased over the three week period at a somewhat constant rate. However, as mentioned previously, no degradation peaks were observed for camphor in any of the gas chromatograms. Therefore, it is not possible to ascertain whether or not camphor was degraded to compounds undetectable by the GC (possibly co-eluting with the solvent) or whether camphor just permeated the cellular membrane and was not capable of being extracted. Abiotic degradation is not likely, because the resulting ratio of the inoculated concentrations to that of the control systems would produce a straight line of zero slope.

Figure 4.3.1-3. Experiment 4; Camphor Concentration Versus Time

Viable colony count data, shown in Table 4.3.1-1 indicate a decrease in the number of living microbes in the inoculated reactor systems. As in previous experiments, no contamination was observed in the control vials.

Table 4.3.1-1. Counts of Viable Colonies for 2 mg/L DBCP + Camphor Systems.

<u>Time (Weeks)</u>	<u>Viable Colonies (per ml)</u>	
	<u>INOC A</u>	<u>INOC B</u>
0	6.9 - 7.7 X 10 ⁶	5.4 - 6.4 X 10 ⁶
1	4.7 - 5.5 X 10 ⁶	4.9 - 5.8 X 10 ⁶
2	4.1 - 5.0 X 10 ⁶	3.6 - 3.8 X 10 ⁶
3	0.9 - 1.6 X 10 ⁶	4.7 - 5.6 X 10 ⁶

While the trends show a steady decrease in the number of viable cells, the rate and overall magnitude of the reduction are significantly lower than those observed in Experiments 1 through 3. This could be attributed to the lower DBCP concentration used, or the presence of camphor. While no degradation peaks of camphor were observed, it was noted that the camphor concentration decreased steadily. It is possible that one of the cultures was able to metabolize camphor, while the other two were not. The growth of one and the corresponding death of the other two, could possibly lead to such a reduced decline in the overall number of viable cells. However, since the microbes were essentially indistinguishable (visually) counts of each individual species were not possible. Therefore, no definitive conclusions can be drawn based on these data alone and further studies are required.

4.3.2 Experiment 5; 10 mg/L DBCP + 10 mg/L Camphor

Figure 4.3.2-1 shows a typical chromatogram for an inoculated reactor containing both 10 mg/L DBCP and camphor after three weeks of incubation. The retention times of DBCP, camphor, benzene and TCB are 11.271, 12.508, 2.713 and 12.261 minutes, respectively. As in the case of the 2 mg/L DBCP + 10 mg/L camphor systems, no extraneous peaks were noted in comparing the inoculated and control chromatograms. In addition, no trends can be seen in the DBCP concentrations in the reactors during the three week period, shown in Figure 4.3.2-2.

Figure 4.3.2-1. Gas Chromatogram for 10 mg/L DBCP + 10 mg/L Camphor Inoculated Reactor after Three Weeks of Incubation

Figure 4.3.2-2. Experiment 5; DBCP Concentration Versus Time

Large fluctuations are noted in the ratio of DBCP concentrations, and as a result of the low uncertainties associated with each measurement, a constant composition cannot be justifiably assumed. The inability to determine experimental trends is also evident in the plot of camphor concentration as a function of time, shown in Figure 4.3.2-3.

Due to the large uncertainties in measurement, a definitive trend cannot be noted from these data. It is evident that camphor was neither degraded nor incorporated into the cells as was seen in the 2 mg/L DBCP + 10 mg/L camphor systems. It is possible that the higher DBCP levels became inhibitory in the inclusion or metabolism of this compound. However, looking at the results from this experiment, it is apparent that the

Figure 4.3.2-3. Experiment 5; Camphor Concentration Versus Time

extraction procedures could have led to the observed trends. Variations in the amount of pentane extractant added to each vial could inherently influence the concentration of the substrates in the organic phase. Looking at both the DBCP and camphor plots, Figure 4.3.2-2 and Figure 4.3.2-3, it is evident that similar trends exist. Both concentrations decreased between Week 0 and Week 1, then increased in Week 2 to a higher level than Week 0. These concentrations finally decreased in Week 3, elucidating the possibility that the observed results were due to experimental errors. Thus, these results are not sufficient to rule out the possible degradation of camphor in Experiment 4.

Counts of viable microbes were also made for this system, summarized in Table 4.3.2-1. As can be seen from these data, the number of colonies decreased steadily and significantly.

Table 4.3.2-1. Counts of Viable Colonies for 10 mg/L DBCP + Camphor Systems.

<u>Time (Weeks)</u>	<u>Viable Colonies (per ml)</u>	
	<u>INOC A</u>	<u>INOC B</u>
0	1.1 - 1.2 X 10 ⁷	6.5 - 8.4 X 10 ⁶
1	5.7 - 5.9 X 10 ⁶	4.8 - 5.6 X 10 ⁶
2	1.0 - 1.6 X 10 ⁶	1.2 - 2.0 X 10 ⁶
3	2.0 - 3.0 X 10 ⁵	7.0 X 10 ⁵

over the experimental period. Comparing these data with those of the 2 mg/L DBCP camphor systems, it is apparent that the higher DBCP concentrations led to an increased rate of cellular mortality observed in these systems. The inoculated systems in the 10 mg/L DBCP systems decreased from an average high of 9.5 x 10⁶ viable colonies to an average low of 4.8 x 10⁵ over a three week period. The 2 mg/L DBCP camphor systems only decreased from an average high of 6.6 x 10⁶ to 3.8 x 10⁶ living organisms per ml of reactor broth within the same time period.

4.4 DBCP and 3-Chloro-1-propanol Co-metabolic Studies

The following sections present and discuss the results of the 2 and 10 mg/L DBCP systems supplemented with 25 mg/L 3-chloro-1-propanol (Experiments 6 and 7). The

same batch of cell inoculum was used in these sets of experiments as was used in the camphor co-metabolic studies. As was stated in section 4.3, the dry cell weight of the inoculum was 0.65 ± 0.02 g cell/L which led to an approximate cell concentration of 0.05 g cells/L in the inoculated reactors.

Preliminary studies were conducted to determine the retention time of chloropropanol (CPL) using the employed gas chromatographic parameters. A sample of the pentane extractant solution was spiked with CPL to a concentration of approximately 1000 mg/L. The resulting chromatograms showed the elution times of CPL to be around 2.730 minutes, which fell within the pentane solvent tail. Experiments were performed to determine the efficiency of extracting the chloropropanol from the aqueous phase using the pentane extractant solution. The results showed that this procedure was ineffective for removing the CPL from the aqueous phase, and that aqueous concentrations of 1,000 mg/L CPL were necessary to produce any resolvable peak in the chromatograms. In addition, direct injection of the aqueous phase was not possible because permanent damage to the GC column would result. Therefore, with the employed system and procedures, a quantitative study of the decomposition of CPL was not possible using the concentration employed. As a result, the following section focuses on the degradation of DBCP and counts of viable colonies in the presence of 25 mg/L 3-chloro-1-propanol.

4.4.1 Experiment 6; 2 mg/L DBCP + 25 mg/L Chloropropanol

Figure 4.4.1-1 shows a typical chromatogram of a 2 mg/L DBCP + 25 mg/L CPL inoculated reactor after three weeks of incubation. The retention times of DBCP, benzene and TCB are 11.275, 2.719 and 12.265 minutes, respectively. As stated previously, CPL was unresolved by this system. After three weeks of incubation, no extraneous peaks were noted as possible degradation products of DBCP. Additional chromatograms for these systems can be viewed in Appendix D.

Figure 4.4.1-1. Gas Chromatogram for 2 mg/L DBCP + 25 mg/L CPL Inoculated Reactor after Three Weeks of Incubation

Figure 4.4.1-2 shows the average concentration of DBCP in the inoculated reactors throughout the duration of this experiment. As with other systems studied, no definitive trends can be established from these data. Due to the large uncertainty and deviations with the measured areas, a constant DBCP concentration can be proposed.

Figure 4.4.1-2. Experiment 6; DBCP Concentration Versus Time

Colony counts conducted show possible signs of cellular growth on chloropropanol, summarized in Table 4.4.1-1.

Table 4.4.1-1. Counts of Viable Colonies for 2 mg/L DBCP + CPL Systems.

<u>Time (Weeks)</u>	<u>Viable Colonies (per ml)</u>	
	<u>INOC A</u>	<u>INOC B</u>
0	7.9×10^6	$7.7 - 8.1 \times 10^6$
1	$0.7 - 1.0 \times 10^7$	$1.4 - 1.5 \times 10^7$
2	$7.1 - 9.3 \times 10^6$	$0.8 - 1.0 \times 10^7$
3	$6.9 - 7.8 \times 10^6$	5.1×10^6

Viable cell numbers in both inoculated systems in the first week of experimentation increased from initial measurements. Microbial populations continued to remain on the order of initial measurements after the second week, despite a small decline. Since there was no observed degradation of DBCP, the observed microbial growth could only be attributed to two other possibilities, the chloropropanol or residual glucose due to incomplete washing of the cell inoculum. It is highly improbable that the latter case could contribute to this increase in viable colonies based on the observations in the camphor co-metabolic study. The same cell inoculum was used in both the camphor and chloropropanol experiments, and no such increase in microbial populations was observed in Experiments 4 and 5. This would lead to the conclusion that chloropropanol was metabolized, but it is not possible to make definitive conclusions, since the analytical techniques were not capable of quantifying CPL concentrations in the reactor systems.

4.4.2 Experiment 7; 10 mg/L DBCP + 25 mg/L Chloropropanol

A typical chromatogram of a 10 mg/L DBCP + 25 mg/L CPL inoculated reactor after three weeks of incubation is shown in Figure 4.4.2-1. The retention times of DBCP, benzene, and TCB are 11.264, 2.710 and 12.254 minutes, respectively. No visible degradation products were found in any of the inoculated systems during any of the sampling periods. In addition, plots of the DBCP concentrations in the reactor vials over the duration of the test show no decrease (shown in Figure 4.4.2-2).

Figure 4.4.2-1. Gas Chromatogram for 10 mg/L DBCP + 25 mg/L CPL Inoculated Reactor after Three Weeks of Incubation

Figure 4.4.2-2. Experiment 7; DBCP Concentration Versus Time

As can be seen, a constant composition in the inoculated reactor systems can be proposed due to the uncertainties associated with the quantitative analysis. Enumeration of viable colonies showed similar trends as was observed in the 2 mg/L DBCP + 25 mg/L CPL studies. Table 4.4.2-1 shows the counts of living microbes throughout the three week experiment.

Table 4.4.2-1. Counts of Viable Colonies for 10 mg/L DBCP + CPL Systems.

<u>Time (Weeks)</u>	<u>Viable Colonies (per ml)</u>	
	<u>INOC A</u>	<u>INOC B</u>
0	8.7×10^6	$4.2 - 5.7 \times 10^6$
1	$1.2 - 1.4 \times 10^7$	$1.1 - 1.4 \times 10^7$
2	$0.9 - 1.0 \times 10^7$	$7.1 - 9.1 \times 10^6$
3	$4.3 - 5.1 \times 10^6$	$3.9 - 6.1 \times 10^6$

Once again, a relative increase in viable populations was observed within the first week of incubation, which persisted throughout the second week. Based on this, and the results from Experiment 6, it is thought that some sort of metabolism of CPL did occur during this time period, but cannot be asserted due to the inability to monitor 3-chloro-1-propanol.

4.5 DBCP as Sole Carbon Source - 9 Culture Consortium

This section discusses the results of the only experiment to use the nine culture consortium. This consortium was closely related to that used by Wallace (1994) in which degradation was thought to have occurred. Measurements of the dry cell weights were made on the cell inoculum used for this experiment and were found to be 2.0 ± 0.5 g cells/L inoculum. This led to an inoculated reactor concentration of 0.15 g cell/L. A typical chromatogram for an inoculated reactor after three weeks of incubation is shown in Figure 4.5-1. The retention times of DBCP, benzene, and tri-chlorobenzene were found to be 11.285, 2.730 and 12.276 minutes respectively. Comparing inoculated reactor chromatograms with the analogous control systems showed no formation of extraneous peaks. A graphical representation of the initial and third week DBCP concentration is shown in Figure 4.5-2. Even with the relatively low values of error associated with substrate concentration measurements, a constant composition can be

assumed. Minimal decrease in the average DBCP concentration occurred in the three week period.

Figure 4.5-1. Gas Chromatogram for 10 mg/L DBCP Inoculated Reactor after Three Weeks of Incubation, 9 Culture Consortium.

Figure 4.5-2. Experiment 8; DBCP Concentration Versus Time

Colony counts conducted on these systems showed a decrease in the population of viable cells, summarized in Table 4.5-1. While there is an evident decrease in the number of microbes in these reactors, the overall magnitude is not significant. When comparing the overall decline to that observed in Experiment 1 (containing 10 mg/L DBCP as a sole carbon source) lower mortality rates were observed. It is not known why the cultures in this consortium are more resilient than those in the previous experiments; however, data show significant dissimilarities.

Table 4.5-1. Counts of Viable Colonies for 10 mg/L DBCP Systems.

<u>Time (Weeks)</u>	<u>Viable Colonies (per ml)</u>	
	<u>INOC A</u>	<u>INOC B</u>
0	2.9 - 5.9X 10 ⁶	4.5 - 4.6 X 10 ⁶
3	1.5 X 10 ⁶	1.2 - 1.5 X 10 ⁶

4.6 Analysis of Errors

The following section discusses the systemic and experimental errors associated with the analytical procedures. While it was not possible to limit the errors introduced by the analytical equipment, great care was taken to minimize errors in the preparative, extraction and sampling procedures.

A significant source of errors and uncertainties associated with this study arises from the detection limits and fluctuations associated with the gas chromatograph. In order to normalize deviations introduced by varying injection volumes, two internal standards were employed. The same batch of extractant pentane was used in all experiments, containing both the benzene and 1,3,5-trichlorobenzene standards. However, the ratio of TCB to benzene was found to vary by approximately 2 to 3 % from injection to injection. In addition DBCP / TCB levels were often found to vary as high 5 % in subsequent injections of the same solution. While it is possible that this could be attributed to inhomogeneity in the solution, it is more likely due to the limitations in the sensitivity of the Flame Ionization Detector used in this experiment.

The limitations of detection in the FID can be attributed to two possible causes: the incomplete combustion and ionization of the carbonaceous compounds and the limited sensitivity of the ion detector itself. Great care was taken to ensure that complete

combustion occurred through the set hydrogen, air and nitrogen gases supplied to the FID. In all cases, a substantial peak for the pentane solvent was resolved, leading to the conclusion that sufficient combustion gases were supplied for the ionization of the chemical species. It is therefore more likely that the errors are a result of the limits of the FID detection. It was found, that extracted aqueous concentrations of DBCP below 0.7 mg/L did not resolve at all and that equivalent concentrations of benzene and TCB resolved quite differently due to the difference in the carbon to hydrogen ratios. An Electron Capture Detector would have been more suited for the types of chemical species being studied, perhaps giving resolution to DBCP peaks below aqueous concentrations of 0.7 mg/L. This might have enabled the detection of trace degradation products not detected by the FID.

Even though great care was taken to minimize the introduction of experimental/procedural errors in these experiments, data for the 10 mg/L DBCP + 10 mg/L camphor experiments suggests that errors were introduced. The largest source of errors appears to arise from the extraction procedure. As noted previously, the fluctuations in the amount of the pentane extractant added could inherently affected the observed results. A 2.5 ml syringe was used to inject 2 ml of pentane into each of the sampled vials for extraction. Recall that a 27 ml aqueous solution was extracted with 2 ml pentane. Deviations of 1 % would lead to concentration fluctuations in the organic layer of up to 13 % due to the concentrating effect of the DBCP from the aqueous to organic phase after extraction.

Therefore, variations in the volumes of pentane added could lead to errors twice the magnitude of the uncertainties associated with the GC, making this a significant source of error. However, the limits of detection of the GC are still important in resolving peaks due to trace amounts of carbonaceous compounds.

Another source of experimental error is noted in the colony count procedures and methods used. As mentioned before, the results from the colony counts are highly qualitative. Even though sampling methods were consistent, it is difficult to get homogeneous suspensions; therefore, CFU measurements varied significantly. This could be improved by taking more samples of the same suspension, or increasing the amount of the suspension spread on each agar plate. Nonetheless, it is reasonable to assume that these measurements are accurate within an order of magnitude, thus the observations in the chloropropanol systems would be valid.

