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Dissolved Organic Carbon (DOC) Production from Cultivated Organic Soils on Twitchell Island, Sacramento – San Joaquin Delta, California

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TECHNICAL COMPLETION REPORT

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TECHNICAL COMPLETION REPORT

PROJECT NUMBER: W-891 **START:** July 1, 1997

TITLE: DOC PRODUCTION FROM CULTIVATED, ORGANIC SOILS ON TWITCHELL ISLAND, SACARAMENTO – SAN JOAQUIN DELTA

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KEY WORDS:

leaching (1380), peat (1720), soil moisture (2185), soil salinity (2200), surface drainage (0625), temperature (2355), water quality (2615)

ABSTRACT

Agricultural drainage from Delta islands is known to be a significant contributor of DOC (Dissolved Organic Carbon) that forms THMs (Trihalomethanes) when drinking water is chlorinated. The current agricultural practices create seasonal wet-dry cycles in the fields so that salinity, sodicity, temperature and moisture content of soils are varied. This study was carried out to understand the influences of the current agricultural practices on the production of DOC and THM from surface (oxidized) and subsurface (reduced) peat soil of the Sacramento-San Joaquin Delta. Both abiotic and biotic factors are examined independently in order to identify the major DOC and THM precursors production processes. Abiotic factors examined with successive batch soil solution extraction were salinity (EC from 0 to 4 dS/m) and sodicity (SAR from 0 to ∞) that affect the coagulation and dispersion of soil organic matter (SOM). Biotic factors examined with 8-week batch incubation were temperature (10, 20, 30 °C) and moisture (30, 70, 200 % moisture) that affect the rate of microbial decay of SOM, producing CO_2 and DOC.

In the abiotic experiment, the results showed that the increase of the soil-water salinity decreases the amount of DOC and decreases its aromaticity. A decrease of SAR also decreases the amount of DOC and decreases its aromaticity. The results of the abiotic experiment showed that the salt accumulation of the summer irrigation is not the major production of DOC; instead, the salt accumulation may reduce the DOC leaching from the peat soil, if we consider the salt effects alone.

In the biotic experiment, the 8-week incubation experiments showed that temperature, moisture content and wet-dry cycles affect the microbial activities in soils, but only the flooded and the wet-dry cycle incubations increase the DOC concentration in the oxidized peat soil. However, the extracted DOC from the incubated peat soils showed lower STHMFP although there was increases in the concentration and SUV_{254}.

In summary, the current agricultural practices alter the soil salinity and create the wet-dry and flooded conditions in the fields. The summer irrigation increases the soil salinity. However, the increase of salinity decreases the DOC productions but increases the STHMFP. On the other hand, the wet-dry cycle in the summer and flooded conditions in the winter did produce the DOC, but the STHMFP of DOC produced in these conditions decreased.

Key Words: leaching (1380), peat (1720), soil moisture (2185), soil salinity (2200), surface drainage (0625), temperature (2355), water quality (2615)

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CHAPTER I – INTRODUCTION

Critical Problem

The Sacramento-San Joaquin Delta is a source of drinking water for about 22 million people in California. Unfortunately, high THMs (trihalomethanes) have been reported from treating drinking water from this source area (California Department of Water Resources, 1994). Trihalomethanes, which have the general form CHX_3, where X can be Cl, Br, or I, are formed when natural dissolved organic matter reacts with chlorine during the disinfecting process in water treatment. THMs are of concern because they are believed to have carcinogenic and mutagenic properties (Tariff, 1977; Craun, 1985). Chlorinated Delta waters can, at times, exceed the current U.S. Environmental Protection Agency's (USEPA's) maximum contaminant level (MCL) of drinking water standard of 80 ppb (California Department of Water Resources, 1994). Moreover, a lower level of MCL (40 ppb) has been proposed for the Year 2002 (Federal Register, v.59, No. 145). This new MCL will make it difficult and expensive for water treatment plants using Delta source water because excessive levels of THMs will need to be removed.

Water in the Delta contains elevated concentrations of DOC because the Delta contains about 250,000 acres of high organic matter soils, a source of DOC. In some areas, these organic soils are up to 60 feet in depth and consist of 50-80% organic matter (California Department of Water Resources, 1993). This thick organic material in the peat deposits of the Sacramento-San Joaquin Delta provides a productive agricultural land for Californians; however, the agricultural drainage from cultivated islands in the Delta contribute significant amounts of DOC and THM precursors to Delta channel waters (Amy et al., 1990). The trihalomethane formation potential (THMFP), determined by spiking samples with chlorine and incubating the sample at controlled temperatures and pH and then measuring the THM concentration, of water from Delta agricultural drains was higher on islands with peat soils compared to those islands comprised of mineral soils. Water obtained from agricultural drains had higher THMFP:DOC ratios than water obtained from the delta water channels, which indicates that the DOC in the drains are more reactive with chlorine and are able to form more THM per unit weight (Amy et al., 1990).

In addition, seasonal fluctuations in DOC and THMFP are observed in the Delta water corresponding to the current agricultural practices in the Delta, which creates seasonal wet-dry cycles and aerobic-anaerobic conditions in the agricultural fields. There are typically two wet seasons annually, summer and winter (California Department of Water Resources, 1990). The wet season in summer is typically from July to August and corresponds to intensive irrigation. The wet season in winter is in December and January and is caused by the flooding of fields by landowners to leach out salts accumulated in the soils from summer irrigation. Winter rainfall may also contribute to leaching of DOC. The maximum values of DOC and THMFP are observed in the summer and winter months. The THM precursors in Delta agricultural drainage in 1988 contributed about 40-50% of the TFPC (THM formation potential carbon) during the irrigation months (April-August) and 38-50% during the winter months (November-February) (California Department of Water Resources, 1990).

Agricultural drainage from cultivated islands in the Delta has been identified as a significant source of humic THM precursors in Delta water channels (California Department of Water Resources, 1982 and 1990; Amy et al., 1990). In order to maintain the agricultural productivity of the Delta; meanwhile, reduce the concentration of THM and improve channel water quality in the Sacramento-San Joaquin Delta, the factors affecting DOC productions in the peat soils needs to be better understood. This research project address both abiotic and biotic factors affecting DOC production in cultivated organic soils.

Research Objectives:

The physical and chemical environments of the peat soil in the Delta are significantly affected by the annual summer irrigation and the annual winter leaching practices. The salinity of soil-water is changed with these agricultural practices. The soil profile has the highest salinity at the end of the summer irrigation and the lowest salinity after the winter flooding (California Department of Water Resources, 1982). Similarly, the soil profile has the highest sodicity (SAR (Sodium Adsorption Ratio) or ESP (Exchangeable Sodium Percentage)) at the end of summer irrigation and the lowest after the winter flooding. The salinity and sodicity status in soils can affect the flocculation of soil particles and the coagulation of dissolved organic matter. In addition, both soil moisture and soil temperature vary with these seasonal practices. The soil moisture in the agricultural field is increased and the water table is raised in both the irrigation and leaching periods. The soil temperature is higher in the summer and lower in the winter. These environmental conditions can affect microbial activity and they have been identified as the major factors on the decomposition of peat materials and the subsequent subsidence of organic soils (Eggelsmann, 1984). Therefore, both salinity leaching and microbial activity play important roles in DOC production in the Sacramento – San Joaquin Delta. However, the major processes in increasing DOC and THMFP in summer and winter peak drainage have not been fully studied under controlled conditions. The mechanisms of DOC and THM precursor production processes need to be more fully understood in relation to the quality of Delta waters exported for drinking water.

In order to systematically understand the processes involved in the DOC production in the Sacramento – San Joaquin Delta, this research is designed to examine both biotic and abiotic factors in the Delta organic soils. The chemical characteristics of DOC produced under these varied conditions will be evaluated and its relationships with THMFP will be established.

Specific Objectives:

A. Abiotic effects on DOC production

- Evaluate the quality and quantity of DOC leaching from oxidized and reduced organic soils from Twitchell Island under a range of salinity and sodicity representing the different seasons.

B. Biotic effects on DOC production

- Examine the relationships between DOC production and emission of CO_2 and CH_4 under varied soil conditions in order to relate to DOC production from oxidized and reduced organic soils from Twitchell Island.
- Determine the kinetics of DOC production in organic soils from Twitchell Island under laboratory - controlled conditions by varying soil moisture and temperature, and wet-dry cycles.

C. Characteristics of DOC and THMFP under Varied Conditions:

- Assess the potential formation of THM and chemical character of the hydrophobic humic acid, hydrophobic fulvic acid and hydrophilic acid fractions of the DOC produced under varied soil conditions indicated in A and B above.

Methodology

This research was designed to examine both biotic and abiotic effects on DOC production in peat soils under certain laboratory-controlled conditions. For abiotic effect, successive extractions with waters of differing EC (salinity) and SAR (Na/Ca ratio) are performed on samples from the oxidized soils in the vadose zone and on fibrous peaty soils from the saturated zone. One set of experiments is set up to perform successive extracts on soils using the same EC water but with SAR varied. A second set of successive extractions is carried out with a fixed SAR water but EC varied. Successive extractions are performed until the concentration of DOC leached shows an asymptotic response. The details of this experiment are described in Chapter II.

For the biotic effects, batch incubation experiments are conducted in the laboratory under controlled conditions to evaluate microbial activity subject to varying moisture content and temperature, and wet-dry cycles. The rates of CO_2 and CH_4 evolution are measured in all the incubation experiments to serve as an indicator of the microbial activity. The details of the methods are described in Chapter III.

After the major factors affecting DOC production have been determined, the solutions extracted from these abiotic and biotic experiments are characterized. The chemical characteristics of DOC are evaluated by XAD-8 and XAD-4 resin fractionation so that the relationships of chemical structure of DOC and THMFP could be established. The details of the characterization of DOC and THM precursors are described in Chapter IV.

In the above studies, the soils used are decomposed peaty soil from the upper oxidized zone (1-2 ft) and partially decomposed peaty soil from the lower reduced zone (8-10 ft). Figure 1.1 presents an overview of the three types of studies conducted as related to abiotic effects, biotic effects and chemical characterization.

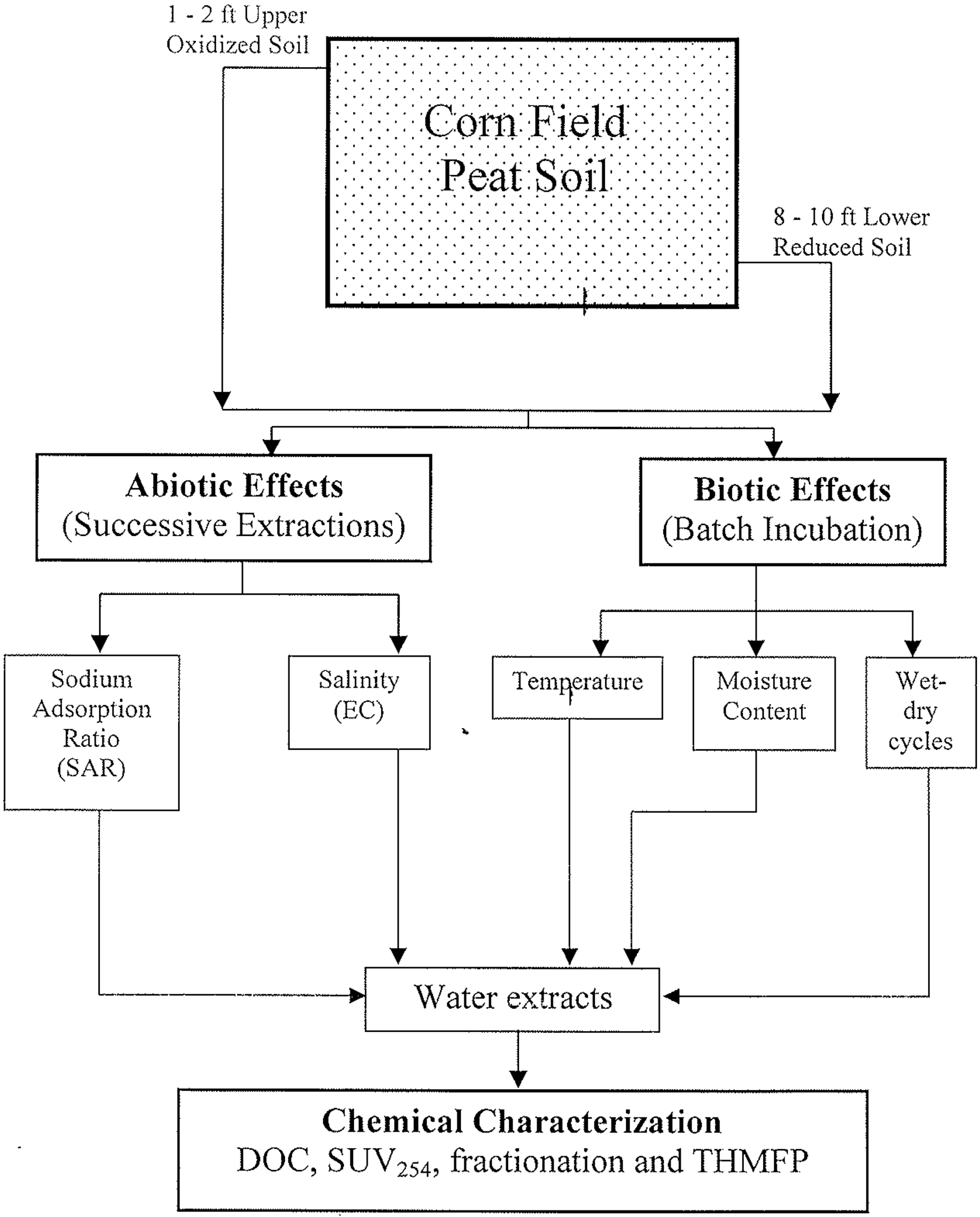


Figure 1.1. An overview of the experimental design for this research project.