Chapter 5. Conclusions

This study was conducted to evaluate the potential of microbes isolated from *Plocamium cartilagineum*. toward the degradation of 1,2-dibromo-3-chloropropane both as a sole carbon source and as a co-substrate. From the data obtained, it was determined that no degradative activity was observed in any of the systems of the target substrate. In addition, it was found that DBCP was highly inhibitive to cellular growth at aqueous concentrations of 100 mg/L whereas only moderate effects were noted at concentrations below 50 mg/L.

There appeared to be some degradative activity toward camphor in Experiment 5, noted by a continuous decline in the camphor concentration over the three week investigation. In these systems no extraneous peaks were observed, implying that camphor was incorporated into the cellular structure or degraded to undetectable compounds (such as CH₄ or CO₂). However, similar experiments with camphor and increased levels of DBCP did not show any of these trends. In addition, counts conducted to determine viable microbial populations did not show any significant growth, thus implying that camphor could have permeated the cell membrane and been incorporated into the microbe. This assumption would only be valid if the cells were not lysed upon extraction with pentane, which may be fallible, since the microbes are assumed gram negative. The inner and outer membranes of gram negative bacteria have complex polysaccharides which serve to

retain important cellular material. These membranes are often weakened and ruptured when exposed to organic solvents.

Studies using 3-chloro-1-propanol as a co-substrate revealed the possibility of some microbial activity toward the degradation and metabolism of this compound. While a quantitative analysis of CPL concentration was not possible, there appeared to be a relative increase in microbial populations after one week of incubation. This trend was noted for experiments containing both 2 and 10 mg/L DBCP in addition to 25 mg/L CPL. Also, since no growth occurred in other systems employing the same cell stock solution, it is highly improbable that this could be due to residual glucose, as discussed previously.

The studies using the cultures isolated from both *Plocamium cartilagineum* and the *Laurencia sp.* showed no degradative activity toward DBCP as was have thought to have occurred by the initial work of Wallace (1994).

Future studies should look into a different method for the isolation and culturing of these microbes. Previous studies have shown these species of marine macro-algae to possess copious amounts of halogenated compounds. Since it is recognized that microbial degradation and decomposition are paramount in the transformation of dead plants to usable nutrients, substantial populations of microbes could inherently be obtained by allowing the living tissue to die and decay. After a significant period, microbial cultures

with such activity may be in sufficient numbers to isolate and culture. If employed, future studies with DBCP could produce significantly different results.

The most interesting work which could be conducted to follow this work is the investigation of the degradation of chloropropanol. Previous studies by Bloom and Alexander (1990) showed that microbes cultured on CPL were eventually able to degrade DBCP. While chloropropanol does not possess the high halogen / carbon ratios of many biocides employed in the agricultural industry, studies could determine whether or not dehalogenation reactions are occurring. This could eventually lead to the isolation of the dehalogenating enzyme(s) which could be used for the degradation of other analogous compounds.

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Appendix A

Reduced Chromatography Data

Table A.1.1. Chromatography data for Week 0; 10 mg/L DBCP reactors using the three strain consortium.

	AREA RATIOS		AQUEOUS CONCENTRATIONS(mg/L)	
	DBCP/TCB		DBCP	
CONTROL A	RUN 273		10.0511	
	RUN 274		10.2241	
	RUN 275	AVERAGE	10.1193	10.15
	RUN 276	ST. DEV.	10.2021	0.08
CONTROL B	RUN 277		10.2788	
	RUN 278		10.1423	
	RUN 279	AVERAGE	10.0120	10.1
	RUN 280	ST. DEV.	9.9601	0.1
INOCULATED A	RUN 281		9.9922	
	RUN 282		9.7913	
	RUN 283	AVERAGE	10.3292	10.1
	RUN 284	ST. DEV.	10.1295	0.2
INOCULATED B	RUN 285		9.2571	
	RUN 286		10.4405	
	RUN 287	AVERAGE	10.2637	10.0
	RUN 288	ST. DEV.	9.8896	0.5
INOCULATED C	RUN 289		9.6217	
	RUN 290		9.4468	
	RUN 291	AVERAGE	9.5721	9.6
	RUN 292	ST. DEV.	9.2696	0.4
RUN 293	1.284243		10.2280	

Table A.1.2. Chromatography data for Week 1; 10 mg/L DBCP reactors using the three strain consortium.

		<u>AREA RATIOS</u>		<u>AQUEOUS CONCENTRATIONS(mg/L)</u>	
		DBCP/TCB		DBCP	
CONTROL A	RUN 377	1.140702		9.0848	
	RUN 378	1.152297		9.1772	
	RUN 379	1.266983	AVERAGE 1.19	10.0905	AVERAGE 9.50
	RUN 380	1.211824	ST. DEV. 0.06	9.6512	ST. DEV. 0.46
CONTROL B	RUN 381	1.30317		10.3787	
	RUN 382	1.273771		10.1446	
	RUN 383	1.197682	AVERAGE 1.23	9.5384	AVERAGE 9.8
	RUN 384	1.162748	ST. DEV. 0.07	9.2604	ST. DEV. 0.5
INOCULATED A	RUN 385	1.243377		9.9025	
	RUN 386	1.212986		9.6605	
	RUN 387	1.298784	AVERAGE 1.25	10.3438	AVERAGE 10.0
	RUN 388	1.258888	ST. DEV. 0.04	10.0261	ST. DEV. 0.3
INOCULATED B	RUN 389	1.203802		9.5874	
	RUN 390	1.229845		9.7948	
	RUN 391	1.21019	AVERAGE 1.23	9.6382	AVERAGE 9.8
	RUN 392	1.276695	ST. DEV. 0.03	10.1679	ST. DEV. 0.3
INOCULATED C	RUN 393	1.248442		9.9429	
	RUN 394	1.192434		9.4968	
	RUN 395	1.18181	AVERAGE 1.19	9.4122	AVERAGE 9.3
	RUN 396	1.144559	ST. DEV. 0.04	9.1155	ST. DEV. 0.2

Table A.1.3. Chromatography data for Week 2; 10 mg/L DBCP reactors using the three strain consortium.

	<u>AREA RATIOS</u>		<u>AQUEOUS CONCENTRATIONS(mg/L)</u>	
	DBCPT/CB		DBC	BCP
CONTROL A				
RUN 477	1.233022		9.8201	
RUN 478	1.198146		9.5423	
RUN 479	1.237713		9.8574	
RUN 480	1.252538	AVERAGE 1.22	9.9755	9.73
RUN 481	1.184103	ST. DEV. 0.03	9.4305	0.23
CONTROL B				
RUN 482	1.108651		8.8295	
RUN 483	1.233357		9.8227	
RUN 484	1.13472	AVERAGE 1.17	9.0372	9.3
RUN 485	1.191774	ST. DEV. 0.06	9.4916	0.4
INOCULATED A				
RUN 486	1.148929		9.1503	
RUN 487	1.020371		8.1265	
RUN 488	1.27424	AVERAGE 1.17	10.1483	9.3
RUN 489	1.225932	ST. DEV. 0.11	9.7636	0.9
INOCULATED B				
RUN 490	1.219451		9.7120	
RUN 491	1.205026		9.5971	
RUN 492	1.231542	AVERAGE 1.22	9.8083	9.7
RUN 493	1.204525	ST. DEV. 0.01	9.5931	0.1
INOCULATED C				
RUN 494	1.170741		9.3240	
RUN 495	1.189374		9.4724	
RUN 496	1.141135	AVERAGE 1.18	9.0883	9.5
RUN 497	1.233083	ST. DEV. 0.04	9.8206	0.4

Table A.1.4. Chromatography data for Week 3; 10 mg/L DBCP reactors using the three strain consortium.

		<u>AREA RATIOS</u>		<u>AQUEOUS CONCENTRATIONS(mg/L)</u>	
		<u>DBCP/TCB</u>		<u>DBCP</u>	
CONTROL A	RUN 573	1.067648		8.5030	
	RUN 574	1.12028		8.9222	
	RUN 575	1.127614	AVERAGE 1.12	8.9806	AVERAGE 8.9
	RUN 576	1.150325	ST. DEV. 0.03	9.1615	ST. DEV. 0.3
CONTROL B	RUN 577	1.250768		9.9614	
	RUN 578	1.179638		9.3949	
	RUN 579	1.167632	AVERAGE 1.19	9.2993	AVERAGE 9.5
	RUN 580	1.16861	ST. DEV. 0.04	9.3071	ST. DEV. 0.3
INOCULATED A	RUN 581	1.131707		9.0132	
	RUN 582	1.149152		9.1521	
	RUN 583	1.090963	AVERAGE 1.13	8.6887	AVERAGE 9.0
	RUN 584	1.130249	ST. DEV. 0.02	9.0016	ST. DEV. 0.2
INOCULATED B	RUN 585	1.175873		9.3649	
	RUN 586	1.167186		9.2957	
	RUN 587	1.140874	AVERAGE 1.16	9.0862	AVERAGE 9.2
	RUN 588	1.143143	ST. DEV. 0.02	9.1042	ST. DEV. 0.1
INOCULATED C	RUN 589	1.138692		9.0688	
	RUN 591	1.160556		9.2429	
	RUN 592	1.1648	AVERAGE 1.15	9.2767	AVERAGE 9.2
	RUN 593	1.131713	ST. DEV. 0.02	9.0132	ST. DEV. 0.1

Table A.2.1. Chromatography data for Week 0; 50 mg/L DBCP reactors using the three strain consortium.

		<u>AREA RATIOS</u>		<u>AQUEOUS CONCENTRATIONS(mg/l)</u>	
		DBCP/TCB		DBCP	
CONTROL A	RUN 297	6.541779		52.1002	
	RUN 299	6.797159		54.1341	
	RUN 300	6.66979		53.1197	
	RUN 301	6.258297	AVERAGE 6.55	49.8425	AVERAGE 52.1
	RUN 302	6.464159	ST. DEV. 0.20	51.4820	ST. DEV. 1.6
CONTROL B	RUN 303	5.941101		47.3163	
	RUN 304	5.927512		47.2081	
	RUN 305	6.047992	AVERAGE 6.00	48.1676	AVERAGE 47.7
	RUN 306	6.065162	ST. DEV. 0.07	48.3043	ST. DEV. 0.6
INOCULATED A	RUN 307	6.201805		49.3926	
	RUN 308	6.178373		49.2060	
	RUN 309	6.03631	AVERAGE 6.19	48.0745	AVERAGE 49.3
	RUN 310	6.334829	ST. DEV. 0.12	50.4520	ST. DEV. 1.0
INOCULATED B	RUN 311	5.991154		47.7149	
	RUN 312	6.22728		49.5955	
	RUN 313	6.201601	AVERAGE 6.17	49.3910	AVERAGE 49.1
	RUN 314	6.240797	ST. DEV. 0.12	49.7031	ST. DEV. 0.9
INOCULATED C	RUN 315	6.384357		50.8465	
	RUN 316	6.017215		47.9225	
	RUN 317	6.129261	AVERAGE 6.24	48.8148	AVERAGE 49.3
	RUN 318	6.427565	ST. DEV. 0.20	51.1906	ST. DEV. 1.7

Table A.2.2. Chromatography data for Week 1; 50 mg/L DBCP reactors using the three strain consortium.

	<u>AREA RATIOS</u>		<u>AQUEOUS CONCENTRATIONS(mg/l)</u>	
	DBCP/TCB		DBCP	
CONTROL A				
RUN 399	6.610601		52.6483	
RUN 400	6.501469		51.7792	
RUN 401	6.518509	AVERAGE 6.54	51.9149	AVERAGE 52.1
RUN 402	6.519706	ST. DEV. 0.05	51.9244	ST. DEV. 0.4
CONTROL B				
RUN 403	6.093986		48.5339	
RUN 404	5.566326		44.3315	
RUN 405	5.678974	AVERAGE 5.76	45.2286	AVERAGE 45.9
RUN 406	5.69303	ST. DEV. 0.23	45.3406	ST. DEV. 1.8
INOCULATED A				
RUN 407	5.825893		46.3987	
RUN 408	6.122827		48.7636	
RUN 409	5.797522	AVERAGE 5.96	46.1728	AVERAGE 47.5
RUN 410	6.108704	ST. DEV. 0.18	48.6511	ST. DEV. 1.4
INOCULATED B				
RUN 411	5.961215		47.4765	
RUN 412	5.664502		45.1134	
RUN 413	6.175074	AVERAGE 5.95	49.1797	AVERAGE 47.4
RUN 414	6.010241	ST. DEV. 0.21	47.8669	ST. DEV. 1.7
INOCULATED C				
RUN 415	6.260518		49.8602	
RUN 416	6.243461		49.7243	
RUN 417	5.944314	AVERAGE 6.23	47.3419	AVERAGE 49.5
RUN 418	6.461138	ST. DEV. 0.21	51.4580	ST. DEV. 2.1

Table A.2.3. Chromatography data for Week 2; 50 mg/L DBCP reactors using the three strain consortium.

	<u>AREA RATIOS</u>		<u>AQUEOUS CONCENTRATIONS(mg/l)</u>	
	<u>DBCP/TCB</u>		<u>DBCP</u>	
CONTROL A				
RUN 500	6.333195		50.4390	
RUN 501	6.344123		50.5260	
RUN 502	6.122112	AVERAGE 6.31	48.7579	AVERAGE 50.2
RUN 503	6.433819	ST. DEV. 0.13	51.2404	ST. DEV. 1.1
CONTROL B				
RUN 504	6.234825		49.6556	
RUN 505	6.043325		48.1304	
RUN 506	5.946013	AVERAGE 6.05	47.3554	AVERAGE 48.2
RUN 507	5.977626	ST. DEV. 0.13	47.6072	ST. DEV. 1.0
INOCULATED A				
RUN 508	6.190858		49.3054	
RUN 509	6.162914		49.0828	
RUN 510	6.098434	AVERAGE 6.11	48.5693	AVERAGE 48.6
RUN 511	5.972593	ST. DEV. 0.10	47.5671	ST. DEV. 0.8
INOCULATED B				
RUN 512	5.850286		46.5930	
RUN 513	5.844644		46.5481	
RUN 514	5.698798	AVERAGE 5.85	45.3865	AVERAGE 46.6
RUN 515	6.00742	ST. DEV. 0.13	47.8445	ST. DEV. 1.0
INOCULATED C				
RUN 516	6.032391		48.0433	
RUN 517	6.010505		47.8690	
RUN 518	5.847895	AVERAGE 5.95	46.5740	AVERAGE 47.1
RUN 519	5.898422	ST. DEV. 0.09	46.9764	ST. DEV. 0.7

Table A.2.4. Chromatography data for Week 3; 50 mg/L DBCP reactors using the three strain consortium.

	AREA RATIOS		AQUEOUS CONCENTRATIONS(mg/L)	
	DBCPTCB		DBCP	
CONTROL A				
RUN 596	5.789029		46.1051	
RUN 597	5.930068		47.2284	
RUN 599	5.849642	AVERAGE 5.83	46.5879	46.4
RUN 600	5.749603	ST. DEV. 0.08	45.7911	0.6
CONTROL B				
RUN 601	5.816402		46.3231	
RUN 602	5.769166		45.9469	
RUN 603	5.550746	AVERAGE 5.72	44.2074	45.5
RUN 604	5.730303	ST. DEV. 0.12	45.6374	0.9
INOCULATED A				
RUN 605	5.851457		46.6023	
RUN 606	5.687831		45.2992	
RUN 607	5.780485	AVERAGE 5.77	46.0371	45.9
RUN 608	5.74515	ST. DEV. 0.07	45.7557	0.5
INOCULATED B				
RUN 610	5.732344		45.6537	
RUN 611	5.712066		45.4922	
RUN 613	5.585133	AVERAGE 5.69	44.4813	45.3
RUN 614	5.716714	ST. DEV. 0.07	45.5292	0.5
INOCULATED C				
RUN 615	5.558947		44.2727	
RUN 616	5.584088		44.4729	
RUN 617	5.687251	AVERAGE 5.49	45.2946	43.5
RUN 618	5.133133	ST. DEV. 0.24	40.8814	2.3

Table A.3.1. Chromatography data for Week 0; 100 mg/L DBCP reactors using the three strain consortium.

	<u>AREA RATIOS</u>		<u>AQUEOUS CONCENTRATIONS(mg/l)</u>	
	DBCP/TCB		DBCP	
CONTROL A				
RUN 321	13.17758		104.9492	
RUN 322	12.73206		101.4011	
RUN 323	13.24556	AVERAGE 13.12	105.4906	AVERAGE 104.5
RUN 324	13.33602	ST. DEV. 0.27	106.2111	ST. DEV. 2.1
CONTROL B				
RUN 325	13.34789		106.3056	
RUN 326	13.20976		105.2055	
RUN 327	13.18848	AVERAGE 13.18	105.0361	AVERAGE 104.9
RUN 328	12.961	ST. DEV. 0.16	103.2244	ST. DEV. 1.3
INOCULATED A				
RUN 329	12.69708		101.1224	
RUN 330	13.01824		103.6802	
RUN 331	12.73054	AVERAGE 12.97	101.3889	AVERAGE 103.3
RUN 332	13.44199	ST. DEV. 0.34	107.0550	ST. DEV. 2.7
INOCULATED B				
RUN 333	13.19851		105.1160	
RUN 334	12.5545		99.9869	
RUN 335	13.21207	AVERAGE 13.00	105.2240	AVERAGE 103.5
RUN 336	13.01627	ST. DEV. 0.31	103.6645	ST. DEV. 2.4
INOCULATED C				
RUN 337	13.0113		103.6249	
RUN 338	13.45047		107.1226	
RUN 339	13.00339	AVERAGE 13.00	103.5620	AVERAGE 103.5
RUN 340	12.53266	ST. DEV. 0.37	99.8130	ST. DEV. 3.7

Table A.3.2. Chromatography data for Week 1; 100 mg/L DBCP reactors using the three strain consortium.

	AREA RATIOS		AQUEOUS CONCENTRATIONS(mg/l)	
	DBCP/TCB		DBCP	
CONTROL A				
RUN 421	11.92088		94.9406	
RUN 422	12.46111		99.2431	
RUN 423	12.93856	AVERAGE 12.51	103.0457	AVERAGE 99.7
RUN 424	12.73112	ST. DEV. 0.44	101.3935	ST. DEV. 3.5
CONTROL B				
RUN 425	12.73747		101.4441	
RUN 426	12.26507		97.6818	
RUN 427	12.59201	AVERAGE 12.45	100.2856	AVERAGE 99.2
RUN 428	12.21051	ST. DEV. 0.25	97.2472	ST. DEV. 2.0
INOCULATED A				
RUN 429	12.86139		102.4310	
RUN 430	12.16352		96.8731	
RUN 431	12.41717	AVERAGE 12.46	98.8931	AVERAGE 99.2
RUN 432	12.39203	ST. DEV. 0.29	98.6929	ST. DEV. 2.3
INOCULATED B				
RUN 433	12.3025		97.9799	
RUN 434	12.21157		97.2557	
RUN 435	12.44718	AVERAGE 12.28	99.1322	AVERAGE 97.8
RUN 436	12.16204	ST. DEV. 0.13	96.8613	ST. DEV. 1.0
INOCULATED C				
RUN 437	12.28375		97.8306	
RUN 438	12.15344		96.7927	
RUN 439	12.48311	AVERAGE 12.36	99.4183	AVERAGE 98.7
RUN 440	12.53224	ST. DEV. 0.18	99.8096	ST. DEV. 1.6

Table A.3.3. Chromatography data for Week 2; 100 mg/L DBCP reactors using the three strain consortium.

	AREA RATIOS		AQUEOUS CONCENTRATIONS(mg/l)	
	DBCP/TCB		DBCP	
CONTROL A	11.85164		94.3892	
	11.88724		94.6727	
	11.80687	AVERAGE 11.88	94.0326	AVERAGE 94.6
	11.9628	ST. DEV. 0.07	95.2745	ST. DEV. 0.5
CONTROL B	11.84636		94.3471	
	11.66758		92.9233	
	11.77417	AVERAGE 11.78	93.7722	AVERAGE 93.8
	11.81496	ST. DEV. 0.08	94.0970	ST. DEV. 0.6
INOCULATED A	11.95406		95.2048	
	12.03341		95.8368	
	11.80893	AVERAGE 11.93	94.0490	AVERAGE 95.0
	11.93951	ST. DEV. 0.09	95.0890	ST. DEV. 0.7
INOCULATED B	11.72083		93.3474	
	11.60869		92.4542	
	11.43307	AVERAGE 11.63	91.0555	AVERAGE 92.6
	11.76512	ST. DEV. 0.15	93.7001	ST. DEV. 1.2
INOCULATED C	11.96286		95.2750	
	11.8959		94.7417	
	12.02859	AVERAGE 11.97	95.7984	AVERAGE 95.3
	11.99161	ST. DEV. 0.06	95.5039	ST. DEV. 0.5

Table A.3.4. Chromatography data for Week 3; 100 mg/L DBCP reactors using the three strain consortium.

		AREA RATIOS		AQUEOUS CONCENTRATIONS(mg/L)	
		DBCP/TCB		DBCP	
CONTROL A	RUN 621	11.19312		89.1445	
	RUN 622	11.06832		88.1506	
	RUN 623	11.56308	AVERAGE 11.32	92.0910	AVERAGE 90.1
	RUN 624	11.45097	ST. DEV. 0.23	91.1981	ST. DEV. 1.8
CONTROL B	RUN 625	11.35131		90.4044	
	RUN 626	11.17641		89.0114	
	RUN 627	10.89733	AVERAGE 11.05	86.7888	AVERAGE 88.0
	RUN 628	10.7775	ST. DEV. 0.26	85.8344	ST. DEV. 2.1
INOCULATED A	RUN 629	11.07453		88.2001	
	RUN 630	11.16315		88.9059	
	RUN 631	11.05486	AVERAGE 11.11	88.0434	AVERAGE 88.5
	RUN 632	11.15081	ST. DEV. 0.05	88.8076	ST. DEV. 0.4
INOCULATED B	RUN 633	11.40378		90.8223	
	RUN 634	11.5112		91.6778	
	RUN 635	11.28562	AVERAGE 11.34	89.8812	AVERAGE 90.3
	RUN 636	11.16396	ST. DEV. 0.15	88.9123	ST. DEV. 1.2
INOCULATED C	RUN 637	11.21856		89.3472	
	RUN 638	11.09898		88.3948	
	RUN 639	11.22593	AVERAGE 11.21	89.4059	AVERAGE 89.3
	RUN 640	11.30948	ST. DEV. 0.09	90.0713	ST. DEV. 0.8

Table A.4.1. Chromatography data for Week 0; 2 mg/L DBCP + 10 mg/L Camphor using the three strain consortium.

	AREA RATIOS			AQUEOUS CONCENTRATIONS(mg/L)		
	DBCP/TCB	CAM/TCB	DBCP	DBCP	CAM	
CONTROL A						
RUN 782	0.460103	5.655346	3.231304		N/A	
RUN 783	0.465621	5.718978	3.270057	AVERAGE	N/A	
RUN 784	0.47699	5.832723	3.349903	ST. DEV.	N/A	
INOCULATED A						
RUN 785	0.45412	5.610455	3.189283		N/A	
RUN 786	0.459388	6.119581	3.226279	AVERAGE	N/A	
RUN 787	0.470259	7.010903	3.302631	ST. DEV.	N/A	
INOCULATED B						
RUN 788	0.448501	6.405518	3.14982		N/A	
RUN 789	0.461027	6.254294	3.237791	AVERAGE	N/A	
RUN 790	0.460478	6.49843	3.233937	ST. DEV.	N/A	

Table A.4.2. Chromatography data for Week 1; 2 mg/L DBCP + 10 mg/L Camphor using the three strain consortium.

	AREA RATIOS			AQUEOUS CONCENTRATIONS(mg/L)		
	DBCP/TCB	CAM/TCB	DBCP	DBCP	CAM	
CONTROL A						
RUN 832	0.438912	5.200282	3.082477		N/A	
RUN 833	0.457559	5.435748	3.21344	AVERAGE	3.2	
RUN 836	0.455455	5.353691	3.198658	ST. DEV.	0.1	
INOCULATED A						
RUN 837	0.458324	5.359349	3.218809		N/A	
RUN 838	0.452106	5.3952	3.175142	AVERAGE	3.2	
RUN 839	0.460423	5.453709	3.233547	ST. DEV.	0.0	
INOCULATED B						
RUN 840	0.466188	5.754031	3.274111		N/A	
RUN 841	0.4571	5.887109	3.210213	AVERAGE	3.2	
RUN 842	0.459625	6.084521	3.227943	ST. DEV.	0.0	

Table A.4.3. Chromatography data for Week 2; 2 mg/L DBCP + 10 mg/L Camphor using the three strain consortium.

	AREA RATIOS			AQUEOUS CONCENTRATIONS(mg/L)		
	DBCP/TCB	CAM/TCB	DBCP	DBCP	CAM	
CONTROL A						
RUN 887	0.436513	6.270447	3.065628		N/A	
RUN 888	0.422507	5.859114	2.967268	AVERAGE	3.0	
RUN 889	0.437133	6.195129	3.069983	ST. DEV.	0.1	
INOCULATED A						
RUN 890	0.407513	5.835879	2.861966		N/A	
RUN 891	0.421919	6.032476	2.963136	AVERAGE	3.0	
RUN 892	0.435805	5.797403	3.060658	ST. DEV.	0.1	
INOCULATED B						
RUN 893	0.459607	6.388798	3.227822		N/A	
RUN 894	0.449439	6.242138	3.156412	AVERAGE	3.2	
RUN 895	0.459571	6.173077	3.220543	ST. DEV.	0.0	

Table A.4.4. Chromatography data for Week 3; 2 mg/L DBCP + 10 mg/L Camphor using the three strain consortium.

	AREA RATIOS			AQUEOUS CONCENTRATIONS(mg/L)		
	DBCP/TCB	CAM/TCB	DBCP	CAM		
CONTROL A						
RUN 951	0.4508					
RUN 952	0.4557	6.389507	3.16623			N/A
RUN 953	0.4668	6.146481	3.20041		AVERAGE	3.2
		6.284373	3.278244		ST. DEV.	0.1
INOCULATED A						
RUN 954	0.4432	5.781437	3.112768			N/A
RUN 955	0.4431	5.608558	3.111774		AVERAGE	3.1
RUN 956	0.4417	5.854095	3.102398		ST. DEV.	0.0
INOCULATED B						
RUN 957	0.4446	6.162334	3.122446			N/A
RUN 958	0.4487	6.146396	3.151066		AVERAGE	3.1
RUN 959	0.4406	5.641788	3.094413		ST. DEV.	0.0

Table A.5.1. Chromatography data for Week 0; 10 mg/L DBCP + 10 mg/L Camphor using the three strain consortium.

	AREA RATIOS			AQUEOUS CONCENTRATIONS(mg/L)		
	DBCP/TCB	CAW/TCB	DBCP	CAM		
CONTROL A						
RUN 791	2.3637	6.320808	16.60025	N/A		
RUN 792	2.3630	6.322315	16.59569	N/A	AVERAGE	16.6
RUN 793	2.3813	6.235344	16.72397	N/A	ST. DEV.	0.1
INOCULATED A						
RUN 794	2.3557	6.265987	16.54379	N/A		
RUN 795	2.3531	6.150829	16.52601	N/A	AVERAGE	16.6
RUN 796	2.3953	6.406741	16.82235	N/A	ST. DEV.	0.2
INOCULATED B						
RUN 797	2.3579	6.16904	16.55954	N/A		
RUN 798	2.3820	6.346662	16.72893	N/A	AVERAGE	16.7
RUN 799	2.3910	6.196681	16.79206	N/A	ST. DEV.	0.1

Table A.5.2. Chromatography data for Week 1; 10 mg/L DBCP + 10 mg/L Camphor using the three strain consortium.

AREA RATIOS				AQUEOUS CONCENTRATIONS(mg/L)		
	DBCP/TCB	CAM/TCB		DBCP		CAM
CONTROL A						
	RUN 843					
	RUN 846					
INOCULATED A						
	RUN 849					
	RUN 850					
INOCULATED B						
	RUN 852					
	RUN 853					
	RUN 799					

Table A.5.3. Chromatography data for Week 2; 10 mg/L DBCP + 10 mg/L Camphor using the three strain consortium.

AREA RATIOS				AQUEOUS CONCENTRATIONS(mg/L)		
	DBCP/TCB	CAM/TCB		DBCP		CAM
CONTROL A						
	RUN 896	2.3075	6.072197	16.20558		N/A
	RUN 897	2.3126	6.017192	16.24162	AVERAGE	N/A
INOCULATED A						
	RUN 898	2.1561	4.990334	15.14199	ST. DEV.	N/A
INOCULATED B						
	RUN 899	2.2822	5.741221	16.02759		N/A
	RUN 900	2.2914	5.911467	16.0927	AVERAGE	N/A
	RUN 901	2.3242	6.20713	16.32292	ST. DEV.	N/A
INOCULATED B						
	RUN 902	2.4170	6.236315	16.97452		N/A
	RUN 903	2.3568	5.851472	16.55171	AVERAGE	N/A
	RUN 905	2.4159	6.037569	16.96687	ST. DEV.	N/A

Table A.5.4. Chromatography data for Week 3; 10 mg/L DBCP + 10 mg/L Camphor using the three strain consortium.

AREA RATIOS				AQUEOUS CONCENTRATIONS(mg/L)			
	DBCP/TCB	CAW/TCB		DBCP		CAM	
CONTROL A							
	RUN 960	2.3441		16.46261		N/A	
	RUN 961	2.3363	AVERAGE 2.32	16.40768	AVERAGE 16.3	N/A	
	RUN 962	2.2909	ST. DEV. 0.03	16.0889	ST. DEV. 0.2	N/A	
INOCULATED A							
	RUN 963	2.2786		16.0094		N/A	
	RUN 964	2.3164	AVERAGE 2.28	16.26843	AVERAGE 16.0	N/A	
	RUN 965	2.2482	ST. DEV. 0.03	15.78916	ST. DEV. 0.2	N/A	
INOCULATED B							
	RUN 966	2.2484		15.79026		N/A	
	RUN 967	2.3002	AVERAGE 2.27	16.15419	AVERAGE 15.9	N/A	
	RUN 968	2.2516	ST. DEV. 0.03	15.81266	ST. DEV. 0.2	N/A	

Table A.6.1. Chromatography data for Week 0; 2 mg/L DBCP + 25 mg/L Chloropropanol using the three strain consortium.

	AREA RATIOS			AQUEOUS CONCENTRATIONS(mg/L)		
	DBCP/TCB		CPL/TCB	DBCP		CPL
CONTROL A						
	0.298436		N/A	2.095918		N/A
	0.284285	AVERAGE	0.29	1.996533	AVERAGE	N/A
	0.280793	ST. DEV.	0.01	1.97201	ST. DEV.	N/A
INOCULATED A						
	0.256616		N/A	1.802213		N/A
	0.299502	AVERAGE	0.28	2.103406	AVERAGE	N/A
	0.29805	ST. DEV.	0.02	2.093307	ST. DEV.	N/A
INOCULATED B						
	0.270911		N/A	1.902611		N/A
	0.30156	AVERAGE	0.29	2.117854	AVERAGE	N/A
	0.285723	ST. DEV.	0.02	2.00663	ST. DEV.	N/A

Table A.6.2. Chromatography data for Week 1; 2 mg/L DBCP + 25 mg/L Chloropropanol using the three strain consortium.