CHAPTER II – ABIOTIC EFFECTS

Introduction

Waters passing through the Sacramento-San Joaquin Delta contain elevated concentrations of dissolved organic carbon (DOC). Drainage waters from Delta islands contribute about 20 to 50% of the DOC that leads to the formation of trihalomethane precursors (THMs) in Delta waters exported from the H.O. Harvey Banks pumping (California Department of Water Resources, 1990). The principal source of DOC in drainage waters is attributed to the decomposition of high organic matter Delta soils (Amy et al., 1990). In a field study monitoring DOC concentrations in soil water on Twitchell Island, Fujii et al.(1998) measured median concentrations ranging from 46 to 83 mg/L DOC in the upper oxidized soil zone (0.5 to 1.5 ft) and from 49 to 82 mg/L DOC in the lower reduced soil zone (4.5 to 6.5 ft).

The Delta was formerly a tidal marsh area that was drained in the 1920's to form islands for agricultural use (Cosby, 1935) and now contains about 250,000 acres of peaty organic soils. The agricultural practices and drainage from cultivated islands have been identified as a significant source of DOC and THM precursors in Delta channels (California Department of Water Resources, 1982 and 1990; Amy et. al., 1990). The maximum values of DOC and trihalomethane formation potential (THMFP) are observed in the periods of summer irrigation and winter salt-leaching practices (California Department of Water Resources, 1990).

The current agricultural practices annually create two wet seasons in cultivated peat lands, summer and winter (California Department of Water Resources, 1990). The wet season in the summer is typically in July-August and corresponds to special sub-irrigation methods. Sub-irrigation is practiced because the water infiltration rate is too high on many organic soils for gravity surface irrigation methods such as furrows and basins. In lands having land surface elevations lower than the surrounding Delta channel waters, one sub-irrigation method is to allow the water table to rise naturally by stopping the island drainage pumps to irrigate the rootzone and then resume pumping to lower the water table until the next irrigation. Another method of sub-irrigation is by spud ditches originated when the islands were heavily devoted to potato production. Water is introduced to the field through mutually connected widely-spaced narrow trenches and the soil is wetted horizontally between spud ditches and vertically upwards. After wetting across between the spud ditches, the field is drained to allow root-water extraction until the next irrigation. The other wet season is from December and January and is caused by the flooding of fields by landowners to leach out salts accumulated in the soils. The field is flooded for about a month or two before draining to leach out salts accumulated from summer irrigation (Cosby, 1935). Some farmers flood their fields in late fall to attract migratory water birds for bird watching and hunting by duck clubs.

Summer irrigation and winter flooding affect soil salinity. Changes in the soil salinity can potentially affect the concentrations of DOC in the drainage water. Tanji and Doneen (1961) noted that at elevated salinity the leaching waters from columns of Delta peat soils were straw-colored. When the salinity became low, the leachates changed from straw-colored to grayish-black and contained high concentrations of dispersed organic colloidal matter. Moreover, several studies showed that there is a negative relationship between leached DOC and ionic strength of soil solutions (Chang et al., 1984; Evans et al., 1988 and Andersson et al., 1994). Indeed, Sholkovitz (1976) found that the removal of DOC increased with salinity. Thurman (1985) also pointed out that the solubility of natural organic acids decreases with an increase of the ionic strength of the soil water.

In addition to salinity, the sodicity of the soil water may play an important role in the DOC concentrations. Not all cations have the same effectiveness on DOC coagulation. Ong and Bisque (1968) showed that divalent cations were more effective flocculants than monovalent cations and conformed to the Schultze-Hardy rule. For instance, the divalent calcium ions can effectively flocculate up to 50% of the DOC originally present in the water samples (Romkens and Dolfing, 1998).

The above findings indicate that the salinity and sodicity may play an important role on the leaching processes of DOC in the soil-water matrix. Unfortunately, most of these studies on salinity and sodicity were carried out on mineral soils or water environments. Their effects on the DOC and THM precursors from the Delta peat soils have not been fully investigated. Thus, one of the principal focuses of this research is to study the effects of water salinity and sodicity on DOC production and its chemical character.

Materials and Experimental Methods

Site Description and Soil Sampling. Figure 2.1 shows the location of the 10 km^2 Twitchell Island in the west central Sacramento-San Joaquin Delta, California. The peat soils used in this study were collected from an agricultural field on this island that represented a typical land-use practice in the Delta. Corn, which is one of the predominant crops in the Delta, has been grown in this particular field for several years. Twitchell Island is composed of highly organic surface soils under agricultural cultivation. The soil at the sampling site is classified as a Rindge muck, with oxidized, well-decomposed peat dominating from the surface to about 2 ft below land surface, and reduced, fibrous peat dominating below about 3.5 to 4 ft (Fujii et al., 1998). Our soil samples were collected from two soil depths: 1-2 ft and 8-10 ft from the surface in the vicinity of field studies by Fujii et al. (1998). These soils were used to examine the abiotic effects on DOC production in both oxidized and reduced peat soils.

Soil Sampling and Soil Treatment. The collected topsoil (oxidized peat soil) was sieved through a 2 mm sieve after air drying at room temperature. Then, the soil was stored at 4°C in a dark room in plastic bags until further use. A Giddings drilling machine was initially used to collect the soil from the 8-10 ft deep reduced zone. But unfortunately, each drilling required at least half an hour and only small amount of soil was collected from each drilling. At times, samples could not be obtained due to the suction force of the wet soil core. Thus, this sampling method was abandoned. Instead, a 10-ft deep trench was dug manually so as to reach the deeper reduced layer. The seepage from the walls of the trench was slow enough that water did not accumulate in the bottom of the trench while sampling.

Fibrous peat samples were taken from the walls of the trench and promptly put into plastic bags and sealed with N_2 to preserve the reduced condition, and then stored in ice chests for transport to the laboratory. When the reduced soil was brought back to the laboratory, all the samples were double bagged and refilled with N_2 gas before transfer to a 4°C refrigerator. Before the successive extraction experiment, the reduced soil was sieved through a 9.5 mm sieve in a glove bag filled with N_2.

Table 2.1 presents some physical and chemical properties of the oxidized and reduced peaty soils relevant to abiotic studies. More complete characterizations of both soils are summarized in Appendix I. Contrasting differences are noted for these two soil samples. The saturation water percentage for the reduced soil is exceedingly high indicating the undecomposed fibrous nature of the peat while that of the oxidized soil is about twice that of clayey mineral soils. The SOM is similar; however, the TOC in the saturation extract is about 14 times greater in the oxidized than the reduced soil giving some indication of the state of decomposition of SOM. The surface soil was saline from sub-irrigation while the subsurface was nonsaline. The water-soluble constituents in the saline soil are dominated by Na, Cl and SO_4 ions and the nonsaline soil by mixed cations and Cl ions. The SAR of the surface soil was twice as large than the reduced soil.

Successive Extractions. The abiotic effects of salinity and SAR on both oxidized and reduced peat soils were determined by successive extractions of 1:10 soil-to-solution slurry. The synthesized solutions used in the experiments were prepared from reagent grade $CaCl_2$ and NaCl dissolved in double distilled water (DDW). The electrolyte and sodicity of the test solutions used were in the range of waters present on this island. For the salinity experiment, the EC of the solutions were 0.0 (DDW), 0.5, 1.0 and 4.0 dS/m with SAR fixed at 5. The DDW had an EC less than 0.001 dS/m close to rainwater. The soil-solution mixture was shaken for 2 hrs at 4°C. The purpose of the cold environment was to minimize any microbial activity during the shaking periods. Then, the samples were centrifuged for 20 min at 16270 g RCF (Relative Centrifugal Force). The supernatants were collected and filtered through a 1.2μm glass fiber filter (Fisher G4) and then through a 0.45 μm membrane filter (Supor-450). The extracted soil residues were retained, the same solution was added at 1:10 soil to solution ratio, and then shaken again before the next extraction. Successive extractions were continued until the concentrations of DOC extracted showed an asymptotic response.

The effects of SAR on DOC production were also determined through a series of 1:10 soil to solution successive extractions on samples from both the oxidized and reduced zones. The solutions used in this extraction experiment were at fixed EC of 4 dS/m (~ 0.04N) and the SAR was 0, 5 and ∞. An SAR of 0 is pure $CaCl_2$ solution and SAR of ∞ is pure NaCl solution. SAR is defined as $[Na/(Ca)^{0.5}]$ with ion concentrations in mM/L. An SAR of 5 was prepared by an appropriate mixture of NaCl and $CaCl_2$ solutions.

In order to minimize the effects of oxidization of reduced peat soils, all the solutions were bubbled with N_2 for not less than 5 min before the test solutions were added to the reduced soils. The dissolved oxygen was measured and it was about 0.5 mg/L or less.

Results and Discussion

Both oxidized and reduced peat soils were extracted for at least five successive times with electrolyte solutions of various combinations of EC and SAR. The effects of electrolyte concentration on DOC extraction from oxidized and reduced soils are shown in Figures 2.2, 2.3 and 2.4. Except for the DDW treatment, EC of zero and SAR of zero, DOC in mg Carbon extracted per g of soil progressively decreased with successive extraction and approached their own asymptotes (Figs. 2.2. and 2.3). The results from the DDW treatment will be discussed later.

For both oxidized and reduced soils (Figs. 2.2 and 2.3), an increase in EC resulted in progressively less carbon extracted. Moreover, the concentrations of DOC extracted from the oxidized peat soils were higher than that from the reduced peat soils at the same electrolyte concentration. The highest salinity solutions (EC = 4 dS/m) in the experiments withdrew about 0.10 mg C/g soil in both the oxidized and reduced soils in the first extraction, but the other solutions with lower EC (0.125 dS/m $\leq$ EC $\leq$ 1dS/m) extracted about 0.15 – 0.20 mg C/g soil. The higher the salinity of the solution is, the smaller is the amount of DOC extracted.

The oxidized peat soil contained larger quantities of smaller organic fragments than the largely undecomposed reduced soil which readily leach to become DOC. These smaller organic fragments in the oxidized peat soils are possibly the byproducts of microbial activity. Chang and Alexander (1984) indicated that the reductions of leached DOC in the organic soil horizons were attributed to reduced microbial activity. Microbes use the peat fibers as food and carbon sources and they can break down large complex molecules of the humic substances. Moreover, the surface peat soils have unlimited access to oxygen from the atmosphere while the deeper-seated reduced, fibrous peat are isolated in an oxygen poor environment. Thus, the microbial activity in the surface soils is expected to be higher and hence the DOC production is larger.

In the extreme case, the DDW which had an EC < 0.001dS/m had the highest DOC concentrations in the successive extractions. In contrast with other salinity extractions, the DOC extracted with DDW remained more or less constant for oxidized peat soil (Fig. 2.2) or increased with the successive extractions for the reduced soil (Fig. 2.3). Why DOC extracted rose after the third successive extraction in the reduced soil is addressed later. Moreover, DOC extracted by the EC 0.125 dS/m test solution remained more or less constant after the first extraction in the reduced soil.

Figure 2.4 summarizes the effects of water salinity on DOC production for five successive extractions. The total concentration of DOC in the water extracts decreased rapidly from DDW to solution with EC of 0.5 dS/m and the change from EC of 0.5 dS/m to 4 dS/m is relatively small. It appears that the threshold electrolyte concentration for large DOC production is about 0.5 dS/m.

The effects of the electrolytes on the configuration of the humic substance and the coagulation processes may possibly explain these phenomena. Humic substances are anionic polyelectrolytes. Their configurations are dependent on the total ionic strength of the solution. As shown in Box 2.1, Ong et al. (1970) suggested that the flocculation of organic colloids occurs by a three-stage mechanism. First, the negatively charged hydrophilic organic colloid attracts metal ions (or cations) to form a hydrophilic metal-organic complex. Once the cations are combined, there is a marked decrease in the intra-molecular coulombic repulsion in the polymer chain which, in turn, results in coiling of the chain. This dehydration process known as Fuoss effect can be visualized as "squeezing" the water of hydration out of the molecule to form a hydrophobic colloid, which behaves like a clay particle obeying the double-layer theory. Addition of further metal cation now produces flocculation.

When the peat soils are extracted with DDW or low ionic strength solution, these polyelectrolytes have stretched configurations due to mutual repulsion of the negative charges on dissociated or ionized functional groups (Ong et al., 1970 and Stumm, 1992). Such configuration alternations or soil dispersion could result in the release of sterically trapped or weakly coordinated organic into the soil solution (Sposito, 1989). Therefore, the DOC extracted by in DDW was highest. Indeed, the concentrations of DOC in the last extraction were higher than the previous ones and it also had a lower salinity in the successive extractions. In the higher salinity extractions, the polyelectrolytes should have coiled configuration and the organic colloid behaves as clay particles (Ong et al., 1970). The increases of salt in the water can reduce both the effective surface potential and the extent of the diffuse layer, which give a lower colloid stability (Gregory, 1989).

Sodicity or SAR also affects the DOC leaching from both oxidized and reduced peat soils. As shown in Figures 2.5 and 2.6, the pure NaCl solution with EC of 4 dS/m, which has SAR of ∞, extracted more DOC from both soils, compared to the same EC solution with SAR of 0 and the solution with SAR = 5. If the DDW treatment is set as the maximum removal of DOC, the pure calcium solution can reduce up to 50% of DOC extracted in the soil solutions in the last extractions. This behavior is due to the ineffectiveness of Na ion as a bridging cation when compared with the divalent Ca ion (Churchman, 1993). In fact, Ca ion is particularly effective as a bridging ion in soil organic-mineral associations (Muneer and Oades, 1989). The bridging cations can link clays with permanent negative charges to anionic functional groups on SOM or bind SOM together. These coagulation processes can reduce their solubility and finally precipitate out from the water solutions.

For the extraction with a SAR of 5, the DOC removal ability is similar to SAR of 0 (Figs. 2.5 and 2.6). Such behavior may imply that the concentrations of Ca ion in this salinity level (EC of 4 dS/m) exceed the available binding sites of the polyelectrolytes. Therefore, the excess Ca ions in the SAR 0 solution do not further reduce the concentrations of DOC in the water extracted. In fact, the SAR values of the soil solutions from a field experiment (Fujii et al., 1998) and the soil saturated paste for soil characterization in this experiment (Table 2.1) range from 2 - 8 $(mmol/L)^{1/2}$. The comparatively small variation in DOC extracted by solutions in the small range of SAR in the field and this experiment (except SAR_{∞}) imply that the sodicity is not a major factor on the DOC leaching processes in the delta soils, compared to the salinity effects.