	AREA RATIOS			AQUEOUS CONCENTRATIONS(mg/L)		
	DBCP/TCB		CPL/TCB	DBCP		CPL
CONTROL A						
RUN 857	0.285307		N/A	2.003714		N/A
RUN 858	0.302513	AVERAGE 0.29	N/A	2.124549	AVERAGE 2.0	N/A
RUN 859	0.285868	ST. DEV. 0.01	N/A	2.007649	ST. DEV. 0.1	N/A
INOCULATED A						
RUN 860	0.289752		N/A	2.034929		N/A
RUN 861	0.308251	AVERAGE 0.30	N/A	2.164844	AVERAGE 2.1	N/A
RUN 862	0.301355	ST. DEV. 0.01	N/A	2.116415	ST. DEV. 0.1	N/A
INOCULATED B						
RUN 863	0.27843		N/A	1.955413		N/A
RUN 864	0.274418	AVERAGE 0.29	N/A	1.927236	AVERAGE 2.0	N/A
RUN 865	0.315172	ST. DEV. 0.02	N/A	2.21345	ST. DEV. 0.2	N/A

Table A.6.3. Chromatography data for Week 2; 2 mg/L DBCP + 25 mg/L Chloropropanol using the three strain consortium.

	<u>AREA RATIOS</u>			<u>AQUEOUS CONCENTRATIONS(mg/L)</u>		
	DBCP/TCB		CPL/TCB	DBCP		CPL
CONTROL A						
RUN 909	0.305911		N/A	2.148414		N/A
RUN 910	0.309371	AVERAGE 0.30	N/A	2.172716	AVERAGE 2.1	N/A
RUN 911	0.294564	ST. DEV. 0.01	N/A	2.06872	ST. DEV. 0.1	N/A
INOCULATED A						
RUN 912	0.308488		N/A	2.166511		N/A
RUN 913	0.299585	AVERAGE 0.31	N/A	2.103987	AVERAGE 2.2	N/A
RUN 914	0.313731	ST. DEV. 0.01	N/A	2.20333	ST. DEV. 0.1	N/A
INOCULATED B						
RUN 915	0.32045		N/A	2.250517		N/A
RUN 916	0.279961	AVERAGE 0.30	N/A	1.966165	AVERAGE 2.1	N/A
RUN 917	0.300255	ST. DEV. 0.02	N/A	2.108691	ST. DEV. 0.1	N/A

Table A.6.4. Chromatography data for Week 3; 2 mg/L DBCP + 25 mg/L Chloropropanol using the three strain consortium.

	<u>AREA RATIOS</u>			<u>AQUEOUS CONCENTRATIONS(mg/L)</u>		
	DBCPTCB		CPLTCB	DBCP		CPL
CONTROL A						
RUN 971	0.294881		N/A	2.070951		N/A
RUN 972	0.28829	AVERAGE 0.29	N/A	2.024662	AVERAGE 2.0	N/A
RUN 973	0.29051	ST. DEV. 0.00	N/A	2.040254	ST. DEV. 0.0	N/A
INOCULATED A						
RUN 974	0.271822		N/A	1.909002		N/A
RUN 975	0.301738	AVERAGE 0.29	N/A	2.119105	AVERAGE 2.0	N/A
RUN 976	0.283288	ST. DEV. 0.02	N/A	1.989518	ST. DEV. 0.1	N/A
INOCULATED B						
RUN 977	0.276591		N/A	1.942498		N/A
RUN 978	0.29842	AVERAGE 0.28	N/A	2.095807	AVERAGE 2.0	N/A
RUN 979	0.275336	ST. DEV. 0.01	N/A	1.933683	ST. DEV. 0.1	N/A

Table A.7.1. Chromatography data for Week 0; 10 mg/L DBCP + 25 mg/L Chloropropanol using the three strain consortium.

AREA RATIOS			AQUEOUS CONCENTRATIONS(mg/L)		
	DBCP/TCB		CPL/TCB	DBCP	CPL
CONTROL A RUN 813 RUN 814 RUN 815	1.420806		N/A	9.978321	N/A
	1.400409	AVERAGE 1.39	N/A	9.835074	AVERAGE 9.8
	1.381551	ST. DEV. 0.03	N/A	9.582171	ST. DEV. 0.2
INOCULATED A RUN 817 RUN 818 RUN 819	1.378938		N/A	9.684283	N/A
	1.453447	AVERAGE 1.39	N/A	10.20756	AVERAGE 9.8
	1.350011	ST. DEV. 0.05	N/A	9.491127	ST. DEV. 0.4
INOCULATED B RUN 820 RUN 821 RUN 822	1.3276		N/A	9.323737	N/A
	1.396447	AVERAGE 1.39	N/A	9.807249	AVERAGE 9.7
	1.435065	ST. DEV. 0.05	N/A	10.07848	ST. DEV. 0.4

Table A.7.2. Chromatography data for Week 1; 10 mg/L DBCP + 25 mg/L Chloropropanol using the three strain consortium.

	AREA RATIOS			AQUEOUS CONCENTRATIONS(mg/L)		
	DBCP/TCB		CPL/TCB	DBCP		CPL
CONTROL A	1.407664		N/A	9.886027		N/A
	1.472646	AVERAGE 1.45	N/A	10.3424	AVERAGE 10.2	N/A
	1.465013	ST. DEV. 0.04	N/A	10.28878	ST. DEV. 0.2	N/A
INOCULATED A	1.418085		N/A	9.959211		N/A
	1.412881	AVERAGE 1.41	N/A	9.922664	AVERAGE 9.9	N/A
	1.408478	ST. DEV. 0.00	N/A	9.891742	ST. DEV. 0.0	N/A
INOCULATED B	1.455781		N/A	10.22395		N/A
	1.404615	AVERAGE 1.43	N/A	9.864608	AVERAGE 10.1	N/A
	1.436753	ST. DEV. 0.03	N/A	10.09032	ST. DEV. 0.2	N/A

Table A.7.3. Chromatography data for Week 2; 10 mg/L DBCP + 25 mg/L Chloropropanol using the three strain consortium.

	<u>AREA RATIOS</u>			<u>AQUEOUS CONCENTRATIONS(mg/L)</u>		
	DBCP/TC8		CPL/TC8	DBCP		CPL
CONTROL A						
RUN 918	1.41137		N/A	9.912049		N/A
RUN 919	1.504163	AVERAGE 1.46	N/A	10.56374	AVERAGE 10.2	N/A
RUN 920	1.462222	ST. DEV. 0.05	N/A	10.26918	ST. DEV. 0.3	N/A
INOCULATED A						
RUN 921	1.427068		N/A	10.0223		N/A
RUN 922	1.411349	AVERAGE 1.41	N/A	9.911904	AVERAGE 9.9	N/A
RUN 923	1.399818	ST. DEV. 0.01	N/A	9.830918	ST. DEV. 0.1	N/A
INOCULATED B						
RUN 924	1.408041		N/A	9.888674		N/A
RUN 925	1.446312	AVERAGE 1.43	N/A	10.15745	AVERAGE 10.0	N/A
RUN 926	1.428625	ST. DEV. 0.02	N/A	10.03323	ST. DEV. 0.1	N/A

Table A.7.4. Chromatography data for Week 3; 10 mg/L DBCP + 25 mg/L Chloropropanol using the three strain consortium.

	<u>AREA RATIOS</u>			<u>AQUEOUS CONCENTRATIONS(mg/L)</u>		
	DBCP/TCB		CPJ/TCB	DBCP		CPL
CONTROL A						
RUN 980	1.455468		N/A	10.22175		N/A
RUN 981	1.374293	AVERAGE 1.40	N/A	9.651658	AVERAGE 9.9	N/A
RUN 982	1.377879	ST. DEV. 0.05	N/A	9.676844	ST. DEV. 0.3	N/A
INOCULATED A						
RUN 983	1.444969		N/A	10.14802		N/A
RUN 984	1.37852	AVERAGE 1.39	N/A	9.681348	AVERAGE 9.7	N/A
RUN 985	1.33401	ST. DEV. 0.06	N/A	9.38875	ST. DEV. 0.4	N/A
INOCULATED B						
RUN 986	1.406351		N/A	9.876807		N/A
RUN 987	1.387966	AVERAGE 1.38	N/A	9.747882	AVERAGE 9.7	N/A
RUN 988	1.358643	ST. DEV. 0.02	N/A	9.541747	ST. DEV. 0.2	N/A

Table A.8.1. Chromatography data for Week 0; 10 mg/L DBCP reactors using the nine strain consortium.

	<u>AREA RATIOS</u>		<u>AQUEOUS CONCENTRATIONS</u>	
	DBCP/TCB		DBCP	
CONTROL A				
RUN 771	1.4670		10.3026	
RUN 772	1.4546	AVERAGE	10.2154	AVERAGE
RUN 773	1.4737	ST. DEV.	10.3496	ST. DEV.
				10.3
				0.1
INOCULATED A				
RUN 774	1.4489		10.1756	
RUN 775	1.4471	AVERAGE	10.1633	AVERAGE
RUN 776	1.4791	ST. DEV.	10.3879	ST. DEV.
				10.2
				0.1
INOCULATED B				
RUN 777	1.4328		10.0629	
RUN 778	1.4314	AVERAGE	10.0530	AVERAGE
RUN 779	1.4482	ST. DEV.	10.1707	ST. DEV.
				10.1
				0.1

Table A.8.2. Chromatography data for Week 3; 10 mg/L DBCP reactors using the nine strain consortium.

	<u>AREA RATIOS</u>		<u>AQUEOUS CONCENTRATIONS</u>	
	DBCP/TCB		DBCP	
CONTROL A				
RUN 939	1.4649		10.2879	
RUN 940	1.4327	AVERAGE 1.45	10.0615	AVERAGE 10.2
RUN 941	1.4614	ST. DEV. 0.02	10.2637	ST. DEV. 0.1
INOCULATED A				
RUN 942	1.3999		9.8317	
RUN 943	1.4212	AVERAGE 1.43	9.9808	AVERAGE 10.0
RUN 944	1.4550	ST. DEV. 0.03	10.2182	ST. DEV. 0.2
INOCULATED B				
RUN 945	1.4311		10.0510	
RUN 946	1.4278	AVERAGE 1.43	10.0271	AVERAGE 10.0
RUN 947	1.4177	ST. DEV. 0.01	9.9566	ST. DEV. 0.0

Appendix B

Viable Colony Count Data

Table B.1. Colony Counts for 10 mg/L DBCP experiments using the three strain consortium.

<u>VIABLE COLONIES IN AQUEOUS MEDIA (CFU/ml)</u>									
	<u>WEEK 0</u>		<u>WEEK 1</u>		<u>WEEK 2</u>		<u>WEEK 3</u>		
	#1	#2	#1	#2	#1	#2	#1	#2	
CONTROL B									
PURE	0	0	0	0	0	0	0	0	
INOCULATED B									
1/1000 DIL.	N/A	N/A	>300	N/A	168	127	21	25	
1/100,000 DIL.	N/A	N/A	165	N/A	3	0	3	0	
1/10,000,000 DIL.	N/A	N/A	15	N/A	0	0	0	0	
INOCULATED C									
1/1000 DIL.	N/A	N/A	N/A	N/A	164	138	36	40	
1/100,000 DIL.	N/A	N/A	N/A	N/A	1	0	3	3	
1/10,000,000 DIL.	N/A	N/A	N/A	N/A	0	0	0	0	

Table B.2. Colony Counts for 50 mg/L DBCP experiments using the three strain consortium.

<u>VIALE COLONIES IN AQUEOUS MEDIA (CFU/ml)</u>									
	<u>WEEK 0</u>		<u>WEEK 1</u>		<u>WEEK 2</u>		<u>WEEK 3</u>		
	#1	#2	#1	#2	#1	#2	#1	#2	
CONTROL B									
PURE	0	0	0	0	0	0	0	0	
INOCULATED B									
1/1000 DIL.	N/A	N/A	>300	>300	173	122	10	15	
1/100,000 DIL.	N/A	N/A	141	142	0	1	0	0	
1/10,000,000 DIL.	N/A	N/A	0	0	0	0	0	0	
INOCULATED C									
1/1000 DIL.	N/A	N/A	>300	>300	54	79	40	22	
1/100,000 DIL.	N/A	N/A	178	100	0	1	0	0	
1/10,000,000 DIL.	N/A	N/A	3	4	0	0	0	0	

Table B.3. Colony Counts for 100 mg/L DBCP experiments using the three strain consortium.

<u>VIABLE COLONIES IN AQUEOUS MEDIA (CFU/ml)</u>									
	<u>WEEK 0</u>		<u>WEEK 1</u>		<u>WEEK 2</u>		<u>WEEK 3</u>		
	#1	#2	#1	#2	#1	#2	#1	#2	
CONTROL B									
PURE	0	0	0	0	0	0	0	0	
INOCULATED B									
1/1000 DIL.	N/A	N/A	>300	>300	53	45	2	3	
1/100,000 DIL.	N/A	N/A	4	0	6	2	0	0	
1/10,000,000 DIL.	N/A	N/A	0	0	0	0	0	0	
INOCULATED C									
1/1000 DIL.	N/A	N/A	79	N/A	15	46	9	17	
1/100,000 DIL.	N/A	N/A	3	0	0	0	0	0	
1/10,000,000 DIL.	N/A	N/A	0	0	0	0	0	0	

Table B.4. Colony Counts for 2 mg/L DBCP + Camphor experiments using the three strain consortium.

<u>VIABLE COLONIES IN AQUEOUS MEDIA (CFU/ml)</u>									
	<u>WEEK 0</u>		<u>WEEK 1</u>		<u>WEEK 2</u>		<u>WEEK 3</u>		
	#1	#2	#1	#2	#1	#2	#1	#2	
CONTROL A									
PURE	0	0	0	0	0	0	0	0	
INOCULATED A									
1/1000 DIL.	>300	>300	>300	>300	>300	>300	>300	>300	>300
1/100,000 DIL.	77	69	47	75	50	41	16	9	
1/10,000,000 DIL.	0	1	0	0	1	0	0	0	
INOCULATED B									
1/1000 DIL.	>300	>300	>300	>300	>300	>300	>300	>300	>300
1/100,000 DIL.	64	54	58	49	36	38	56	47	
1/10,000,000 DIL.	0	2	1	0	0	0	1	0	

Table B.5. Colony Counts for 10 mg/L DBCP + Camphor experiments using the three strain consortium.

<u>VIABLE COLONIES IN AQUEOUS MEDIA (CFU/ml)</u>									
	<u>WEEK 0</u>		<u>WEEK 1</u>		<u>WEEK 2</u>		<u>WEEK 3</u>		
	#1	#2	#1	#2	#1	#2	#1	#2	
CONTROL A									
PURE	0	0	0	0	0	0	0	0	
INOCULATED A									
1/1000 DIL.	>300	>300	>300	>300	>300	>300	>300	>300	>300
1/100,000 DIL.	114	117	59	57	16	10	3	2	
1/10,000,000 DIL.	1	0	2	0	0	0	0	0	
INOCULATED B									
1/1000 DIL.	>300	>300	>300	>300	>300	>300	>300	>300	>300
1/100,000 DIL.	84	65	58	48	20	12	7	7	
1/10,000,000 DIL.	3	0	0	0	0	0	1	0	

Table B.6. Colony Counts for 2 mg/L DBCP + 25 mg/L Chloropropanol experiments using the three strain consortium.

<u>VIABLE COLONIES IN AQUEOUS MEDIA (CFU/ml)</u>									
	<u>WEEK 0</u>		<u>WEEK 1</u>		<u>WEEK 2</u>		<u>WEEK 3</u>		
	#1	#2	#1	#2	#1	#2	#1	#2	
CONTROL A									
PURE	0	0	0	0	0	0	0	0	
INOCULATED A									
1/1000 DIL.	>300	>300	>300	>300	>300	>300	>300	>300	
1/100,000 DIL.	79	79	104	71	71	93	69	78	
1/10,000,000 DIL.	1	1	1	1	0	2	2	1	
INOCULATED B									
1/1000 DIL.	>300	>300	>300	>300	>300	>300	>300	>300	
1/100,000 DIL.	81	77	137	153	100	82	51	51	
1/10,000,000 DIL.	1	0	contam.	contam.	0	1	1	0	

Table B.7. Colony Counts for 10 mg/L DBCP + 25 mg/L Chloropropanol experiments using the three strain consortium.

Viable Colonies in Aqueous Media (CFU/ml)									
	WEEK 0		WEEK 1		WEEK 2		WEEK 3		
	#1	#2	#1	#2	#1	#2	#1	#2	
CONTROL A									
PURE	0	0	0	0	0	0	0	0	
INOCULATED A									
1/1000 DIL.	>300	>300	>300	>300	>300	>300	>300	>300	
1/100,000 DIL.	contam.	87	121	114	100	92	51	43	
1/10,000,000 DIL.	0	0	1	3	0	1	0	0	
INOCULATED B									
1/1000 DIL.	>300	>300	>300	>300	>300	>300	>300	>300	
1/100,000 DIL.	42	57	139	109	91	71	39	61	
1/10,000,000 DIL.	2	1	2	0	1	1	1	0	

Table B.8. Colony Counts for 10 mg/L DBCP experiments using the nine strain consortium.

		<u>VIAL COLONIES IN AQUEOUS MEDIA (CFU/ml)</u>					
		<u>WEEK 0</u>		<u>WEEK 3</u>			
		#1	#2	#1	#2		
CONTROL A	PURE	0	0	0	0		
INOCULATED A	1/1000 DIL.	>300	>300	>300	>300		
	1/100,000 DIL.	29	59	15	15		
	1/10,000,000 DIL.	0	1	0	1		
INOCULATED B	1/1000 DIL.	>300	>300	>300	>300		
	1/100,000 DIL.	46	45	12	15		
	1/10,000,000 DIL.	0	0	0	0		

Appendix C

Raw Experimental Data

Table C.1.1.1. Raw data for Week 0 - 10 mg/L DBCP using the three strain consortium

	<u>RETENTION TIMES</u>				<u>PEAK AREAS</u>				<u>AREA RATIOS</u>	
	DBCP	TCB	BEN		DBCP	TCB	BEN	TOTAL	DBCP/BEN	DBCP/TCB
CONTROL A										
RUN 273	11.445	12.439	2.840		98470	78025	200568	3.28E+09	0.4910	1.2620
RUN 274	11.440	12.432	2.829		100122	77992	203148	3.32E+09	0.4929	1.2837
RUN 275	11.451	12.446	2.840		94865	74662	193140	3.19E+09	0.4912	1.2706
RUN 276	11.461	12.455	2.850		103641	80907	208810	3.42E+09	0.4963	1.2810
CONTROL B										
RUN 277	11.467	12.460	2.852		108715	84235	209682	3.5E+09	0.5185	1.2906
RUN 278	11.470	12.463	2.857		104007	81671	210780	3.4E+09	0.4934	1.2735
RUN 279	11.475	12.470	2.859		99726	79329	199268	3.31E+09	0.5005	1.2571
RUN 280	11.478	12.472	2.858		101708	81327	204270	3.39E+09	0.4979	1.2506
INOCULATED A										
RUN 281	11.487	12.480	2.865		102179	81441	205574	3.37E+09	0.4970	1.2546
RUN 282	11.487	12.481	2.867		92621	75338	199584	3.22E+09	0.4641	1.2294
RUN 283	11.489	12.483	2.866		55154	42526	115168	1.84E+09	0.4789	1.2969
RUN 284	11.462	12.455	2.845		93974	73886	192227	3.15E+09	0.4889	1.2719
INOCULATED B										
RUN 285	11.466	12.460	2.850		92659	79718	211329	3.4E+09	0.4385	1.1623
RUN 286	11.465	12.458	2.849		105352	80365	206386	3.34E+09	0.5105	1.3109
RUN 287	11.475	12.470	2.858		100713	78149	205047	3.36E+09	0.4912	1.2887
RUN 288	11.476	12.470	2.858		97619	78614	210852	3.36E+09	0.4630	1.2418
INOCULATED C										
RUN 289	11.485	12.480	2.864		95622	79150	201145	3.31E+09	0.4754	1.2081
RUN 290	11.492	12.485	2.872		27278	22997	69171	1.12E+09	0.3944	1.1862
RUN 291	11.493	12.487	2.870		32070	26683	76109	1.21E+09	0.4214	1.2019
RUN 292	11.501	12.495	2.889		79336	68164	168857	2.96E+09	0.4698	1.1639
RUN 293	11.489	12.481	2.886		100379	78162	190041	3.3E+09	0.5282	1.2842

Table C.1.2. Raw data for Week 1; 10 mg/L DBCP using the three strain consortium

	<u>RETENTION TIMES</u>				<u>PEAK AREAS</u>			<u>AREA RATIOS</u>	
	DBCP	TCB	BEN	DBCP	TCB	BEN	TOTAL	DBCP/BEN	DBCP/TCB
CONTROL A									
RUN 377	11.471	12.462	2.869	92268	80887	208989	3.33E+09	0.4415	1.1407
RUN 378	11.435	12.426	2.834	93994	81571	206400	3.46E+09	0.4554	1.1523
RUN 379	11.410	12.402	2.815	103752	81889	213807	3.46E+09	0.4853	1.2670
RUN 380	11.400	12.394	2.808	94166	77706	209914	3.42E+09	0.4486	1.2118
CONTROL B									
RUN 381	11.393	12.386	2.799	110243	84596	211004	3.51E+09	0.5225	1.3032
RUN 382	11.398	12.390	2.802	106207	83380	217448	3.53E+09	0.4884	1.2738
RUN 383	11.398	12.391	2.803	98849	82535	218322	3.55E+09	0.4528	1.1977
RUN 384	11.390	12.391	2.803	92278	79362	208280	3.44E+09	0.4430	1.1627
INOCULATED A									
RUN 385	11.421	12.414	2.820	99025	79642	216022	3.47E+09	0.4584	1.2434
RUN 386	11.402	12.393	2.802	96379	79456	215853	3.46E+09	0.4465	1.2130
RUN 387	11.408	12.400	2.809	104769	80667	210822	3.47E+09	0.4970	1.2988
RUN 388	11.402	12.395	2.805	100949	80189	215183	3.53E+09	0.4691	1.2589
INOCULATED B									
RUN 389	11.405	12.396	2.805	92387	76746	213226	3.52E+09	0.4333	1.2038
RUN 390	11.402	12.396	2.806	97828	79545	211123	3.45E+09	0.4634	1.2298
RUN 391	11.405	12.396	2.806	95766	79133	209993	3.45E+09	0.4560	1.2102
RUN 392	11.405	12.398	2.806	101030	79134	210603	3.44E+09	0.4797	1.2767
INOCULATED C									
RUN 393	11.430	12.424	2.826	102979	82486	209534	3.52E+09	0.4915	1.2484
RUN 394	11.435	12.429	2.827	97497	81763	210596	3.5E+09	0.4630	1.1924
RUN 395	11.441	12.435	2.834	92479	78252	214446	3.45E+09	0.4312	1.1818
RUN 396	11.451	12.446	2.840	92248	80597	219510	3.52E+09	0.4202	1.1446

Table C.1.3. Raw data for Week 2; 10 mg/L DBCP using the three strain consortium

	<u>RETENTION TIMES</u>				<u>PEAK AREAS</u>			<u>AREA RATIOS</u>		
	DBCP	TCB	BEN	TOTAL	DBCP	TCB	BEN	DBCP/BEN	DBCP/TCB	DBCP/TCB
CONTROL A										
RUN 477	11.445	12.436	2.843	3.48E+09	99516	80709	205694	0.4838	1.2330	
RUN 478	11.411	12.403	2.815	3.43E+09	94741	79073	211828	0.4473	1.1981	
RUN 479	12.458	13.480	3.467	2.86E+09	85245	68873	181058	0.4708	1.2377	
RUN 480	11.398	12.389	2.838	2.88E+09	85016	67875	158103	0.5377	1.2525	
RUN 481	11.380	12.380	2.790	3.41E+09	89234	75360	202539	0.4406	1.1841	
CONTROL B										
RUN 482	11.374	12.365	2.786	3.47E+09	89171	80432	214237	0.4162	1.1087	
RUN 483	11.368	12.360	2.777	3.48E+09	102085	82770	219820	0.4644	1.2334	
RUN 484	11.366	12.359	2.780	3.44E+09	89366	78756	205331	0.4352	1.1347	
RUN 485	11.369	12.361	2.784	3.38E+09	94224	79062	202493	0.4653	1.1918	
INOCULATED A										
RUN 486	11.370	12.361	2.783	3.61E+09	95862	83436	217255	0.4412	1.1489	
RUN 487	11.369	12.360	2.778	3.48E+09	76936	75400	216904	0.3547	1.0204	
RUN 488	11.369	12.360	2.780	3.61E+09	104847	82282	204833	0.5119	1.2742	
RUN 489	11.365	12.359	2.781	3.42E+09	94653	77209	198776	0.4762	1.2259	
INOCULATED B										
RUN 490	11.368	12.358	2.779	3.5E+09	98489	80765	206874	0.4761	1.2195	
RUN 491	11.374	12.367	2.777	3.26E+09	92111	76439	199028	0.4628	1.2050	
RUN 492	11.392	12.386	2.798	3.31E+09	94729	76919	194638	0.4867	1.2315	
RUN 493	11.398	12.390	2.803	3.35E+09	94183	78191	199955	0.4710	1.2045	
INOCULATED C										
RUN 494	11.409	12.401	2.806	3.38E+09	94542	80754	208326	0.4538	1.1707	
RUN 495	11.415	12.408	2.814	3.37E+09	94943	79826	204517	0.4642	1.1894	
RUN 496	11.420	12.412	2.816	3.33E+09	86538	75835	192749	0.4490	1.1411	
RUN 497	11.425	12.418	2.819	3.38E+09	96416	78191	201856	0.4776	1.2331	

Table C.1.4. Raw data for Week 3; 10 mg/L DBCP using the three strain consortium

	<u>RETENTION TIMES</u>				<u>PEAK AREAS</u>				<u>AREA RATIOS</u>	
	DBCP	TCB	BEN	TOTAL	DBCP	TCB	BEN	TOTAL	DBCP/BEN	DBCP/TCB
CONTROL A										
RUN 573	11.470	12.462	2.854		86251	80786	215926	3.27E+09	0.3994	1.0676
RUN 574	11.450	12.422	2.830		86014	76779	206974	3.17E+09	0.4156	1.1203
RUN 575	11.400	12.391	2.801		83192	73777	196272	3.1E+09	0.4239	1.1276
RUN 576	11.396	12.390	2.801		92087	80053	208590	3.28E+09	0.4415	1.1503
CONTROL B										
RUN 577	11.395	12.387	2.795		97685	78100	201138	3.1E+09	0.4857	1.2508
RUN 578	11.394	12.387	2.800		100747	85405	227684	3.5E+09	0.4425	1.1796
RUN 579	11.401	12.395	2.803		94772	81166	224313	7602979	0.4225	1.1676
RUN 580	11.399	12.391	2.804		97628	83542	225638	3.51E+09	0.4327	1.1686
INOCULATED A										
RUN 581	11.400	12.394	2.803		94364	83382	218362	3.45E+09	0.4321	1.1317
RUN 582	11.399	12.391	2.802		97555	84893	227642	3.43E+09	0.4285	1.1492
RUN 583	11.411	12.405	2.812		87984	80648	222470	3.42E+09	0.3955	1.0910
RUN 584	11.400	12.393	2.808		94334	83463	222470	1.73E+09	0.4240	1.1302
INOCULATED B										
RUN 585	11.400	12.395	2.805		100944	85846	229615	3.52E+09	0.4396	1.1759
RUN 586	11.399	12.390	2.799		97013	83117	216246	3.44E+09	0.4486	1.1672
RUN 587	11.406	12.400	2.801		90161	79028	221331	3.36E+09	0.4074	1.1409
RUN 588	11.418	12.408	2.819		97797	85551	218800	3.49E+09	0.4470	1.1431
INOCULATED C										
RUN 589	11.420	12.413	2.813		90222	79233	221759	3.41E+09	0.4068	1.1387
RUN 591	11.447	12.442	2.842		82114	70754	165523	2.82E+09	0.4961	1.1606
RUN 592	11.467	12.461	2.821		65096	55886	134722	2.29E+09	0.4832	1.1648
RUN 593	11.477	12.470	2.854		93707	82801	223510	3.43E+09	0.4193	1.1317

Table C.2.1. Raw data for Week 0; 50 mg/L DBCP using the three strain consortium

	<u>RETENTION TIMES</u>				<u>PEAK AREAS</u>				<u>AREA RATIOS</u>	
	DBCP	TCB	BEN		DBCP	TCB	BEN	TOTAL	DBCP/BEN	DBCP/TCB
CONTROL A										
RUN 297	11.398	12.385	2.796		520549	79573	201432	3.34E+09	2.5842	6.5418
RUN 299	11.390	12.381	2.813		255546	37596	89269	1.69E+09	2.8627	6.7972
RUN 300	11.399	12.366	2.815		380845	57100	140289	2.47E+09	2.7147	6.6698
RUN 301	11.402	12.390	2.804		466337	74515	199185	3.54E+09	2.3412	6.2583
RUN 302	11.401	12.389	2.807		499143	77217	199698	3.52E+09	2.4995	6.4642
CONTROL B										
RUN 303	11.407	12.395	2.805		437675	73669	205164	3.44E+09	2.1333	5.9411
RUN 304	11.404	12.391	2.809		435601	73488	193744	3.42E+09	2.2483	5.9275
RUN 305	11.402	12.390	2.804		453678	75013	202138	3.43E+09	2.2444	6.0480
RUN 306	11.404	12.392	2.810		459715	75796	191320	3.43E+09	2.4029	6.0652
INOCULATED A										
RUN 307	11.405	12.392	2.808		463740	74775	192736	3.33E+09	2.4061	6.2018
RUN 308	11.410	12.396	2.810		476680	77153	195837	3.45E+09	2.4341	6.1784
RUN 309	11.407	12.395	2.805		485766	80474	214754	3.53E+09	2.2620	6.0363
RUN 310	11.407	12.394	2.811		478495	75534	192324	3.36E+09	2.4880	6.3348
INOCULATED B										
RUN 311	11.410	12.396	2.810		472073	78795	204312	3.5E+09	2.3105	5.9912
RUN 312	11.408	12.395	2.811		479239	76958	203585	3.5E+09	2.3540	6.2273
RUN 313	11.407	12.394	2.810		460872	74315	193324	3.36E+09	2.3839	6.2016
RUN 314	11.408	12.395	2.810		473508	75873	194707	3.42E+09	2.4319	6.2408
INOCULATED C										
RUN 315	11.430	12.415	2.826		503464	78859	201846	3.53E+09	2.4943	6.3844
RUN 316	11.402	12.390	2.805		441802	73423	192291	3.36E+09	2.2976	6.0172
RUN 317	11.402	12.390	2.805		470715	76798	203466	3.43E+09	2.3135	6.1293
RUN 318	11.404	12.391	2.808		484362	75357	195380	3.42E+09	2.4791	6.4276

Table C.2.2. Raw data for Week 1; 50 mg/L DBCP using the three strain consortium

	<u>RETENTION TIMES</u>				<u>PEAK AREAS</u>				<u>AREA RATIOS</u>	
	<u>DBCP</u>		<u>TCB</u>		<u>DBCP</u>	<u>TCB</u>	<u>BEN</u>	<u>TOTAL</u>	<u>DBCP/BEN DBCP/TCB</u>	
CONTROL A										
RUN 399	11.453	12.439	2.845		504726	76351	211527	3.47E+09	2.3861	6.6106
RUN 400	11.435	12.423	2.825		531170	81700	215176	3.48E+09	2.4685	6.5015
RUN 401	11.434	12.420	2.824		526852	80824	216698	3.5E+09	2.4313	6.5185
RUN 402	11.434	12.420	2.827		513466	78756	217357	3.48E+09	2.3623	6.5197
CONTROL B										
RUN 403	11.420	12.407	2.817		493235	80938	218435	3.51E+09	2.2580	6.0940
RUN 404	11.413	12.402	2.814		419996	75453	214465	3.49E+09	1.9583	5.5663
RUN 405	11.410	12.398	2.811		446958	78704	214129	3.46E+09	2.0873	5.6790
RUN 406	11.416	12.405	2.814		445861	78317	209943	3.51E+09	2.1237	5.6930
INOCULATED A										
RUN 407	11.435	12.423	2.825		439150	75379	208413	3.47E+09	2.1071	5.8259
RUN 408	11.425	12.413	2.822		473717	77369	212204	3.46E+09	2.2324	6.1228
RUN 409	11.420	12.407	2.820		431898	74497	204943	3.43E+09	2.1074	5.7975
RUN 410	11.420	12.406	2.815		469851	76915	211171	3.44E+09	2.2250	6.1087
INOCULATED B										
RUN 411	11.420	12.406	2.815		462787	77633	207646	3.43E+09	2.2287	5.9612
RUN 412	11.415	12.403	2.814		437917	77309	214705	3.44E+09	2.0396	5.6645
RUN 413	11.416	12.405	2.815		470096	76128	210391	3.41E+09	2.2344	6.1751
RUN 414	11.435	12.421	2.830		447769	74501	208186	3.34E+09	2.1508	6.0102
INOCULATED C										
RUN 415	11.427	12.415	2.821		503258	80386	220477	3.48E+09	2.2826	6.2605
RUN 416	11.428	12.415	2.822		493377	79023	218465	3.46E+09	2.2584	6.2435
RUN 417	11.420	12.407	2.818		480788	80882	218458	3.49E+09	2.2008	5.9443
RUN 418	11.416	12.403	2.814		503271	77892	217113	3.48E+09	2.3180	6.4611