The decrease in DOC in the extractions is also possibly related to the pH of the soil extracts. As seen in Figure 2.7 and 2.8, the higher the salinity of the water extract, the lower the pH. The dissociation constant of an acid or a base is influenced by the ionic strength of the solution (Stumm and Morgan, 1996). Thus, the ionic strength in the solution could change the dissociation constants of functional groups on the polyelectrolytes and affect the pH of the solution. In addition, low pH in the high salinity water may result from cation exchange. For instance, the cations in the solution can replace hydrogen ion from the organic matter and lower the solution pH.

$$\text{SOM-H} + \text{Na}^{+}_{(aq)} \rightarrow \text{OM-Na} + \text{H}^{+}$$
$$\text{2OM-H} + \text{Ca}^{2+}_{(aq)} \rightarrow \text{OM-Ca-OM} + 2\text{H}^{+}$$

As the pH drops, the anionic groups are protonated and they are no longer negatively charged. The intramolecular repulsion decreases and the molecules flocculate and precipitate. Thus, the higher the water salinity the lower the pH and the lower DOC extracted.

Conclusion

The increase of soil-water salinity to about EC 0.5 dS/m can reduce DOC leaching from the peat soils. Thus, the salt accumulation in the summer irrigation periods may not be the principal DOC production process in the Sacramento-San Joaquin Delta. The high DOC in summer drainage is possibly attributed to microbial activity in the flooded condition and wet-dry cycles (Chapter III). However, the winter flooding, which introduces low salinity water, is probably the major mechanism that disperses soil particles and release DOC from the peat soils. Also, we noted that the calcium ions have better flocculation ability than sodium ions to reduce DOC leaching, but the sodicity effects are relatively small, compared to the salinity effects on the DOC leaching processes.

Table 2.1. Relevant properties of the oxidized surface soil and reduced subsoil for the abiotic experiments (Mean of 4 samples).

Description	Oxidized soil (1 to 2 ft depth)	Reduced soil (8 to 10 ft depth)
Saturation water percentage, g/100g	156	871
pH of saturated soil extract	6.6	6.7
Eh of saturated soil extract, mV	54.8	128
EC of saturated soil extract, dS/m	4.44	0.59
Soil organic matter (SOM), % (w/w)	49.85	39.35
Total organic carbon (TOC), mg/L	296	21.2
Inorganic carbon (IC), mg/L	18.6	2.26
Total carbon (TC), mg/L	314.6	23.5
Saturation soil extract analyses in mg/L		
Na	505	63.4
Ca	233	14.7
Mg	175	12.1
K	12.8	6.4
Mn	2.45	0.27
NH_4	8.96	6.4
Cl	1092	167
SO_4	897	21.9
Total cations in meq/L	48.9	5.02
Total anions in meq/L	49.4	5.16
Sodium Adsorption Ration (SAR), $(mM/L)^{0.5}$	6.1	3.0

SAR = $Na/(Ca+Mg)^{0.5}$ in mM/L

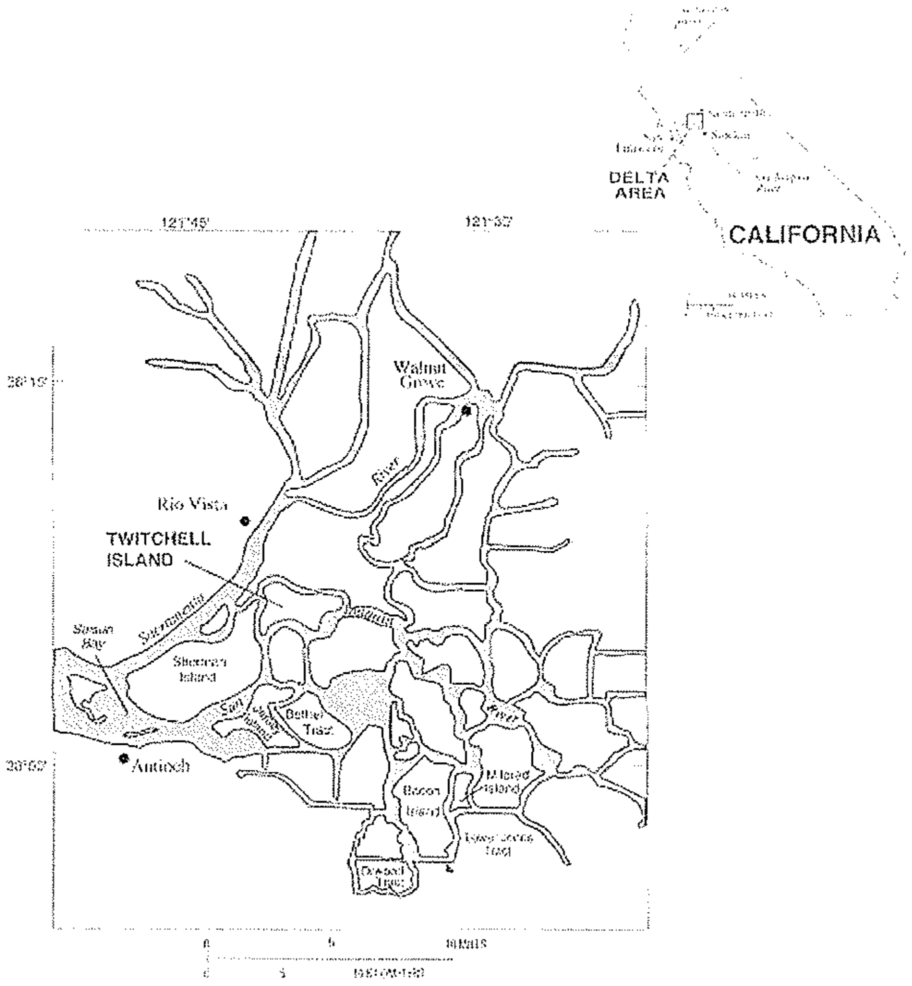


Figure 2.1. Location of Twitchell Island in the Sacramento-San Joaquin Delta of California. The map is adopted from Fujii et al., 1998.

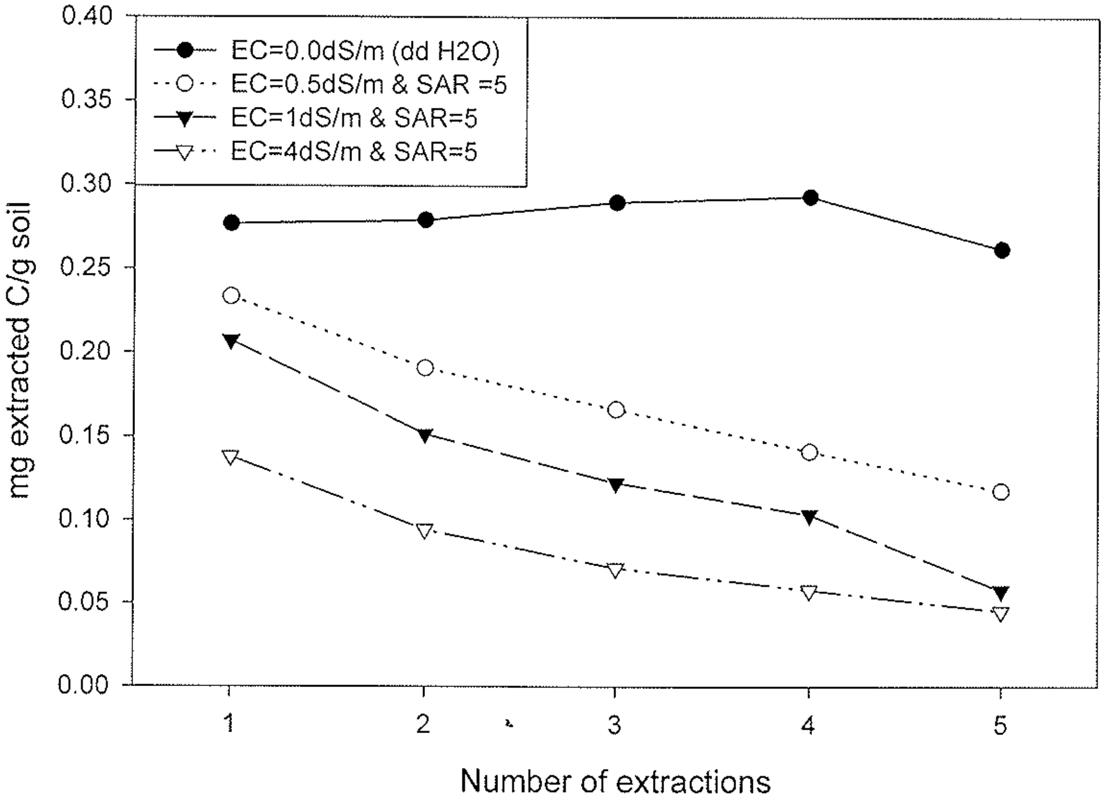


Figure 2.2. Salinity effects on DOC production from oxidized peat soil. The soils were successively extracted with solutions of EC 0.0, 0.5, 1 and 4 dS/m with constant SAR of 5.

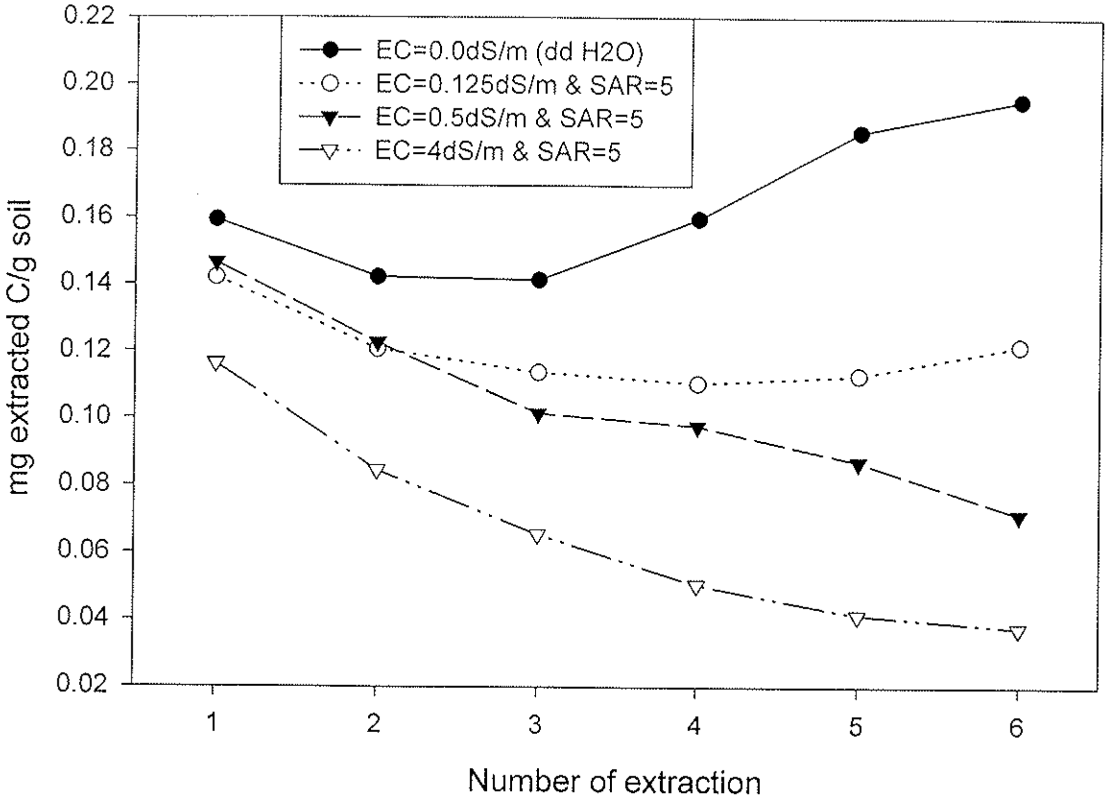


Figure 2.3. Salinity effects on DOC production from reduced peat soil. The soil was successively extracted with solutions of EC 0.0, 0.125, 0.5 and 4 dS/m with constant SAR of 5.

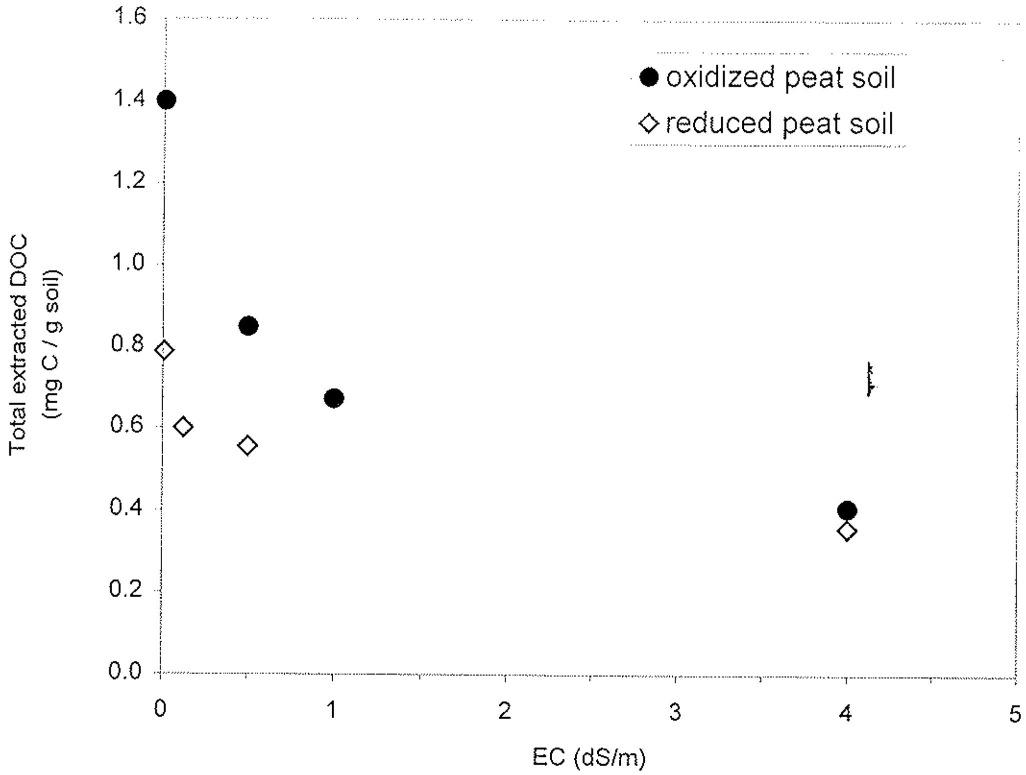


Figure 2.4. The effects of water salinity on total DOC extractions. Total DOC extracted is for five successive extractions for both oxidized and reduced peat soils with constant SAR of 5.