Table C.2.3. Raw data for Week 2; 50 mg/L DBCP using the three strain consortium

	<u>RETENTION TIMES</u>				<u>PEAK AREAS</u>				<u>AREA RATIOS</u>	
	DBCP	TCB	BEN		DBCP	TCB	BEN	TOTAL	DBCP/BEN	DBCP/TCB
CONTROL A										
RUN 500	11.420	12.408	2.820		518049	81799	207455	3.39E+09	2.4972	6.3332
RUN 501	11.411	12.399	2.811		501135	78992	198514	3.34E+09	2.5244	6.3441
RUN 502	11.400	12.389	2.801		486714	79501	206286	3.42E+09	2.3594	6.1221
RUN 503	11.401	12.389	2.805		497064	77258	201175	3.43E+09	2.4708	6.4338
CONTROL B										
RUN 504	11.403	12.391	2.804		472581	75797	197470	3.27E+09	2.3932	6.2348
RUN 505	11.405	12.392	2.802		454869	75268	211689	3.34E+09	2.1488	6.0433
RUN 506	11.406	12.395	2.807		409603	68887	192425	3.27E+09	2.1286	5.9460
RUN 507	11.410	12.396	2.809		438154	73299	200627	3.31E+09	2.1839	5.9776
INOCULATED A										
RUN 508	11.411	12.399	2.808		493238	79672	222817	3.5E+09	2.2136	6.1909
RUN 509	11.411	12.400	2.806		475740	77194	218060	3.43E+09	2.1817	6.1629
RUN 510	11.410	12.399	2.805		466457	76488	216233	3.38E+09	2.1572	6.0984
RUN 511	11.412	12.400	2.811		460027	77023	211376	3.45E+09	2.1763	5.9726
INOCULATED B										
RUN 512	11.414	12.402	2.811		448050	76586	198627	3.36E+09	2.2557	5.8503
RUN 513	11.405	12.391	2.807		450511	77081	205001	3.45E+09	2.1976	5.8446
RUN 514	11.397	12.385	2.797		435297	76384	219151	8306336	1.9863	5.6988
RUN 515	11.390	12.378	2.795		484174	80596	211010	3.48E+09	2.2946	6.0074
INOCULATED C										
RUN 516	11.398	12.385	2.801		459264	76133	197753	3.32E+09	2.3224	6.0324
RUN 517	11.393	12.380	2.795		501210	83389	217204	3.42E+09	2.3076	6.0105
RUN 518	11.382	12.370	2.790		453861	77611	204983	3.4E+09	2.2141	5.8479
RUN 519	11.382	12.369	2.790		460419	78058	198249	3.39E+09	2.3224	5.8984

Table C.2.4. Raw data for Week 3; 50 mg/L DBCP using the three strain consortium

	<u>RETENTION TIMES</u>				<u>PEAK AREAS</u>				<u>AREA RATIOS</u>	
	<u>DBCP</u>		<u>TCB</u>		<u>DBCP</u>	<u>TCB</u>	<u>BEN</u>	<u>TOTAL</u>	<u>DBCP/BEN DBCP/TCB</u>	
CONTROL A										
RUN 596	11.410	12.397	2.810		457588	79044	211744	3.31E+09	2.1610	5.7890
RUN 597	11.396	12.384	2.790		517606	87285	229910	3.48E+09	2.2513	5.9301
RUN 599	11.379	12.366	2.784		482262	82443	220828	3.43E+09	2.1839	5.8496
RUN 600	11.380	12.368	2.784		453063	78799	209242	3.36E+09	2.1653	5.7496
CONTROL B										
RUN 601	11.400	12.386	2.799		494272	84979	213939	3.46E+09	2.3103	5.8164
RUN 602	11.400	12.386	2.798		456116	79061	222074	3.4E+09	2.0539	5.7692
RUN 603	11.380	12.367	2.784		463454	83494	223697	3.52E+09	2.0718	5.5507
RUN 604	11.375	12.363	2.780		474429	82793	223194	3.51E+09	2.1256	5.7303
INOCULATED A										
RUN 605	11.378	12.365	2.781		466326	79694	220032	3.44E+09	2.1194	5.8515
RUN 606	11.375	12.362	2.782		464474	81661	224041	3.53E+09	2.0732	5.6878
RUN 607	11.377	12.364	2.780		485896	84058	222572	3.44E+09	2.1831	5.7805
RUN 608	11.377	12.364	2.781		468201	81495	211169	3.49E+09	2.2172	5.7452
INOCULATED B										
RUN 610	11.377	12.365	2.780		443649	77394	208021	3.39E+09	2.1327	5.7323
RUN 611	11.373	12.360	2.779		482978	84554	221843	3.44E+09	2.1771	5.7121
RUN 613	11.372	12.360	2.782		421281	75429	208417	3.49E+09	2.0213	5.5851
RUN 614	11.373	12.360	2.778		485692	84960	222462	3.43E+09	2.1833	5.7167
INOCULATED C										
RUN 615	11.376	12.364	2.779		444499	79961	218633	3.5E+09	2.0331	5.5589
RUN 616	11.378	12.365	2.777		457750	81974	220504	3.5E+09	2.0759	5.5841
RUN 617	11.384	12.372	2.785		487642	85743	221462	3.55E+09	2.2019	5.6873
RUN 618	11.396	12.386	2.792		377968	73633	222748	3.52E+09	1.6968	5.1331

Table C.3.1. Raw data for Week 0; 100 mg/L DBCP using the three strain consortium

	<u>RETENTION TIMES</u>				<u>PEAK AREAS</u>			<u>AREA RATIOS</u>	
	DBCP	TCB	BEN		DBCP	TCB	BEN	TOTAL	DBCP/BEN DBCP/TCB
CONTROL A									
RUN 321	11.435	12.414	2.825		987040	74903	196953	3.43E+09	5.0141 13.1776
RUN 322	11.423	12.401	2.810		984978	77362	203737	3.37E+09	4.8346 12.7321
RUN 323	11.426	12.405	2.815		1022663	77208	209547	3.42E+09	4.8804 13.2456
RUN 324	11.425	12.404	2.819		1047291	78531	202624	3.46E+09	5.1686 13.3360
CONTROL B									
RUN 325	11.410	12.389	2.810		990934	74239	201863	3.41E+09	4.9089 13.3479
RUN 326	11.400	12.379	2.800		1000494	75739	197374	3.43E+09	5.0690 13.2098
RUN 327	11.401	12.380	2.798		1033476	78362	199449	3.5E+09	5.1817 13.1885
RUN 328	11.401	12.381	2.795		961823	74209	203462	3.42E+09	4.7273 12.9610
INOCULATED A									
RUN 329	11.399	12.376	2.795		966527	76122	208591	3.41E+09	4.6336 12.6971
RUN 330	11.400	12.380	2.797		972996	74741	205160	3.47E+09	4.7426 13.0182
RUN 331	11.398	12.378	2.797		925039	72663	189141	3.34E+09	4.8907 12.7305
RUN 332	11.399	12.379	2.795		954139	70982	192528	3.36E+09	4.9533 13.4420
INOCULATED B									
RUN 333	11.408	12.385	2.800		1008340	76398	201346	3.45E+09	5.0080 13.1985
RUN 334	11.405	12.385	2.797		926133	73769	203364	3.35E+09	4.5541 12.5545
RUN 335	11.400	12.380	2.799		976359	73899	190873	3.35E+09	5.1152 13.2121
RUN 336	11.408	12.388	2.805		984876	75665	195864	3.42E+09	5.0284 13.0163
INOCULATED C									
RUN 337	11.400	12.380	2.797		980076	75325	208323	3.44E+09	4.7046 13.0113
RUN 338	11.405	12.384	2.801		1031530	76891	200301	3.5E+09	5.1499 13.4505
RUN 339	11.398	12.376	2.792		992406	76319	201684	3.37E+09	4.9206 13.0034
RUN 340	11.422	12.401	2.816		941228	75102	200008	3.33E+09	4.7060 12.5327

Table C.3.2. Raw data for Week 1; 100 mg/L DBCP using the three strain consortium

	<u>RETENTION TIMES</u>				<u>PEAK AREAS</u>				<u>AREA RATIOS</u>	
	DBCP	TCB	BEN	TOTAL	DBCP	TCB	BEN	TOTAL	DBCP/BEN	DBCP/TCB
CONTROL A										
RUN 421	11.465	12.444	2.843		973972	81703	213886	3.46E+09	4.5537	11.9209
RUN 422	11.450	12.430	2.832		954521	76600	213605	3.43E+09	4.4686	12.4611
RUN 423	11.451	12.431	2.831		993397	76778	208450	3.41E+09	4.7656	12.9386
RUN 424	11.440	12.419	2.829		1003136	78794	214364	3.45E+09	4.6796	12.7311
CONTROL B										
RUN 425	11.459	12.438	2.845		973996	76467	212948	3.42E+09	4.5739	12.7375
RUN 426	11.425	12.406	2.818		891646	72698	202161	3.26E+09	4.4106	12.2651
RUN 427	11.437	12.417	2.822		934944	74249	205165	3.31E+09	4.5570	12.5920
RUN 428	11.424	12.405	2.817		895604	73347	204617	3.29E+09	4.3770	12.2105
INOCULATED A										
RUN 429	11.423	12.402	2.814		1006751	78277	215168	3.47E+09	4.6789	12.8614
RUN 430	11.420	12.400	2.810		924440	76001	212366	3.39E+09	4.3531	12.1635
RUN 431	11.419	12.400	2.810		924036	74416	205350	3.35E+09	4.4998	12.4172
RUN 432	11.419	12.399	2.810		922438	74438	202707	3.24E+09	4.5506	12.3920
INOCULATED B										
RUN 433	11.420	12.400	2.811		943097	76659	209548	3.37E+09	4.5006	12.3025
RUN 434	11.419	12.400	2.807		895499	73332	209881	3.33E+09	4.2667	12.2116
RUN 435	11.418	12.399	2.805		950031	76325	209387	3.39E+09	4.5372	12.4472
RUN 436	11.418	12.398	2.808		930238	76487	208396	3.35E+09	4.4638	12.1620
INOCULATED C										
RUN 437	11.416	12.396	2.808		976718	79513	209087	3.45E+09	4.6713	12.2838
RUN 438	11.414	12.394	2.805		946862	77909	205971	3.4E+09	4.5971	12.1534
RUN 439	11.408	12.388	2.800		952661	76316	201700	3.35E+09	4.7232	12.4831
RUN 440	11.415	12.394	2.805		966499	77121	213835	3.45E+09	4.5198	12.5322

Table C.3.3. Raw data for Week 2; 100 mg/L DBCP using the three strain consortium

	RETENTION TIMES				PEAK AREAS				AREA RATIOS	
	DBCP	TCB	BEN		DBCP	TCB	BEN	TOTAL	DBCP/BEN	DBCP/TCB
CONTROL A										
	RUN 522	11.391	12.370	2.795	979941	82684	214544	3.39E+09	4.5676	11.8516
	RUN 523	11.379	12.360	2.780	895739	75353	204203	3.38E+09	4.3865	11.8872
	RUN 524	11.366	12.347	2.770	877168	74293	197168	3.35E+09	4.4488	11.8069
RUN 525	11.371	12.352	2.774	925526	77367	200832	3.42E+09	4.6085	11.9628	
CONTROL B										
	RUN 526	11.380	12.360	2.778	979647	82696	215299	3.59E+09	4.5502	11.8464
	RUN 527	11.390	12.369	2.785	979330	83936	216288	3.57E+09	4.5279	11.6676
	RUN 528	11.394	12.374	2.790	972900	82630	215736	3.54E+09	4.5097	11.7742
RUN 529	11.397	12.378	2.792	951943	80571	215570	3.49E+09	4.4159	11.8150	
INOCULATED A										
	RUN 530	11.401	12.380	2.797	974220	81497	212442	3.51E+09	4.5858	11.9541
	RUN 531	11.403	12.385	2.798	958690	79669	224238	3.42E+09	4.2753	12.0334
	RUN 532	11.384	12.369	2.794	923151	78174	203285	3.41E+09	4.5412	11.8089
RUN 533	11.389	12.369	2.794	925981	77556	206886	3.39E+09	4.4758	11.9395	
INOCULATED B										
	RUN 534	11.385	12.365	2.783	933658	79658	208275	3.45E+09	4.4828	11.7208
	RUN 535	11.377	12.360	2.783	855061	73657	197575	3.3E+09	4.3278	11.6087
	RUN 536	11.375	12.355	2.777	894649	78251	204490	3.39E+09	4.3750	11.4331
RUN 537	11.376	12.358	2.780	914503	77730	200607	3.34E+09	4.5587	11.7651	
INOCULATED C										
	RUN 538	11.390	12.371	2.783	980237	81940	208711	3.5E+09	4.6966	11.9629
	RUN 540	11.535	12.523	2.881	947604	79658	211716	3.46E+09	4.4758	11.8959
	RUN 541	11.410	12.390	2.800	946205	78663	211223	3.55E+09	4.4796	12.0286
RUN 542	11.586	12.575	2.913	953741	79534	215859	3.48E+09	4.4184	11.9916	

Table C.3.4. Raw data for Week 3; 100 mg/L DBCP using the three strain consortium

	<u>RETENTION TIMES</u>			<u>PEAK AREAS</u>			<u>AREA RATIOS</u>	
	DBCP	TCB	BEN	DBCP	TCB	BEN	DBCP/BEN	DBCP/TCB
CONTROL A								
RUN 621	11.442	12.423	2.830	913616	81623	225744	4.0471	11.1931
RUN 622	11.422	12.404	2.810	898526	81180	218244	4.1171	11.0683
RUN 623	11.428	12.409	2.812	977034	84496	221069	4.4196	11.5631
RUN 624	11.425	12.407	2.815	869186	75905	218620	3.9758	11.4510
CONTROL B								
RUN 625	11.405	12.390	2.795	744203	65561	200657	3.7088	11.3513
RUN 626	11.424	12.402	2.819	984932	88126	220269	4.4715	11.1764
RUN 627	11.385	12.366	2.784	876287	80413	214815	4.0793	10.8973
RUN 628	11.394	12.377	2.787	808377	75006	222709	3.6297	10.7775
INOCULATED A								
RUN 629	11.413	12.391	2.815	928976	83884	230610	4.0283	11.0745
RUN 630	11.372	12.353	2.770	944503	84609	218422	4.3242	11.1632
RUN 631	11.370	12.350	2.771	911053	82412	221664	4.1101	11.0549
RUN 632	11.392	12.375	2.780	925997	83043	221812	4.1747	11.1508
INOCULATED B								
RUN 633	11.395	12.373	2.795	994398	87199	237724	4.1830	11.4038
RUN 634	11.376	12.356	2.776	957997	83223	234502	4.0852	11.5112
RUN 635	11.375	12.356	2.775	930488	82449	222786	4.1766	11.2856
RUN 636	11.375	12.355	2.777	983578	88103	234518	4.1940	11.1640
INOCULATED C								
RUN 637	11.395	12.375	2.789	951682	84831	213241	4.4629	11.2186
RUN 638	11.384	12.363	2.780	936776	84402	225008	4.1633	11.0990
RUN 639	11.376	12.355	2.776	973423	86712	226253	4.3024	11.2259
RUN 640	11.376	12.356	2.775	917233	81103	231966	3.9542	11.3095