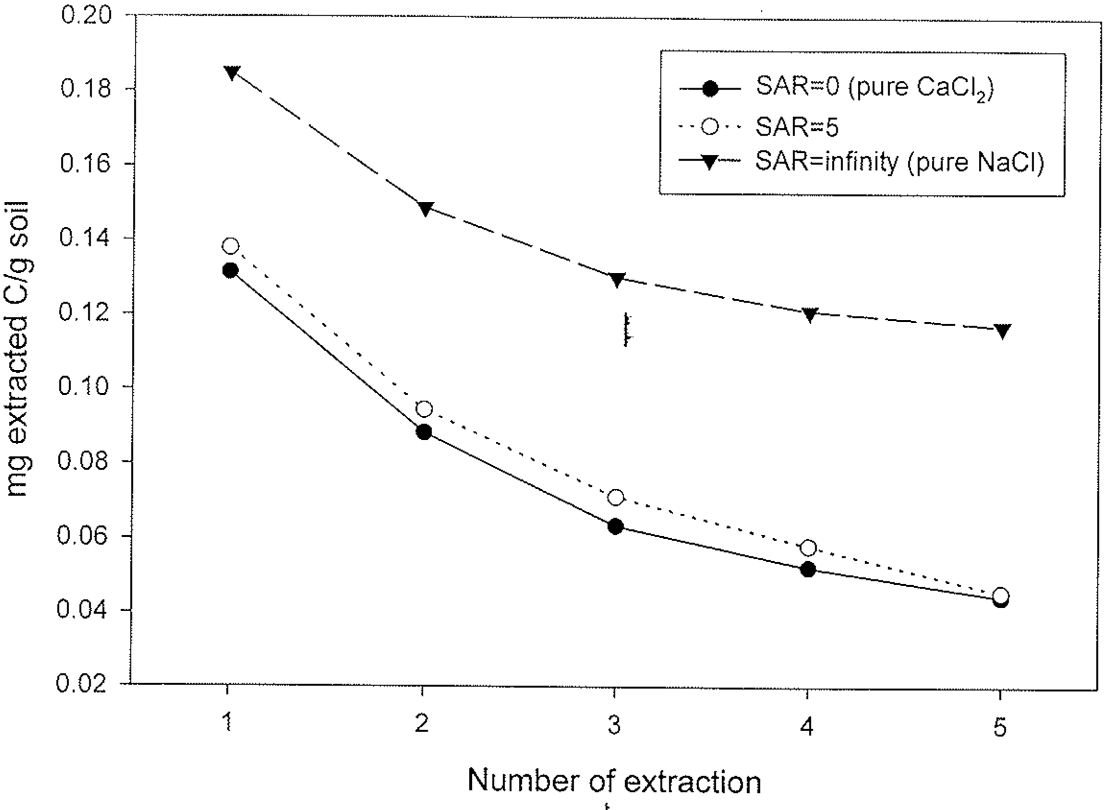


Figure 2.5. SAR effects on DOC production from oxidized peat soil. The soil was successively extracted with solutions of SAR 0, 5 and ∞ with constant EC of 4 dS/m.

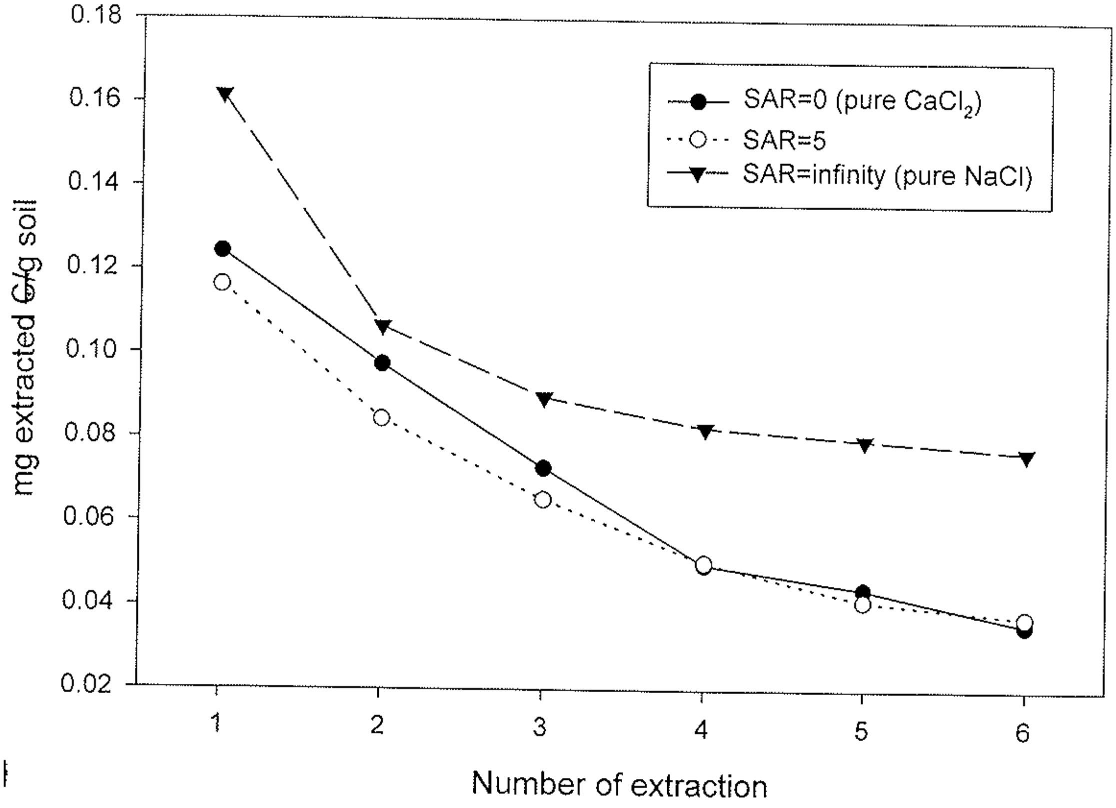


Figure 2.6. SAR effects on DOC production from reduced peat soil. The soil was successively extracted with solutions of SAR 0. 5, and ∞ with constant EC of 4 dS/m.

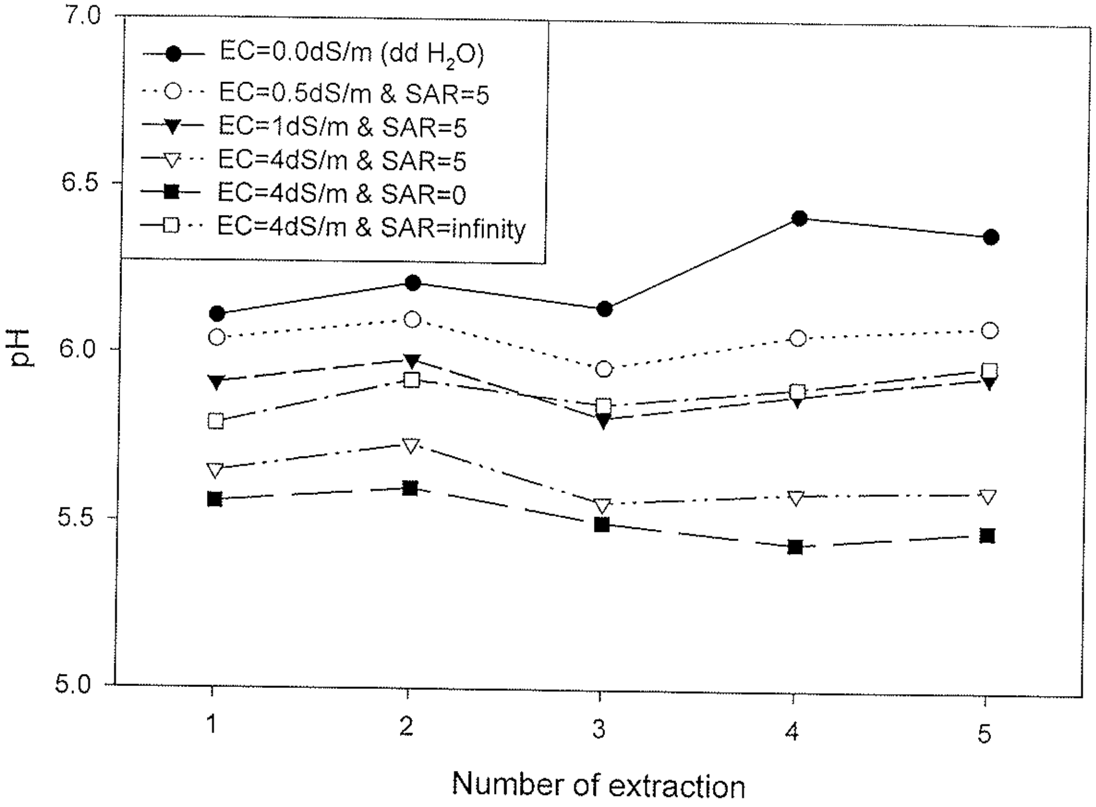


Figure 2.7. The pH values of each successive extraction from oxidized peat soil. The pH values were measured in the supernatant after the soil-solution slurry were centrifuged but before filtering through a 0.45μm filter.

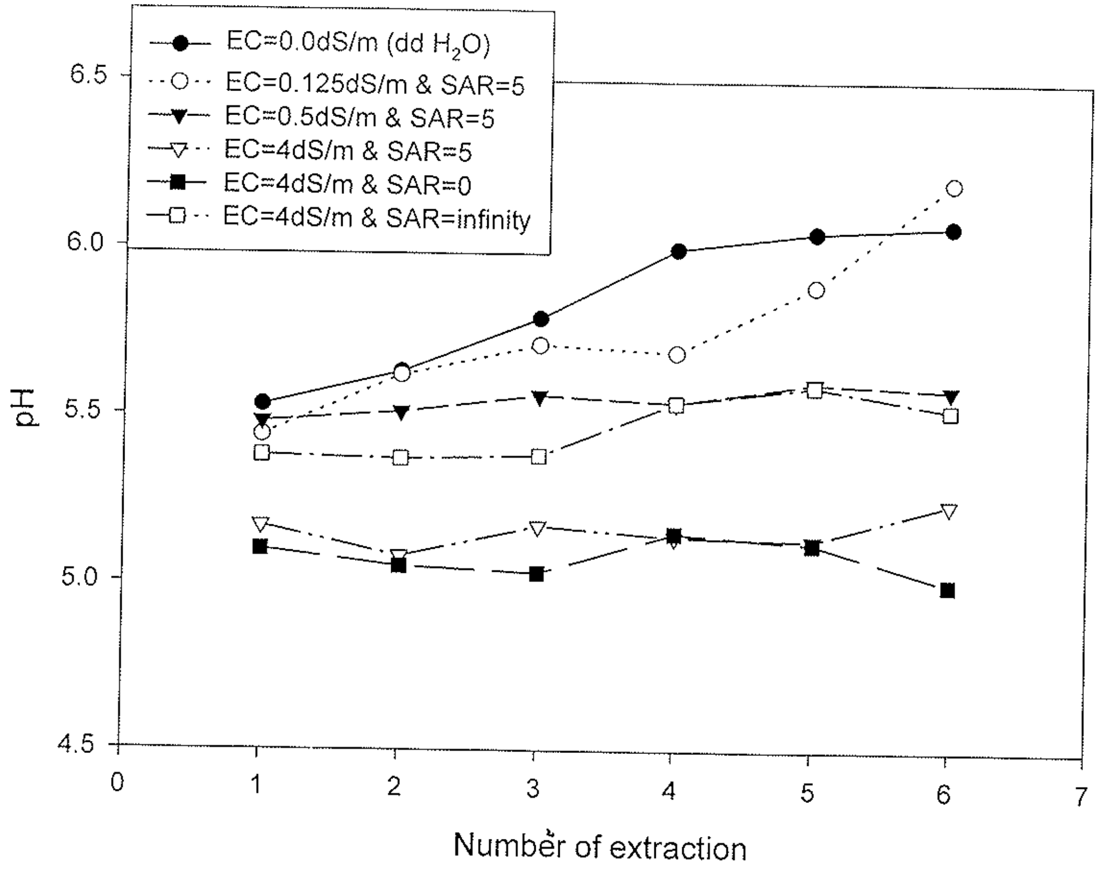
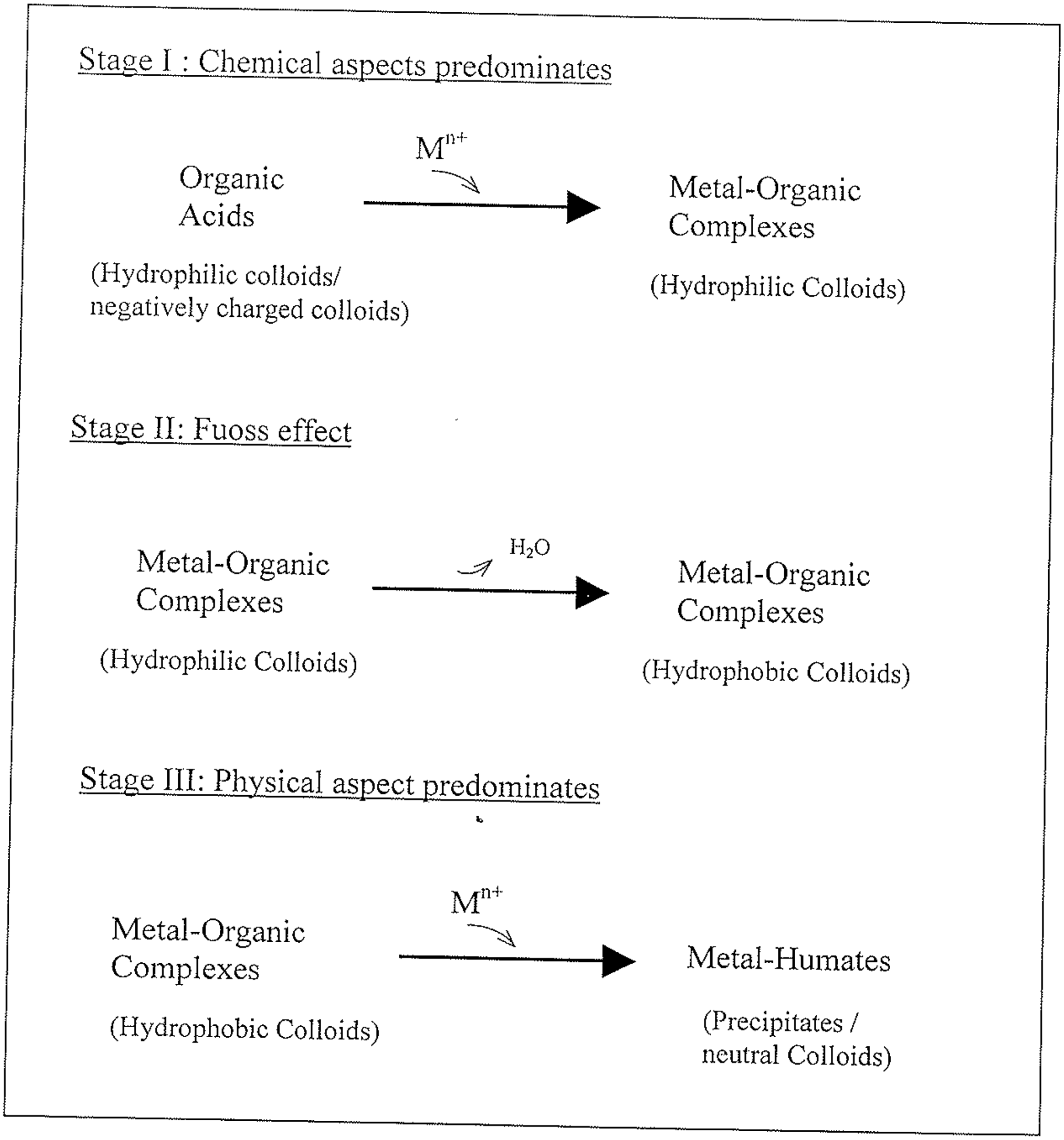


Figure 2.8. The pH values of each successive extraction of reduced peat soil. The pH values were measured in the supernatant after the soil-solution slurry were centrifuged but before filtering through a 0.45µm filter.



Box 2.1. The three stages of organic colloids to form metal-humates from Ong et al. (1970).

CHAPTER III - BIOTIC EFFECTS

Introduction

The Sacramento-San Joaquin Delta lies at the confluence of the Sacramento and San Joaquin rivers at the eastern end of San Francisco Bay, California. The Delta region originally was a large tidal marsh. Thick organic soil formed as tules, bulrushes (*Scirpus spp*.) and reeds (*Phragmites spp*.) were covered by sediments from river flows and tidal action (Atwater, 1977). These inter-tidal organic deposits began to accumulate in the Delta about 7,000 years ago (Shelmon and Begg, 1975). Almost continuous submersion in water retarded natural decomposition through oxidation and resulted in the formation of peat soil. Beginning in the late 1850s, a series of levees were constructed to form islands and the lands were drained for agricultural purposes.

Reclamation of Delta islands by the construction of levees and the de-watering of saturated soils for agricultural production has increased the exposure of these organic soils to oxygen, resulting in subsidence of the land. Microbial oxidation of the peat soils is the predominant process that contributes to the loss of land-surface elevation in the Delta (Rojstaczer and Deverel, 1993, 1995 and 1996). Research on subsidence of organic soils has identified the major factors controlling decomposition of peat material to be the level of the water table, temperature, pH, and the depth of the peat profile (Eggelsmann et. al., 1984). Although the links between microbial activity, peat decomposition, and DOC production has not been fully investigated, it is thought that the factors controlling subsidence also affect the rates of DOC production in organic soils. Andersson and Valeur (1994) performed column experiments to study the influence of dolomite lime application rates on DOC production and CO_2 evolution from soil samples. Microbial respiration and the leaching of DOC were positively correlated in two of the three lime treatments, supporting the hypothesis that increased microbial activity results in higher production levels of soluble carbon decomposition products.

Temperature and soil moisture content is the main factors determining microbial activity in the soil environment. As temperature increases, the rate of microbial oxidation of organic matter in peats increases (Tate, 1980). This effect has been observed in numerous studies on peat land subsidence and CO_2 fluxes (Glenn et. al., 1993; Eggelsmann et. al., 1984). Carbon dioxide emissions are significantly correlated with soil temperature in the Delta (Deveral and Rojstaczer, 1996). It has been demonstrated that DOC concentrations in stream waters (Visser, 1984) and soil solutions (McDowell and Wood, 1984; Moore, 1987; Grieve, 1990) are highest during the summer and autumn months and correspond to elevated seasonal temperatures. The effects of temperature on DOC production has not been systematically examined in Delta soils, but it is thought that increased microbial activity at higher temperatures will result in higher rates of DOC production.

Current agricultural practice consisting of summer irrigation and winter flooding, affect the soil moisture content in the cultivated peat soil (California Department of Water Resources, 1990). This current agricultural practice affects both the mechanism and the rate of decomposition of peat soil, and also affects the quantity as well as the quality of DOC leaching from the cultivated peat land. First, the soil moisture content could affect soil aeration and turn the soil environment anaerobic. Under aerobic conditions, microorganisms decompose soil organic matter (SOM) at a much faster rate with CO_2 and H_2O as ultimate end products (Manahan, 1994). In contrast, decomposition rates of SOM under anaerobic conditions are much slower, producing reduced compounds such as H_2S and CH_4. The degree of organic matter decomposed under differing redox conditions and microbial communities theoretically should vary. Therefore, the quantity and quality of dissolved organic matter released are affected. In addition, diverse microbial communities are promoted by irrigation and leaching practices in the Delta. The surface peat soils have already been exposed to long periods of aerobic decay and may be highly resistant to further decay (Hogg et al, 1992). However, the wet-dry cycles or aerobic-anaerobic cycles in the fields could promote a diversity of microorganisms and provide different pathways to decompose the refractory peat materials throughout the soil profile.

The purpose of this experiment is to examine the effects of temperature, soil moisture content, and wet-dry cycles on DOC production of Delta peat soils. Through a series of batch incubation experiments, we hope to define the major factors affecting DOC production.

Materials and Experimental Method:

The experimental design is shown in Figures 3.1 and 3.2, and the experimental conditions in Table 3.1. A batch incubation experiment (Horwath and Paul, 1994) was used to determine the relationships between CO_2, CH_4 and DOC production from both oxidized and reduced peat soils under various soil moisture and temperature conditions. The oxidized peat soil was sampled from the 1-2 ft depths on Twitchell Island and the reduced peat soil from the 8-10 ft depths. First, the oxidized peat soil was air-dried, sieved through a 2-mm sieve, and washed with a synthesized carbon-free solution (EC = 0.5 dS/m and SAR = 5) to remove excess DOC. This additional procedure was necessary because our preliminary study showed that the background DOC in the surface soil was so high such that the increase of DOC from a two-month incubation experiment was masked by initial values and biotic effects from the experiments were difficult to evaluate. A detailed description of this experimental procedure and the analytical results are shown in Appendix C.

In contrast, the reduced soil was not washed because the concentration of DOC was much lower and it was desirable to maintain its reduced status and minimize any changes in redox status. The reduced fibrous peat soil was not air-dried and the soil was sieved through a 9.5-mm sieve in a glove bag filled with N_2 gas. The soil moisture content was determined by drying in a 55°C oven for 48 hours to avoid excessive oxidation (Gardner, 1986). Freeze drying methods were also used to determine the soil moisture content and the results were the same. The soil moisture content (θ_g) of the oxidized peat soil was about 0.1 % and the reduced peat soil was about 5% on a mass basis. Table 2.1 in the previous chapter presented relevant soil properties. More detailed characterization of both soils are summarized in Appendix A.

Table 3.1 gives the ranges of temperature and moisture contents utilized in this incubation study. As shown in Figure 3.2, there were six replicates with three jars each for a total of eighteen 1-L wide-mouth Mason Jars set up for each temperature and moisture condition. Each jar contained 35 grams (dry weight) of oxidized peat soil or 15 grams (dry weight) reduced peat soil. Different masses of oxidized peat soil and reduced peat soil were used in the incubation experiment because of the lower bulk density of the reduced peat soil. As shown in Figure 3.1, water with EC = 0.5 dS/m and SAR = 5 was sprinkled onto the soils to obtain the desired moisture content. Then, all jars were placed in constant temperature chambers.

In order to determine the DOC production under each condition, five replicates with three jars apiece, totaling 15 Mason jars, were incubated for different periods. The Mason jars for DOC extraction were covered by a lid with a 2-mm opening for gas exchange. Three jars in the first replicate were sampled after a period of one week. Fifteen grams of soil (dry weight) were collected and water with EC = 0.5 dS/m and SAR = 5 were added to form a 1:10 (w:w) soil to water suspension and shaken at 4 °C for 4 hours. The samples were then centrifuged at 16270 RCF (Relative Centrifugal Force) for 20 min and the supernatants were filtered with a 1.2 μm glass fiber (Fisher G4) and a 0.45 μm membrane filter (Supor-450). The incubation period of the other replicates was terminated at weeks 2, 4, 6 and 8. The extracted water was analyzed for DOC, UV_{254}, pH and EC. The extracts were also characterized by XAD Fraction and used to determine the Trihalomethane Formation Potential (THMFP). The data on UV_{254}, XAD Fractionation and THMFP will be addressed in Chapter IV. The DOC was analyzed by a DOHRMANN DC-180 carbon analyzer.

In addition to the water extraction, the last replicates of three jars was used to monitor CO_2 and CH_4 evolution during the course of the 8-week incubation period. The three jars for gas measurement were sealed with a gas-tight lid but with a removable rubber septum in the middle. A rubber septum would be put in place to seal the opening for 24 and 72 hrs before each CO_2 and CH_4 sampling event, respectively. CO_2 was measured approximately twice a week and CH_4, once a week. The CH_4 was analyzed by a SRI 8610 gas chromatograph equipped with a flame ionization detector (FID) and the CO_2 was analyzed by a HORIBA PIR-2000 infra-red CO_2 analyzer.

Results and Discussion

CO_2 evolution. The effects of temperature and moisture on CO_2 evolution from the decay of organic matter have been extensively studied (e.g., Douglas and Tedrow, 1959; Kowalenko, et al., 1978; Howard and Howard, 1993). Carbon dioxide is one of the final products in the decomposition of organic matter and plant residues in soil and this degradation process is highly influenced by both temperature and moisture levels. In general, the CO_2 evolution increases with increasing temperature and moisture content in the soil because microbes are more active under these conditions. Thus, CO_2 production is highly correlated to microbial activity and served as an indicator of microbial activity in this experiment.

Many models for soil organic matter postulate there are different carbon pools in soils and each pool has a different mean residence time (MRT) or turnover time. Therefore, CO_2 evolution has been used to predict the size and the turnover rate of each carbon pool (Bunnell and Tait, 1974; Paul and Clark, 1996; Stevenson and Cole, 1999). The CO_2 accumulation curves during the decomposition of organic matter in these laboratory experiments can be divided in two sections. Each section corresponds to the degradation of its own carbon pool (Paul and Clark, 1996). The first section of the curve, which has the steepest slope and occurs in the beginning of the incubation, represents the rapidly increasing CO_2 production from the decomposition of a very labile carbon pool. The second section of the curve, which has a less steeper slope, represents the decomposition of intermediately resistant to decay carbon pool. The third carbon pool, which represent the recalcitrant carbon pool but its turnover rate may be more than 1000 yrs and thus are not able to be seen in these curves as a result of the short incubation periods (Paul and Clark, 1996).

A summation of two first-order equations is widely used in the decomposition processes of soil organic matter (Bunnell and Tait, 1974; Tate, 1987; Paul and Clark, 1996). The CO_2 curves due to variations in temperature were solved simultaneously by a spreadsheet computer program. The equations are shown in Box 3.1. In order to obtain a unique solution, several assumptions and some constraints must be set. First, the sum of the labile and intermediately resistant carbon pools account for 50% of the total organic carbon in the soil. We have seen that the extracts with EC = 0.5 dS/m and SAR = 5 solution is about 50% of organic carbon of the extracts with distilled water (Chapter 2). These incubated soils had been washed by EC = 0.5 dS/m and SAR = 5 solution to remove initial DOC (Appendix C). We assume that 50% of organic matter are physically protected and are inaccessible to organisms because of coagulation. Second, the turnover rate of the labile carbon pool in the experiment condition is assumed to be less than 100 days except for temperature at 10°C. This model will be shown to fit the 10 °C treatment under other conditions. Most simple organic substrates have a turnover rate of hours to days (Paul and Clark, 1996; Stevenson and Cole, 1999). Therefore, one hundred days should be the upper limit of the turnover rate for the labile carbon pool. Third, the temperature coefficient, $Q_{10} = k_{t+10} / k_t$, for the intermediate carbon pool is of an order between 2 and 3. van't Hoff suggested a general rule of thumb that Q_{10} for a chemical reaction is of the order of 2 or 3 (Forward, 1960). Howard and Howard (1993) showed that most Q_{10} for a wide range of soils, including peat soil, were in the range of 2.01 to 2.83. Thus, $2<Q_{10}<3$ is set as a constraint. However, the van't Hoff rule was not applied to the labile carbon pool because the microbial population might not be stable and CO_2 evolution was not at steady state at the beginning of the incubation. All the constraints are summarized in Box 3.2. The results of curve fitting are listed in Table 3.2 and discussed in the next section.