Table C.4.1. Raw data for Week 0; 2 mg/L DBCP + 10 mg/L camphor using the three strain consortium

	RETENTION TIMES				PEAK AREAS				AREA RATIOS				
	DBCP	CAM	TCB	BEN	DBCP	CAM	TCB	BEN	TOTAL	DBCP/BEN	DBCPTCB	CAM/BEN	CAM/TCB
CONTROL A													
	11.445	12.349	12.439	2.840	102200	393991	69667	185930	3.44E+09	0.5497	0.460103	2.1190	5.6553
	11.440	12.577	12.432	2.829	99498	391201	68404	183182	3.36E+09	0.5432	0.465621	2.1356	5.7190
	11.451	12.573	12.446	2.840	102140	404266	69310	181781	3.44E+09	0.5619	0.47699	2.2239	5.8327
INOCULATED A													
	11.487	12.568	12.480	2.865	99562	385528	68716	189063	3.54E+09	0.5266	0.45412	2.0392	5.6105
	11.487	12.569	12.481	2.867	96491	408034	66877	183349	3.47E+09	0.5263	0.459388	2.2254	6.1196
	11.489	12.568	12.483	2.866	94018	445634	63563	168688	3.29E+09	0.5573	0.470259	2.6418	7.0109
INOCULATED B													
	11.466	12.569	12.460	2.850	94472	422335	65933	184157	3.38E+09	0.5130	0.448501	2.2933	6.4055
	11.465	12.581	12.458	2.849	96342	420939	67304	177310	3.45E+09	0.5434	0.461027	2.3740	6.2543
	11.475	12.577	12.470	2.858	96841	434550	66870	176869	3.46E+09	0.5475	0.460478	2.4569	6.4984

Table C.4.2. Raw data for Week 1; 2 mg/L DBCP + 10 mg/L camphor using the three strain consortium

	RETENTION TIMES				PEAK AREAS				AREA RATIOS				
	DBCP	CAM	TCB	BEN	DBCP	CAM	TCB	BEN	TOTAL	DBCP/BEN	DBCP/TCB	CAM/BEN	CAM/TCB
CONTROL A													
RUN 832	11.347	12.587	12.340	2.774	28603	338892	65168	188183	3.52E+09	0.1520	0.4389	1.8009	5.2003
RUN 833	11.334	12.580	12.343	2.770	29810	354139	65150	186174	3.42E+09	0.1601	0.4576	1.9022	5.4357
RUN 836	11.348	12.587	12.340	2.778	32381	380826	71096	189349	3.56E+09	0.1710	0.4555	2.0102	5.3537
INOCULATED A													
RUN 837	11.349	12.588	12.340	2.772	32739	382829	71432	193953	3.69E+09	0.1688	0.4583	1.9738	5.3593
RUN 838	11.346	12.585	12.337	2.772	32605	389091	72118	202534	3.73E+09	0.1610	0.4521	1.9211	5.3952
RUN 839	11.347	12.588	12.340	2.776	34086	403749	74032	208254	3.79E+09	0.1637	0.4604	1.9387	5.4537
INOCULATED B													
RUN 840	11.360	12.600	12.352	2.785	32784	404635	70322	197889	3.62E+09	0.1657	0.4662	2.0448	5.7540
RUN 841	11.344	12.582	12.336	2.773	32828	421364	71818	191635	3.63E+09	0.1713	0.4571	2.1988	5.6671
RUN 842	11.341	12.580	12.333	2.770	29501	390535	64185	185923	3.29E+09	0.1587	0.4596	2.1005	6.0845

Table C.4.3. Raw data for Week 2; 2 mg/L DBCP + 10 mg/L camphor using the three strain consortium

	RETENTION TIMES				PEAK AREAS				AREA RATIOS			
	DBCP	CAM	TCB	BEN	DBCP	CAM	TCB	BEN	TOTAL	DBCP/BEN	DBCP/TCB	CAM/BEN
CONTROL A												
	RUN 887	11.310	12.545	12.299	2.749	29290	420747	67100	198442	0.1476	0.4365	2.1203
	RUN 888	11.299	12.540	12.290	2.730	27779	385225	65748	185872	0.1495	0.4225	2.0725
	RUN 889	11.290	12.529	12.281	2.730	29972	424769	68565	196590	0.1525	0.4371	2.1607
INOCULATED A												
	RUN 890	11.277	12.515	12.268	2.720	26382	377809	64739	174185	0.1515	0.4075	2.1690
	RUN 891	11.267	12.505	12.257	2.715	30868	441342	73161	202190	0.1527	0.4219	2.1828
	RUN 892	11.264	12.502	12.502	2.715	30580	406798	70169	183434	0.1667	0.4358	2.2177
INOCULATED B												
	RUN 893	11.261	12.500	12.252	2.710	33447	464832	72773	202552	0.1651	0.4596	2.2954
	RUN 894	11.260	12.499	12.250	2.712	31983	444203	71162	195113	0.1639	0.4494	2.2166
	RUN 895	11.258	12.495	12.248	2.709	30655	412664	66949	167971	0.1625	0.4586	2.4158

Table C.4.4. Raw data for Week 3; 2 mg/L DBCP + 10 mg/L camphor using the three strain consortium

	RETENTION TIMES				PEAK AREAS				AREA RATIOS				
	DBCP	CAM	TCB	BEN	DBCP	CAM	TCB	BEN	TOTAL	DBCP/BEN	DBCP/TCB	CAM/BEN	CAM/TCB
CONTROL A RUN 951 RUN 952 RUN 953	31124	441106	12,259	2.749	31124	441106	69036	194708	3.41E+09	0.1598	0.4508	2.2655	6.3895
	30071	405594	12,250	2.730	30071	405594	65988	168007	3.28E+09	0.1790	0.4557	2.4141	6.1465
	30280	407661	12,281	2.730	30280	407661	64869	179622	3.32E+09	0.1686	0.4568	2.2695	6.2844
INOCULATED A RUN 954 RUN 955 RUN 956	31617	412413	12,268	2.720	31617	412413	71334	192329	3.47E+09	0.1644	0.4432	2.1443	5.7814
	29189	369475	12,257	2.715	29189	369475	65877	186444	3.34E+09	0.1566	0.4431	1.9817	5.6086
	29674	393243	12,502	2.715	29674	393243	67174	187142	3.37E+09	0.1586	0.4417	2.1013	5.8541
INOCULATED B RUN 957 RUN 958 RUN 959	31814	440952	12,252	2.710	31814	440952	71556	191129	3.48E+09	0.1665	0.4446	2.3071	6.1623
	30970	424255	12,250	2.712	30970	424255	69025	191908	3.39E+09	0.1614	0.4487	2.2107	6.1464
	30934	396093	12,248	2.709	30934	396093	70207	195519	3.48E+09	0.1582	0.4406	2.0259	5.6418

Table C.5.1. Raw data for Week 0; 10 mg/L DBCP + 10 mg/L camphor using the three strain consortium

	RETENTION TIMES				PEAK AREAS				AREA RATIOS			
	DBCP	CAM	TCB	BEN	DBCP	CAM	TCB	BEN	TOTAL	DBCP/BEN	DBCP/TCB	CAM/BEN
CONTROL A	11.337	12.575	12.327	2.763	189028	452001	71510	191808	3.6E+09	0.8812	2.3637	2.3566
	11.335	12.574	12.325	2.765	165567	442973	70065	176958	3.55E+09	0.9356	2.3630	2.5033
	11.339	12.577	12.330	2.772	157443	412256	66116	162457	3.41E+09	0.9691	2.3813	2.5376
INOCULATED A	11.337	12.575	12.327	2.763	162743	432892	69066	191172	3.54E+09	0.8513	2.3557	2.2644
	11.349	12.579	12.339	2.771	153205	400462	65107	173724	3.37E+09	0.8819	2.3531	2.3052
	11.343	12.580	12.333	2.766	160901	430360	67173	173655	3.42E+09	0.9266	2.3953	2.4782
INOCULATED B	11.374	12.611	12.365	2.794	155612	407066	65996	163909	3.39E+09	0.8461	2.3579	2.2134
	11.348	12.585	12.339	2.767	165791	441734	69601	188386	3.49E+09	0.8801	2.3820	2.3448
	11.340	12.580	12.330	2.765	159619	413678	66758	179142	3.48E+09	0.8910	2.3910	2.3092

Table C.5.2. Raw data for Week 1; 10 mg/L DBCP + 10 mg/L camphor using the three strain consortium

	RETENTION TIMES				PEAK AREAS				AREA RATIOS					
	DBCP	CAM	TCB	BEN	DBCP	CAM	TCB	BEN	TOTAL	DBCP/BEN	DBCP/TCB	CAM/BEN	CAW/TCB	
CONTROL A	RUN 843	11.344	12.582	12.335	2.768	170248	428644	71533	187743	3.64E+09	0.9068	2.3800	2.2725	5.9643
	RUN 846	11.350	12.587	12.341	2.773	157413	370573	65996	188468	3.44E+09	0.8352	2.3852	1.9662	5.6151
	RUN 848	11.346	12.584	12.335	2.772	165455	377051	69185	197631	3.59E+09	0.8372	2.3915	1.9079	5.4499
INOCULATED A	RUN 849	11.343	12.582	12.335	2.770	171457	404749	72377	193193	3.7E+09	0.8875	2.3689	2.0951	5.5922
	RUN 850	11.339	12.575	12.328	2.764	171665	409811	73146	201698	3.68E+09	0.8511	2.3469	2.0318	5.6026
	RUN 851	11.342	12.580	12.333	2.768	174580	425194	74298	198886	3.75E+09	0.8778	2.3497	2.1379	5.7228
INOCULATED B	RUN 852	11.338	12.576	12.328	2.765	158675	350512	69530	202208	3.67E+09	0.7847	2.2691	1.7334	5.0123
	RUN 853	11.348	12.588	12.334	2.762	152724	357087	67196	182338	3.54E+09	0.8376	2.2728	1.9584	5.3141
	RUN 799	11.350	12.590	12.341	2.772	165562	381703	71843	201961	3.69E+09	0.8198	2.3041	1.8900	5.1430

Table C.5.3. Raw data for Week 2; 10 mg/L DBCP + 10 mg/L camphor using the three strain consortium

	RETENTION TIMES				PEAK AREAS				AREA RATIOS				
	DBCP	CAM	TCB	BEN	DBCP	CAM	TCB	BEN	TOTAL	DBCP/BEN	DBCP/TCB	CAM/BEN	CAM/TCB
CONTROL A													
	RUN 896	11.26	12.497	12.25	2.711	172878	454929	74920	196875	3.69E+09	0.8781	2.3075	2.3108
	RUN 897	11.262	12.5	12.253	2.711	160617	417908	69452	190815	3.45E+09	0.8426	2.3126	2.1924
RUN 898	11.258	12.485	12.247	2.71	133613	309256	61971	180079	3.3E+09	0.7420	2.1561	1.7173	4.9903
INOCULATED A													
	RUN 899	11.26	12.497	12.25	2.712	167022	420177	73186	192513	3.62E+09	0.8676	2.2822	2.1826
	RUN 900	11.261	12.498	12.25	2.711	168506	435752	73713	201377	3.61E+09	0.8388	2.2914	2.1639
	RUN 901	11.275	12.513	12.265	2.715	167092	446243	71892	199038	3.53E+09	0.8395	2.3242	2.2420
INOCULATED B													
	RUN 902	11.27	12.508	12.259	2.717	179928	464250	74443	203595	3.62E+09	0.8838	2.4170	2.2803
	RUN 903	11.268	12.505	12.258	2.721	177829	441517	75454	197903	3.69E+09	0.8986	2.3568	2.2310
	RUN 905	11.303	12.537	12.291	2.738	153502	383609	63537	179149	3.15E+09	0.8568	2.4159	2.1413
													6.0376

Table C.5.4. Raw data for Week 3; 10 mg/L DBCP + 10 mg/L camphor using the three strain consortium

	RETENTION TIMES				PEAK AREAS				AREA RATIOS				
	DBCP	CAM	TCB	BEN	DBCP	CAM	TCB	BEN	TOTAL	DBCP/BEN	DBCP/TCB	CAM/TCB	
CONTROL A													
	RUN 960	11.287	12.525	12.278	2.728	159455	408652	68024	198108	3.51E+09	0.8049	2.3441	5.9340
	RUN 961	11.290	12.528	12.280	2.729	165537	438162	70855	184773	3.49E+09	0.8959	2.3363	6.1839
RUN 962	11.271	12.508	12.281	2.713	157936	393831	68941	196051	3.47E+09	0.8056	2.2909	5.7126	
INOCULATED A													
	RUN 963	11.281	12.519	12.721	2.720	163388	428442	71675	199817	3.5E+09	0.8185	2.2796	5.9497
	RUN 964	11.270	12.260	12.260	2.715	154308	400846	66814	189033	3.39E+09	0.8163	2.3164	6.0189
RUN 965	11.271	12.508	12.260	2.711	154553	376249	68745	196350	3.51E+09	0.7871	2.2482	5.4731	
INOCULATED B													
	RUN 966	11.280	12.517	12.270	2.719	152565	388790	67858	195524	3.49E+09	0.7803	2.2484	5.7296
	RUN 967	11.284	12.520	12.272	2.725	157627	411206	68528	187074	3.4E+09	0.8426	2.3002	6.0006
RUN 968	11.268	12.505	12.258	2.712	155436	395483	69035	191023	3.51E+09	0.8137	2.2516	5.7287	

Table C.6.1. Raw data for Week 0; 2 mg/L DBCP + 25 mg/L 3-chloro-1-propanol using the three strain consortium

	RETENTION TIMES				PEAK AREAS				AREA RATIOS		
	DBCP	CPL	TCB	BEN	DBCP	CPL	TCB	BEN	TOTAL	DBCP/BEN	DBCP/TCB
CONTROL A											
	11.375	N/A	12.365	2.795	20288	N/D	67981	178168	3477900000	0.1139	0.2984
	11.355	N/A	12.345	2.775	18922	N/D	66560	190262	3542100000	0.0995	0.2843
	11.355	N/A	12.348	2.777	17631	N/D	62790	179846	3414000000	0.0980	0.2808
INOCULATED A											
	11.357	N/A	12.348	2.778	16417	N/D	63975	191860	3469300000	0.0856	0.2566
	11.346	N/A	12.336	2.771	19984	N/D	66724	189721	3455300000	0.1053	0.2995
	11.335	N/A	12.328	2.765	19705	N/D	68113	185012	3462400000	0.1065	0.2981
INOCULATED B											
	11.330	N/A	12.325	2.761	18351	N/D	67738	197109	3558900000	0.0931	0.2709
	11.358	N/A	12.348	2.787	17188	N/D	56997	155224	2918700000	0.1107	0.3016
	11.330	N/A	12.321	2.858	19450	N/D	68073	197884	3622100000	0.0983	0.2857

Table C.6.2. Raw data for Week 1; 2 mg/L DBCP + 25 mg/L 3-chloro-1-propanol using the three strain consortium

	RETENTION TIMES				PEAK AREAS				AREA RATIOS			
	DBCP	CPL	TCB	BEN	DBCP	CPL	TCB	BEN	TOTAL	DBCP/BEN	DBCP/TCB	
CONTROL A												
	RUN 857	11.365	N/A	12.357	2.790	19735	N/D	69171	196348	3.56E+09	0.1005	0.2853
	RUN 858	11.353	N/A	12.344	2.775	21499	N/D	71068	201777	3.59E+09	0.1065	0.3025
	RUN 859	11.336	N/A	12.327	2.764	19963	N/D	69833	193948	3.6E+09	0.1029	0.2859
INOCULATED A												
	RUN 860	11.337	N/A	12.328	2.763	19908	N/D	68707	203636	3.55E+09	0.0978	0.2898
	RUN 861	11.334	N/A	12.324	2.761	22084	N/D	71643	203078	3.54E+09	0.1087	0.3083
	RUN 862	11.342	N/A	12.334	2.761	21376	N/D	70933	190185	3.52E+09	0.1124	0.3014
INOCULATED B												
	RUN 863	11.355	N/A	12.345	2.774	19046	N/D	68405	194760	3.47E+09	0.0978	0.2784
	RUN 864	11.336	N/A	12.327	2.763	18403	N/D	67062	190031	3.47E+09	0.0968	0.2744
	RUN 865	11.333	N/A	12.327	2.763	21906	N/D	69505	192144	3.46E+09	0.1140	0.3152