Temperature Effects on oxidized peat soils at 30% moisture content. Figures 3.3 and 3.4 show the results of CO_2 evolution and DOC production in oxidized peat soil incubated at 30% moisture content. Note that CO_2 evolution or microbial activity is highly temperature dependent (Fig. 3.3), increasing with increasing incubation temperature. The calculated curve for temperature at 10 °C does not fit too well. As shown in Figure 3.4, the effect of temperature on the concentration of DOC at 30% moisture content does not vary much. The DOC concentration dropped rapidly in the first week of incubation and then slowly decreased throughout the duration of the incubation. Nevertheless, the pattern of the DOC consumption by microbes somewhat matched the CO_2 production. Both had a high initial consumption (DOC) or production (CO_2) rate in the first week but had a much slower rate for the reminder of the incubation periods. We know that both CO_2 and DOC are the products of the microbial decomposition of organic matter or plant residues (Yvaitt, 1994; Grieve, 1990 and Stevenson, 1994). The high initial rates are possibly attributable to the decomposition of the easily accessible and readily available SOM. Due to the initial abundance of DOC, CO_2 evolution initially was rapid. After the labile DOC was rapidly consumed and became scarce, the microbes had to degrade more resistant organic matter as food source instead. The degradation process of the resistant organic matter is slower and so the rate of CO_2 evolution became smaller. Therefore, both CO_2 production and DOC consumption decreased with time.

Temperature effects on reduced peat soils in flooded condition. Figures 3.5 and 3.6 show the results of CO_2 evolution and DOC production in reduced peat soil incubated at a flooded condition. An increase in incubation temperature increased the microbial activity in this condition. The CO_2 curves also have two different sections as in Figure 3.3 because of two different carbon pools. However, there was a constantly steepening trend in for the reduced soil in contrast to the asymptotic nature for the oxidized soil. The fitted carbon mineralization rates for each individual section is given in Table 3.2.

As shown in Figure 3.6 the DOC production in reduced peat soil under flooded condition behaved differently from the oxidized peat soil at 30% moisture content. Except at temperature of 10°C, the DOC concentrations increased slightly in the first week of incubation and then slowly decreased during the course of the incubation. The difference in the trend of DOC between oxidized and reduced soils may be due either to a difference in the size of pools and reaction rates and/or to the inability of maintaining a reduced condition during incubation. Table 3.2 shows that the size of labile carbon pool between oxidized and reduced peat soils are similar (11.2 vs. 9.0 mg C/g soil) but the intermediately resistant carbon pool differs (239 and 137 vs. 391 mg C/g soil). The turnover time and reaction rate of labile carbon between oxidized and reduced soils are similar at the three temperatures. However, the turnover time and reaction rate of intermediately resistant carbon is smaller in the reduced soil and the reaction rate is larger at all three temperatures.

Another likely explanation for the differences between oxidized and reduced soils is that reduced conditions are difficult to maintain. The reduced peat soil was originally from a depth of 8-10 ft and had never been exposed to aerobic conditions. In this experiment, water is added to the soil such that the water level is barely above the soil surface for the flooded condition. During the first week, the reduced condition may be still maintained because of the slow diffusion rate of oxygen from the airspace. However, this raw peat soil has such a low bulk density that it did not settle when soaking in water. Thus, oxygen diffusion may play an important role in the two-inch water-soil layer and oxygen may have been available to microbes even in the flooded condition, especially at higher temperatures. Thus, microbes could possibly obtain oxygen and more effectively decompose organic matter and DOC to CO_2.

Moisture Effects on oxidized peat soils at 20 °C. Figures 3.7 and 3.8 show the results of CO_2 evolution and DOC production from oxidized peat soil incubated at 20°C. Table 3.2 summarizes the calculated reaction rates. The change in the water content in the soil significantly affects the microbial activity. In Figure 3.7, CO_2 production in oxidized peat under $\theta_g = 0.3$ is low and the rates are similar at $\theta_g = 0.7$ and 2.0, producing respectively total CO_2 of 43 and 49 mg C/g soil. However, Figure 3.8 shows that the DOC produced differed between $\theta_g = 0.7$ and 2.0. The former was nearly identical to $\theta_g = 0.3$. The DOC concentration at $\theta_g = 0.3$ and 0.7 decreased rapidly in the first week of incubation and then gradually decreased, but significant DOC production at $\theta_g = 2.0$ occurred in the first week. More than three times the carbon was mineralized in flooded and wet conditions than in the dry incubation environment. Indeed, the carbon mineralization rates are higher in wet and flooded conditions. As shown in Table 3.2, the rates for the intermediately resistant carbon pools in high moisture content incubation are twice faster than the rate in dry condition.

Figure 3.9 presents rates of CH_4 production in flooded oxidized peat soil. After an initial slow rate, CH_4 was produced at increasing rate and then appeared to reach an asymptote. No CH_4 was produced at $\theta_g = 0.3$ and 0.7 because methanogenic conditions were not achieved.

Wet-dry Cycle Effect on Oxidized and Reduced Peat Soils. Figures 3.10 and 3.11 give the effects of wet-dry cycles on oxidized and reduced peat soils at 20 °C. The results show that CO_2 production differed between these two soils. In Figure 3.10 the accumulated CO_2 curve of the wet-dry cycle for the oxidized peat fell in between the flooded and dry soils' CO_2 curves. The shape of the curve displays a tiered trend with each tier corresponding to each successive wet-dry cycle. We note that the CO_2 evolution rapidly increased at the beginning. Then, C mineralization decreased with water content and gradually leveled off. Re-wetting rapidly increased CO_2 evolution again. The maximum quantity of C mineralized progressively decreased with each wet-dry cycle and the trend displayed a decreasing step-height pattern. In other words, the height of each tier is lower than the previous tier. This tier trend shape proves that the water content is an important factor on the soil respiration. The decrease in the height of tier implies that the decreased available labile organic matter slowed the degradation process because the microorganisms had to consume more resistant organic matter.

Moreover, Figure 3.12 show that the DOC production in the oxidized peat soil was higher in wet-dry cycle condition than the flooded condition although the CO_2 evolution was lower in the wet-dry cycle incubation. These wet-dry cycles possibly cause changes in the microbial community and therefore decrease the soil respiration. However, various microbial communities may have different utilization rates of the different carbon pools. As a result, degradation of organic matter becomes more effective in breaking down larger molecules even if the microbial activity is lower.

Furthermore, the SAR values of the soil in the drying process may change because of the ratio law (Schofield, 1947). The fraction of the divalent cations increases as the soil water content decreases. The additional divalent cations may precipitate out the organic matter and protect them from degradation. Thus, the DOC is higher in the water extracts.

In contrast, Figures 3.11 and 3.12 respectively show that the production of CO_2 and DOC in the reduced peat soil display different behavior. The wet-dry cycles increased soil respiration, but the DOC in the water extracts was somewhat similar to the flooding condition. In addition, there is no obvious tier trend in the reduced peat soil curve associated with the wet-dry cycles. Such behavior may be possibly attributed to the abundance of labile organic matter in the reduced peat soil. The organic matter of the reduced peat soil existed in an anaerobic condition for many thousands of years. There is abundant labile organic matter, which could not be degraded because of the reduced condition. The wet-dry cycle rapidly changed the soil from an anaerobic environment to an aerobic environment. The drying process allowed the penetration of air and oxygen into the soil matrix such that the microbial activity increased. Furthermore, there is no significant change in DOC concentration between the two treatments even though the CO_2 evolutions are different. The constant DOC concentration is possibly attributed to the abundance of the labile carbon pool and therefore the DOC pool did not change significantly.

Conclusion

Three environmental factors production (temperature, moisture content and wet-dry cycles) affecting DOC were examined for both oxidized and reduced peat soils from the Sacramento - San Joaquin Delta. Temperature does increase soil respiration but is not the major factor in DOC production in the Delta. Flooding condition and alternate wet-dry cycles do not increase the DOC in reduced peat soil. Only the flooded conditions and wet-dry cycles in oxidized peat soil show an increase of DOC in the water extracts. Thus, the oxidized peat soil is possibly the main source of DOC in the Delta. Finally, the data for CO_2 and DOC is carefully examined but no clear relationship is exhibited.

Table 3.1. Incubation conditions for the biotic effects. Ox represents oxidized peat soil and Red represents reduced peat soil.

		Temperature		
		10°C	20°C	30°C
Moisture Content (Mass Basis)	30%	Ox	Ox	Ox
	70%		Ox	
	Flood	Red/Ox	Red/Ox	Red/Ox
	Wet-Dry Cycle		Red/Ox	

Table 3.2. Reaction rate of carbon mineralization and the size of the carbon pools.

Soil	Temperature (°C)	Moisture Content θ_g	Turnover time		Reaction rate (mg C g soil $^{-1}$ day^{-1})		Size of Carbon Pool (mg C g soil^{-1})		R^2
			Labile Carbon	Intermediately Resistant Carbon	Labile Carbon	Intermediately Resistant Carbon	Labile Carbon	Intermediately Resistant Carbon	
Oxidized Peat Soil	10	0.3	71 days	25.4 yr	0.014	1.08e-4	11.12	238.88	0.970
	20	0.3	2.6 days	8.5 yr	0.391	3.24e-4	11.07	136.56	0.970
	30	0.3	2.2 days	2.8 yr	0.462	9.72e-4	11.07	136.56	0.970
Reduced Peat Soil	10	10 (flooding)	91 days	6.8 yr	0.011	4.05e-4	9.01	390.99	0.990
	20	10 (flooding)	3.6 days	2.9 yr	0.280	9.34e-4	9.01	390.99	0.990
	30	10 (flooding)	1.2 days	1.3 yr	0.867	2.09e-3	9.01	390.99	0.990
Oxidized Peat Soil	20	0.3	2.6 days	8.5 yr	0.391	3.24e-4	11.07	136.56	0.970
	20	0.7	1.9 days	7.2 yr	0.522	1.38e-3	26.88	223.12	0.997
	20	2 (flooding)	2.6 days	4.4 yr	0.390	2.27e-3	22.70	227.30	0.986

Box 3.1. A summation of two first order equations is used to fit the carbon mineralization data.

$$C_T(t) = C_i(1-e^{-k_i^T t}) + C_j(1-e^{-k_j^T t})$$

$C_T(t)$: Accumulated CO2 for temperature T at time t

C_i : Mass of soil organic carbon in the labile carbon pool i.

Cj : Mass of soil organic carbon in the intermediately resistant carbon pool j

k_i^T, k_j^T : Reaction rate of carbon pools i and j at temperature T.

t : Incubation time.

Box 3.2. A series of first-order equations are simultaneously solved and fitted to the carbon mineralization data for temperature effects on oxidized peat soil.

$$C_{10}(t) = C_1(1-e^{-k_1^{10}t}) + C_2(1-e^{-k_2^{10}t}) \qquad [eqn\ 1]$$

$$C_{20}(t) = C_1(1-e^{-k_1^{20}t}) + C_2(1-e^{-k_2^{20}t}) \qquad [eqn\ 2]$$

$$C_{30}(t) = C_1(1-e^{-k_1^{30}t}) + C_2(1-e^{-k_2^{30}t}) \qquad [eqn\ 3]$$

$C_1+C_2 = 250$ mg C/g soil [Constraint 1]

$k_1^T < 0.01$ day^{-1} [Constraint 2]

$2 < k_2^{T+10} / k_2^T < 3$ [Constraint 3]