Table C.6.3. Raw data for Week 2; 2 mg/L DBCP + 25 mg/L 3-chloro-1-propanol using the three strain consortium

	RETENTION TIMES				PEAK AREAS				AREA RATIOS			
	DBCP	CPL	TCB	BEN	DBCP	CPL	TCB	BEN	TOTAL	DBCP/BEN	DBCP/TCB	
CONTROL A												
	RUN 909	11.319	N/A	12.310	2.752	21798	N/D	71256	190248	3.54E+09	0.1146	0.3059
	RUN 910	11.310	N/A	12.300	2.742	20791	N/D	67204	180340	3.41E+09	0.1153	0.3094
RUN 911	11.298	N/A	12.286	2.733	20053	N/D	68077	187590	3.48E+09	0.1069	0.2946	
INOCULATED A												
	RUN 912	11.305	N/A	12.293	2.736	20698	N/D	67095	191775	3.41E+09	0.1079	0.3085
	RUN 913	11.300	N/A	12.290	2.740	20080	N/D	67026	191832	3.41E+09	0.1047	0.2996
	RUN 914	11.285	N/A	12.275	2.724	21494	N/D	68511	189094	3.43E+09	0.1137	0.3137
INOCULATED B												
	RUN 915	11.309	N/A	12.297	2.745	21299	N/D	66466	181171	3.4E+09	0.1176	0.3204
	RUN 916	11.280	N/A	12.270	2.723	17990	N/D	64259	165902	3.36E+09	0.1084	0.2800
	RUN 917	11.280	N/A	12.274	2.720	19195	N/D	63929	176471	3.35E+09	0.1088	0.3003

Table C.6.4. Raw data for Week 3; 2 mg/L DBCP + 25 mg/L 3-chloro-1-propanol using the three strain consortium

	RETENTION TIMES					PEAK AREAS				AREA RATIOS	
	DBCP	CPL	TCB	BEN	DBCP	CPL	TCB	BEN	TOTAL	DBCP/BEN	DBCP/TCB
CONTROL A											
	11.303	N/A	12.292	2.745	20739	N/D	70330	187451	3.37E+09	0.1106	0.2949
	11.282	N/A	12.272	2.720	19841	N/D	68823	192279	3.41E+09	0.1032	0.2883
CONTROL A	11.291	N/A	12.281	2.726	20915	N/D	71994	195371	3.55E+09	0.1071	0.2905
INOCULATED A											
	11.279	N/A	12.271	2.719	19152	N/D	70458	197186	3.52E+09	0.0971	0.2718
	11.275	N/A	12.265	2.719	21373	N/D	70833	193536	3.49E+09	0.1104	0.3017
	11.275	N/A	12.267	2.719	18800	N/D	66364	187466	3.31E+09	0.1003	0.2833
INOCULATED B											
	11.282	N/A	12.273	2.719	18437	N/D	66658	191045	3.35E+09	0.0965	0.2766
	11.290	N/A	12.280	2.724	20329	N/D	68122	181654	3.31E+09	0.1119	0.2984
	11.275	N/A	12.265	2.718	18798	N/D	68273	193685	3.46E+09	0.0971	0.2753

Table C.7.1. Raw data for Week 0; 10 mg/L DBCP + 25 mg/L 3-chloro-1-propanol using the three strain consortium

	RETENTION TIMES				PEAK AREAS				AREA RATIOS	
	DBCP	CPL	TCB	BEN	DBCP	CPL	TCB	BEN	TOTAL	DBCP/BEN DBCP/TCB
CONTROL A RUN 813 RUN 814 RUN 815	11.326	N/A	12.318	2.755	100083	N/D	70441	183389	3.62E+09	0.5457 1.4208
	11.335	N/A	12.325	2.760	97173	N/D	69389	167544	3.54E+09	0.5800 1.4004
	11.328	N/A	12.319	2.760	92998	N/D	69303	182875	3.5E+09	0.5085 1.3616
INOCULATED A RUN 817 RUN 818 RUN 819	11.320	N/A	12.310	2.755	93008	N/D	67449	199271	3.57E+09	0.4667 1.3789
	11.320	N/A	12.312	2.744	86874	N/D	59771	168898	3.11E+09	0.5144 1.4534
	11.332	N/A	12.324	2.758	92523	N/D	68535	194707	3.6E+09	0.4752 1.3500
INOCULATED B RUN 820 RUN 821 RUN 822	11.322	N/A	12.314	2.748	93864	N/D	70702	194599	3.62E+09	0.4823 1.3276
	11.331	N/A	12.322	2.758	97007	N/D	69467	200102	3.63E+09	0.4848 1.3964
	11.326	N/A	12.319	2.755	100466	N/D	70008	198839	3.57E+09	0.5053 1.4351

Table C.7.2. Raw data for Week 1; 10 mg/L DBCP + 25 mg/L 3-chloro-1-propanol using the three strain consortium

	<u>RETENTION TIMES</u>				<u>PEAK AREAS</u>				<u>AREA RATIOS</u>	
	DBCP	CPL	TCB	BEN	DBCP	CPL	TCB	BEN	TOTAL	DBCP/BEN/DBCP/TCB
CONTROL A										
RUN 866	11.333	N/A	12.324	2.758	97782	N/D	69464	196307	3.45E+09	0.4981 1.4077
RUN 867	11.338	N/A	12.330	2.763	99411	N/D	67505	172423	3.4E+09	0.5766 1.4726
RUN 868	11.348	N/A	12.340	2.770	98610	N/D	67310	184333	3.43E+09	0.5350 1.4650
INOCULATED A										
RUN 869	11.355	N/A	12.345	2.775	98737	N/D	69627	187937	3.52E+09	0.5254 1.4181
RUN 870	11.339	N/A	12.330	2.765	94550	N/D	66920	179318	3.39E+09	0.5273 1.4129
RUN 871	11.339	N/A	12.330	2.763	93199	N/D	66170	184678	3.35E+09	0.5047 1.4085
INOCULATED B										
RUN 872	11.340	N/A	12.330	2.761	104544	N/D	71813	185548	3.55E+09	0.5634 1.4558
RUN 873	11.335	N/A	12.327	2.765	91498	N/D	65141	178290	3.32E+09	0.5132 1.4046
RUN 874	11.346	N/A	12.338	2.766	95149	N/D	66225	186989	3.39E+09	0.5088 1.4368

Table C.7.3. Raw data for Week 2; 10 mg/L DBCP + 25 mg/L 3-chloro-1-propanol using the three strain consortium

	RETENTION TIMES					PEAK AREAS					AREA RATIOS	
	DBCP	CPL	TCB	BEN		DBCP	CPL	TCB	BEN	TOTAL	DBCP/BEN	DBCP/TCB
CONTROL A												
	11.285	N/A	12.275	2.725		94566	N/D	67003	185198	3.4E+09	0.5106	1.4114
	11.283	N/A	12.279	2.720		102981	N/D	68464	195725	3.47E+09	0.5262	1.5042
	11.280	N/A	12.269	2.720		106672	N/D	72952	206020	3.55E+09	0.5178	1.4622
INOCULATED A												
	11.274	N/A	12.265	2.720		98285	N/D	68872	188685	3.53E+09	0.5209	1.4271
	11.280	N/A	12.270	2.720		97846	N/D	69328	192504	3.51E+09	0.5083	1.4113
	11.272	N/A	12.263	2.719		95119	N/D	67951	186350	3.49E+09	0.5104	1.3998
INOCULATED B												
	11.280	N/A	12.270	2.719		93539	N/D	66432	188549	3.41E+09	0.4961	1.4080
	11.277	N/A	12.268	2.717		98423	N/D	68051	185042	3.45E+09	0.5319	1.4463
	11.280	N/A	12.270	2.720		98838	N/D	69184	189764	3.45E+09	0.5208	1.4286

Table C.7.4. Raw data for Week 3; 10 mg/L DBCP + 25 mg/L 3-chloro-1-propanol using the three strain consortium

	<u>RETENTION TIMES</u>				<u>PEAK AREAS</u>				<u>AREA RATIOS</u>	
	DBCP	CPL	TCB	BEN	DBCP	CPL	TCB	BEN	TOTAL	DBCP/BEN DBCP/TCB
CONTROL A	11.268	N/A	12.258	2.713	106760	N/D	73351	193519	3.48E+09	0.5517 1.4555
	11.267	N/A	12.258	2.711	94730	N/D	68930	190072	3.38E+09	0.4984 1.3743
	11.266	N/A	12.256	2.712	91414	N/D	66344	181699	3.33E+09	0.5031 1.3779
INOCULATED A	11.266	N/A	12.258	2.709	102522	N/D	70951	193018	3.43E+09	0.5312 1.4450
	11.264	N/A	12.254	2.710	92711	N/D	67254	185085	3.35E+09	0.5009 1.3785
	11.266	N/A	12.256	2.710	86788	N/D	65058	182317	3.26E+09	0.4760 1.3340
INOCULATED B	11.264	N/A	12.253	2.710	99595	N/D	70818	187878	3.43E+09	0.5301 1.4064
	11.260	N/A	12.251	2.706	97984	N/D	70581	191063	3.45E+09	0.5127 1.3880
	11.266	N/A	12.256	2.710	92082	N/D	67775	195690	3.38E+09	0.4706 1.3586

Table C.8.1. Raw data for Week 0; 10 mg/L DBCP sole carbon source study using the nine strain consortium

	<u>RETENTION TIMES</u>			<u>PEAK AREAS</u>			<u>AREA RATIOS</u>	
	DBCP	TCB	BEN	DBCP	TCB	BEN	DBCP/BEN	DBCP/TCB
CONTROL A								
RUN 771	11.445	12.439	2.840	102200	69667	185930	0.5497	1.4670
RUN 772	11.440	12.432	2.829	99498	68404	183182	0.5432	1.4546
RUN 773	11.451	12.446	2.840	102140	69310	181781	0.5619	1.4737
INOCULATED A								
RUN 774	11.487	12.480	2.865	99562	68716	189063	0.5266	1.4489
RUN 775	11.487	12.481	2.867	96491	66677	183349	0.5263	1.4471
RUN 776	11.489	12.483	2.866	94018	63563	168688	0.5573	1.4791
INOCULATED B								
RUN 777	11.466	12.460	2.850	94472	65933	184157	0.5130	1.4328
RUN 778	11.465	12.458	2.849	96342	67304	177310	0.5434	1.4314
RUN 779	11.475	12.470	2.858	96841	66870	176869	0.5475	1.4482

Table C.8.2. Raw data for Week 3; 10 mg/L DBCP sole carbon source study using the nine strain consortium

	<u>RETENTION TIMES</u>				<u>PEAK AREAS</u>			<u>AREA RATIOS</u>	
	DBCP	TCB	BEN		DBCP	TCB	BEN	TOTAL	
CONTROL A									
RUN 939	11.319	12.310	2.840		98688	67369	190460	3.45E+09	0.5182 1.4649
RUN 940	11.304	12.295	2.829		91522	63883	173295	3.26E+09	0.5281 1.4327
RUN 941	11.306	12.297	2.840		98608	67473	195244	3.4E+09	0.5051 1.4614
INOCULATED A									
RUN 942	11.309	12.300	2.865		92719	66231	192357	3.27E+09	0.4820 1.3999
RUN 943	11.304	12.294	2.867		97111	68332	193506	3.47E+09	0.5019 1.4212
RUN 944	11.310	12.300	2.866		99710	68531	194098	3.47E+09	0.5137 1.4550
INOCULATED B									
RUN 945	11.300	12.300	2.850		100511	70231	192089	3.47E+09	0.5233 1.4311
RUN 946	11.323	12.312	2.849		82811	58001	164815	3E+09	0.5024 1.4278
RUN 947	11.285	12.276	2.858		90708	63982	169273	3.46E+09	0.5359 1.4177

Appendix D

Sample Chromatograms

Figure D.1.1. 10 mg/L DBCP, Time = 0, Control, 3 Strain Consortium

Figure D.1.2. 10 mg/L DBCP, Time = 3, Control, 3 Strain Consortium

Figure D.1.3. 10 mg/L DBCP, Time = 0, Inoculated, 3 Strain Consortium

Figure D.1.4. 10 mg/L DBCP, Time = 3, Inoculated, 3 Strain Consortium

Figure D.2.1. 50 mg/L DBCP, Time = 0, Control, 3 Strain Consortium

Figure D.2.2. 50 mg/L DBCP, Time = 3, Control, 3 Strain Consortium

Figure D.2.3. 50 mg/L DBCP, Time = 0, Inoculated, 3 Strain Consortium

Figure D.2.4. 50 mg/L DBCP, Time = 3, Inoculated, 3 Strain Consortium

Figure D.3.1. 100 mg/L DBCP, Time = 0, Control, 3 Strain Consortium

Figure D.3.2. 100 mg/L DBCP, Time = 3, Control, 3 Strain Consortium

Figure D.3.3. 100 mg/L DBCP, Time = 0, Inoculated, 3 Strain Consortium

Figure D.3.4. 100 mg/L DBCP, Time = 3, Inoculated, 3 Strain Consortium

Figure D.4.1. 2 mg/L DBCP + 10 mg/L Camphor, Time = 0, Control

Figure D.4.2. 2 mg/L DBCP + 10 mg/L Camphor, Time = 3, Control

Figure D.4.3. 2 mg/L DBCP + 10 mg/L Camphor, Time = 0, Inoculated

Figure D.4.4. 2 mg/L DBCP + 10 mg/L Camphor, Time = 3, Inoculated

Figure D.5.1. 10 mg/L DBCP + 10 mg/L Camphor, Time = 0, Control

Figure D.5.2. 10 mg/L DBCP + 10 mg/L Camphor, Time = 3, Control

Figure D.5.3. 10 mg/L DBCP + 10 mg/L Camphor, Time = 0, Inoculated

Figure D.5.4. 10 mg/L DBCP + 10 mg/L Camphor, Time = 3, Inoculated

Figure D.6.1. 2 mg/L DBCP + 25 mg/L Chloropropanol, Time = 0, Control

Figure D.6.2. 2 mg/L DBCP + 25 mg/L Chloropropanol, Time = 3, Control

Figure D.6.3. 2 mg/L DBCP + 25 mg/L Chloropropanol, Time = 0, Inoculated

Figure D.6.4. 2 mg/L DBCP + 25 mg/L Chloropropanol, Time = 4, Inoculated

Figure D.7.1. 10 mg/L DBCP + 25 mg/L Chloropropanol, Time = 0, Control

Figure D.7.2. 10 mg/L DBCP + 25 mg/L Chloropropanol, Time = 3, Control

Figure D.7.3. 10 mg/L DBCP + 25 mg/L Chloropropanol, Time = 0, Inoculated

Figure D.7.4. 10 mg/L DBCP + 25 mg/L Chloropropanol, Time = 3, Inoculated

Figure D.8.1. 10 mg/L DBCP, Time = 0, Control, 9 Strain Consortium

Figure D.8.2. 10 mg/L DBCP, Time = 3, Control, 9 Strain Consortium

Figure D.8.3. 10 mg/L DBCP, Time = 0, Inoculated, 9 Strain Consortium

Figure D.8.4. 10 mg/L DBCP, Time = 3, Inoculated, 9 Strain Consortium

Appendix E

Non-Normalized Graphs

Figure E.1. Experiment 1; DBCP Concentration Versus Time

Figure E.2. Experiment 2; DBCP Concentration Versus Time

Figure E.3. Experiment 3. DBCP Concentration Versus Time

Figure E.4. Experiment 4; DBCP Concentration Versus Time

Figure E.5. Experiment 4; Area Ratios of Camphor to TCB Versus Time

Figure E.6. Experiment 5; DBCP Concentration Versus Time

Figure E.7. Experiment 5; Area Ratios of Camphor to TCB Versus Time

Figure E.8. Experiment 6; DBCP Concentration Versus Time

Figure E.9. Experiment 7; DBCP Concentration Versus Time

Figure E.10. Experiment 8; DBCP Concentrations Versus Time