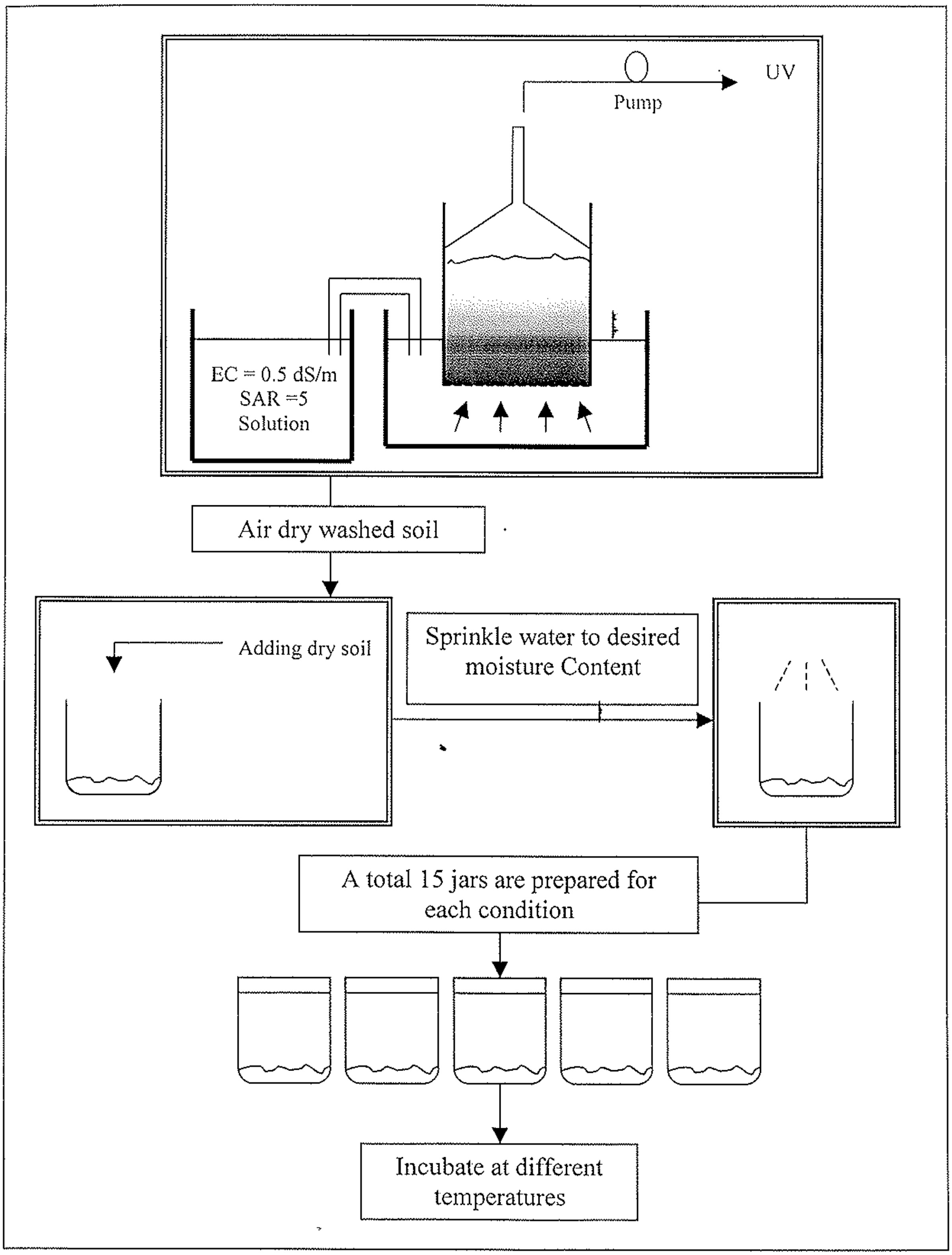


Figure 3.1. The experimental scheme for the incubation of oxidized peat soil

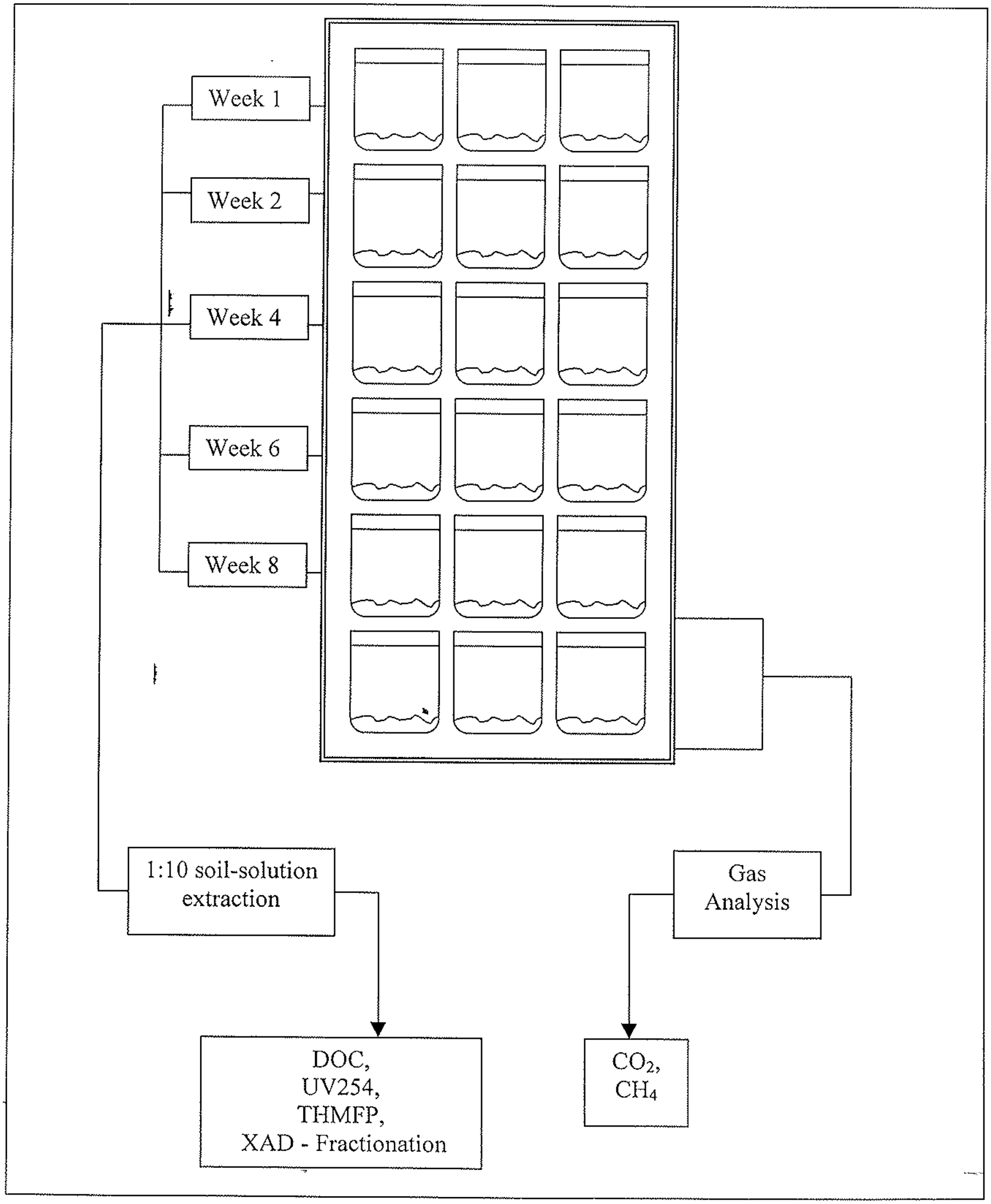


Figure 3.2. Setup for the incubation experiment

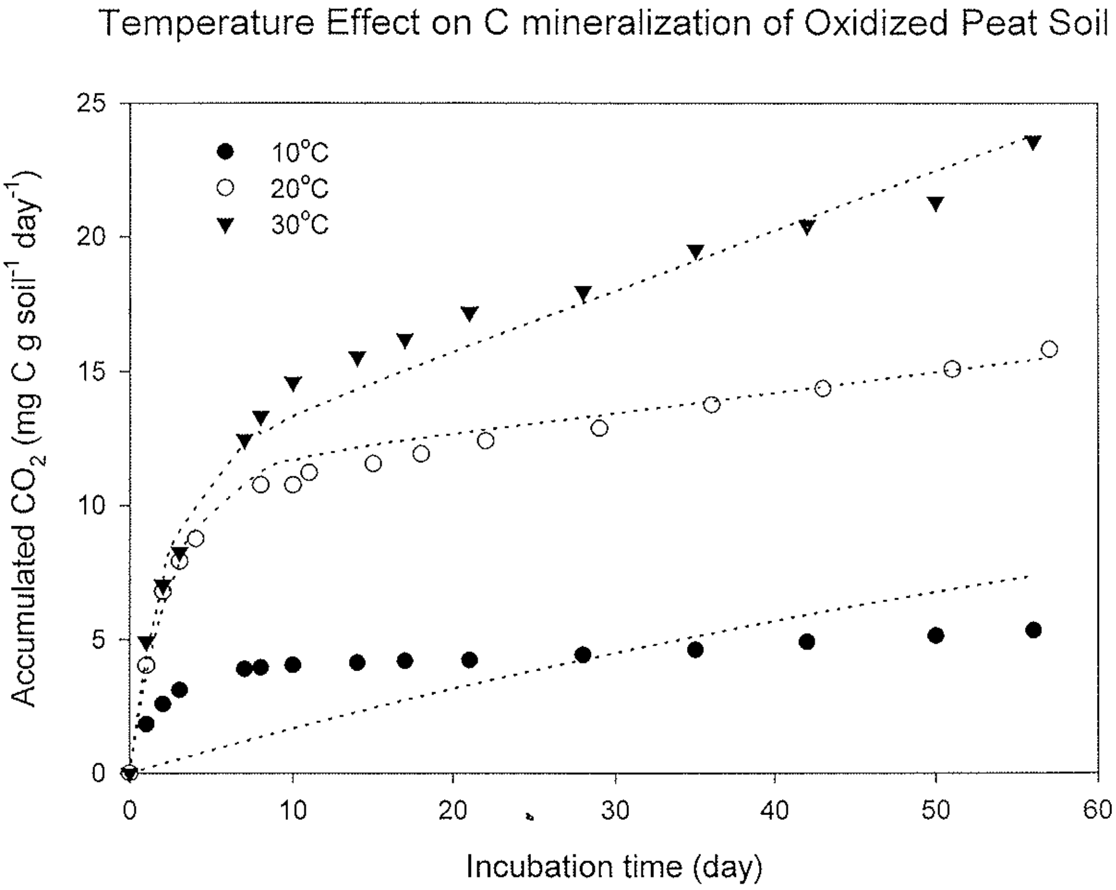


Figure 3.3. Temperature effects with 30% moisture content on CO_2 evolution of oxidized peat soils. The dotted lines are the best fitting line of the data points of a set of first order equations: $C_T(t) = A\ (1\text{-}e^{-kt}) + B\ (1\text{-}e^{-k't})$.

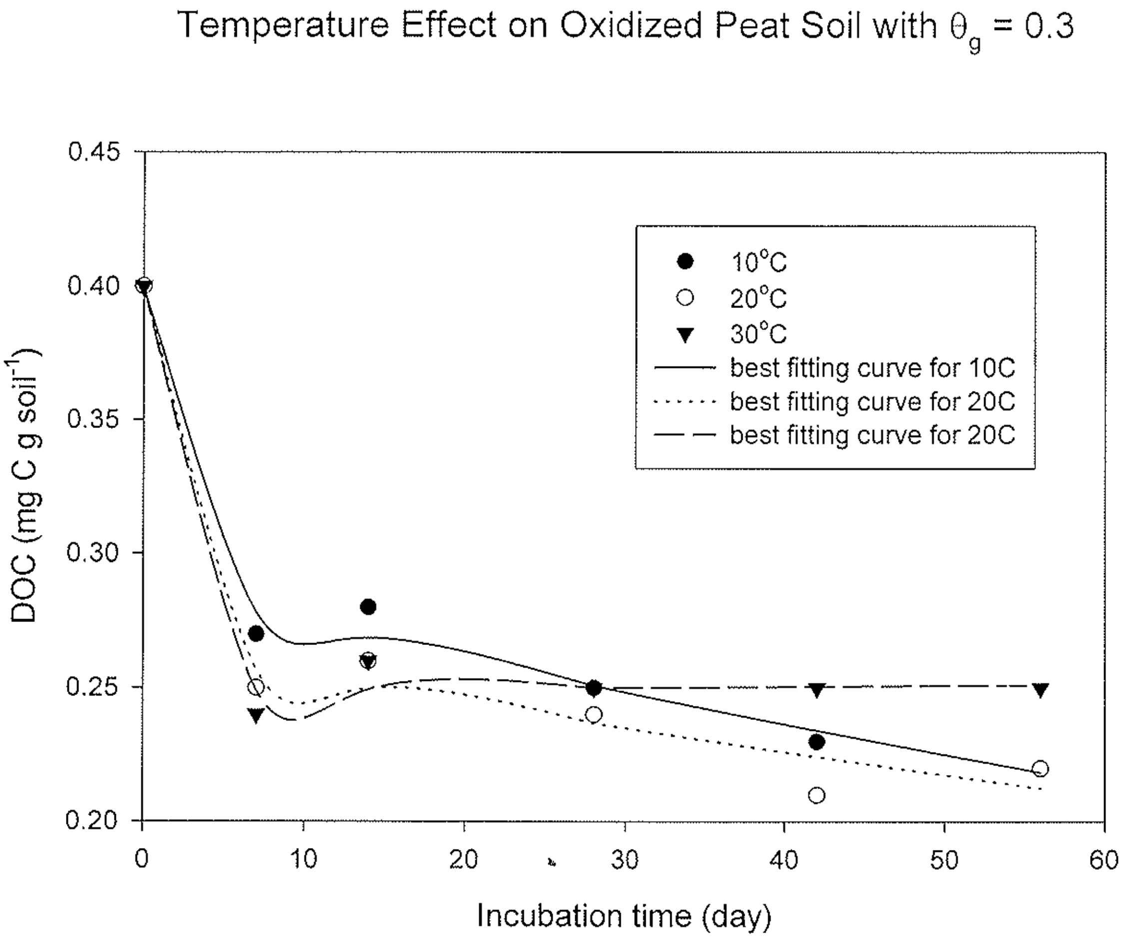


Figure 3.4. Temperature Effects with 30% moisture content on DOC concentration of oxidized peat soils.

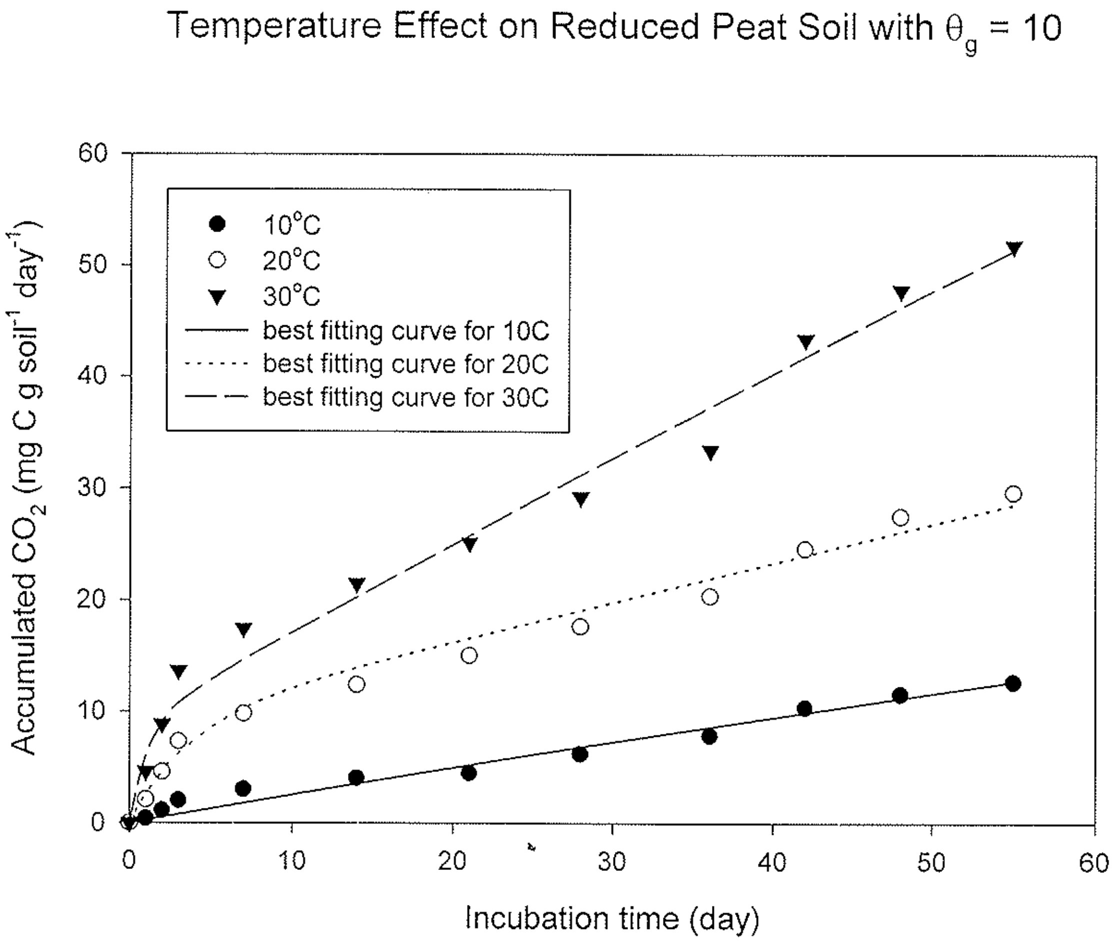


Figure 3.5. Temperature effects on carbon mineralization of reduced peat soil in flooded condition.

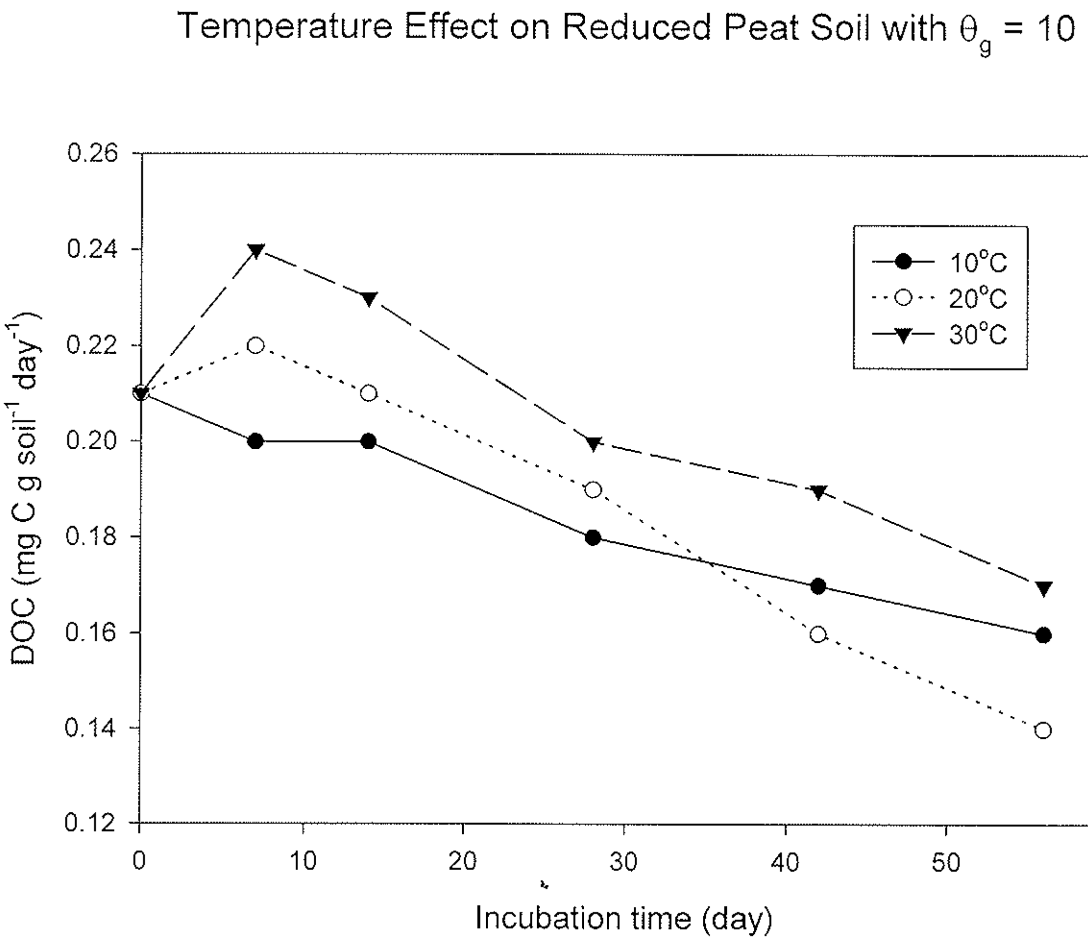


Figure 3.6. Temperature effects on DOC concentrations of reduced peat soils in flooded condition.

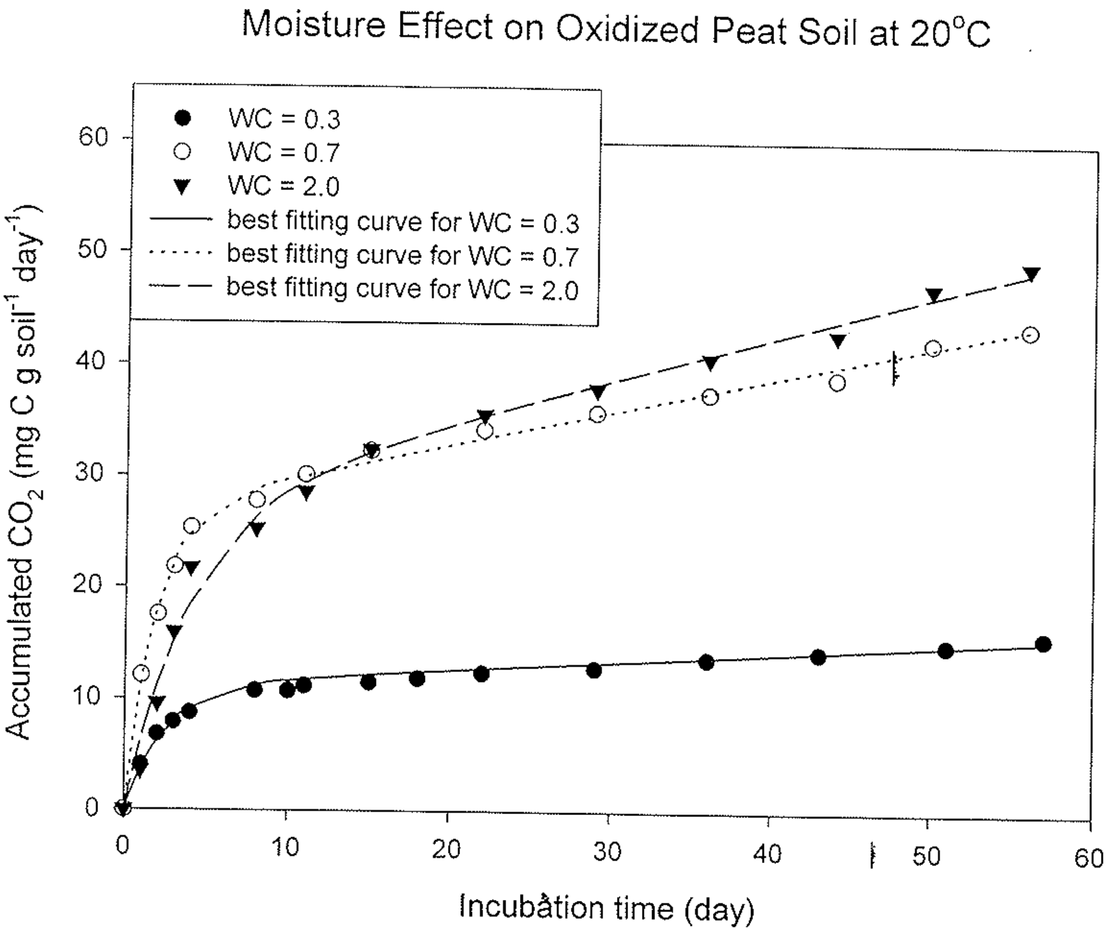


Figure 3.7. Moisture effect on carbon mineralization of oxidized peat soil at 20°C.

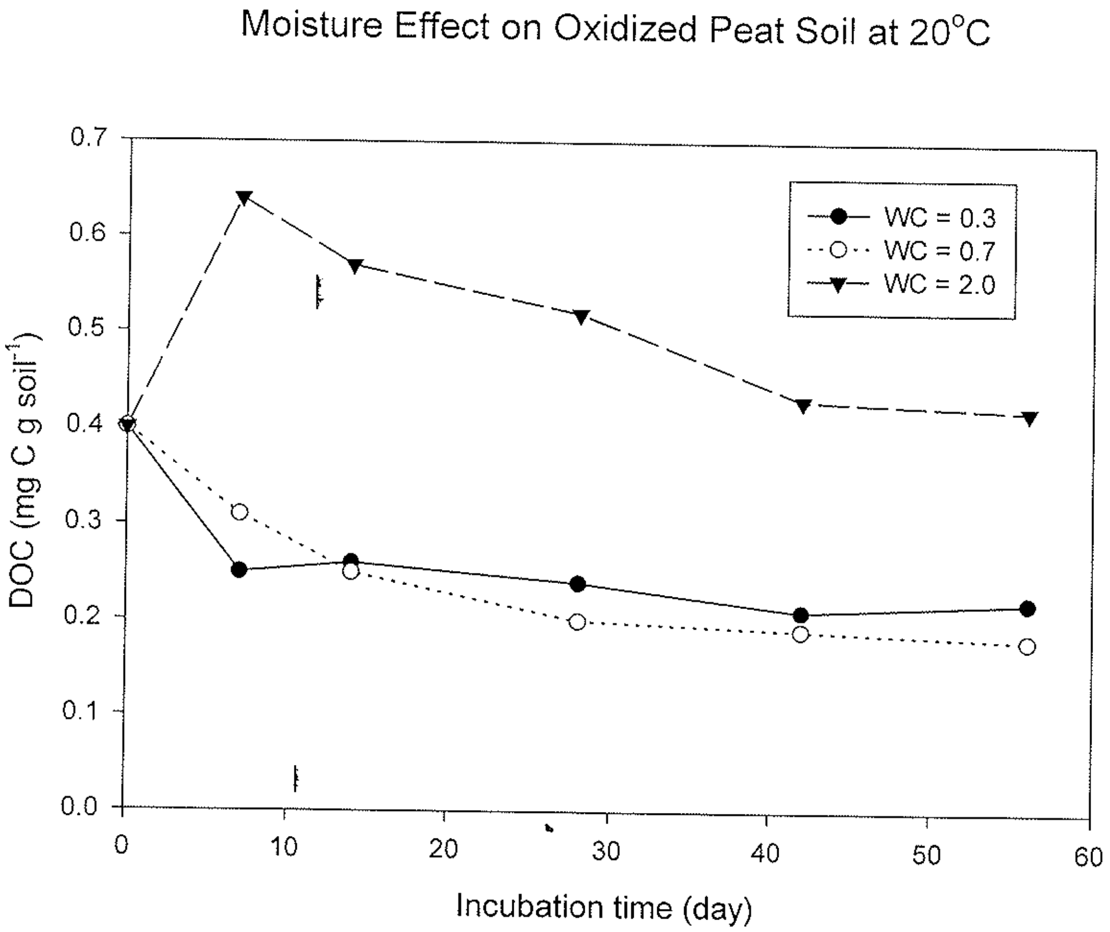


Figure 3.8. Moisture effect on DOC production of oxidized peat soil. The lines connected each data point are not fitting curves.

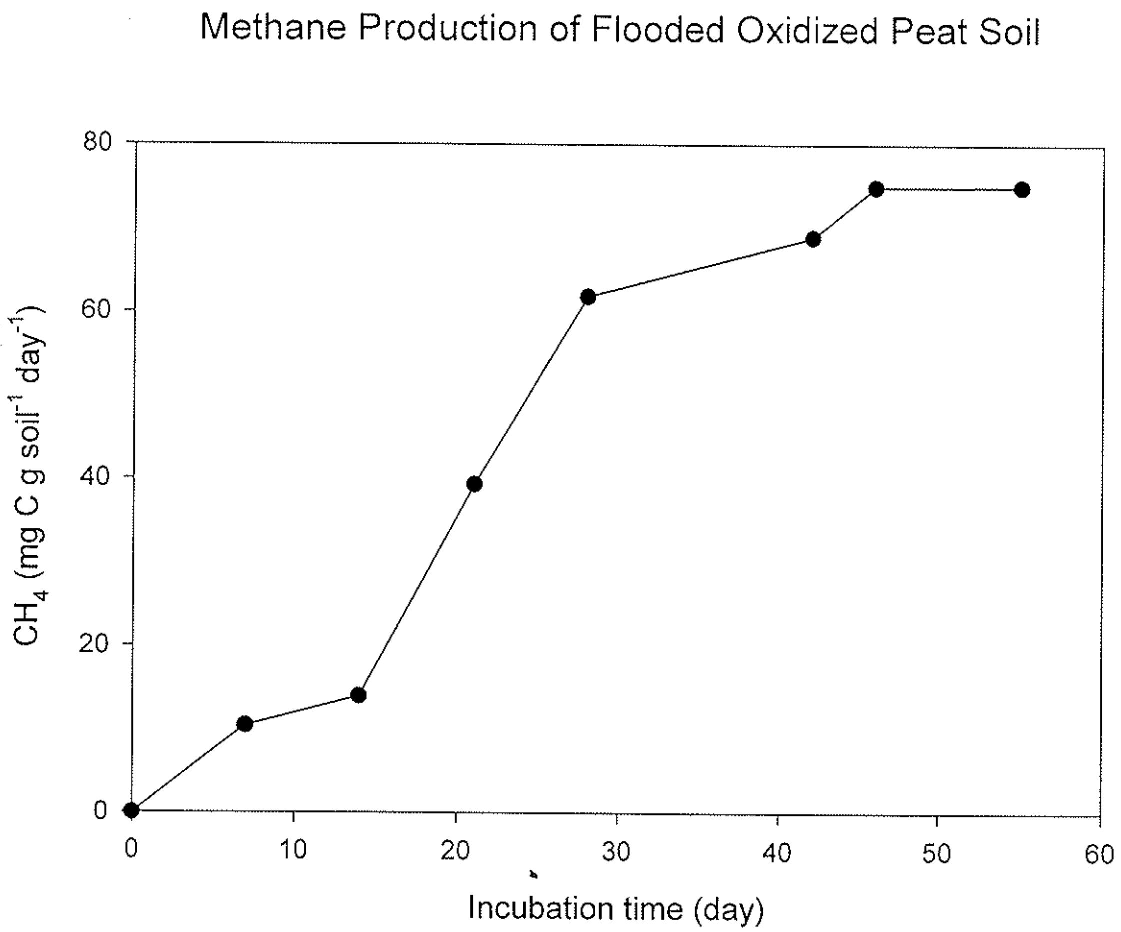


Figure 3.9. Methane production of flooded surface soil.

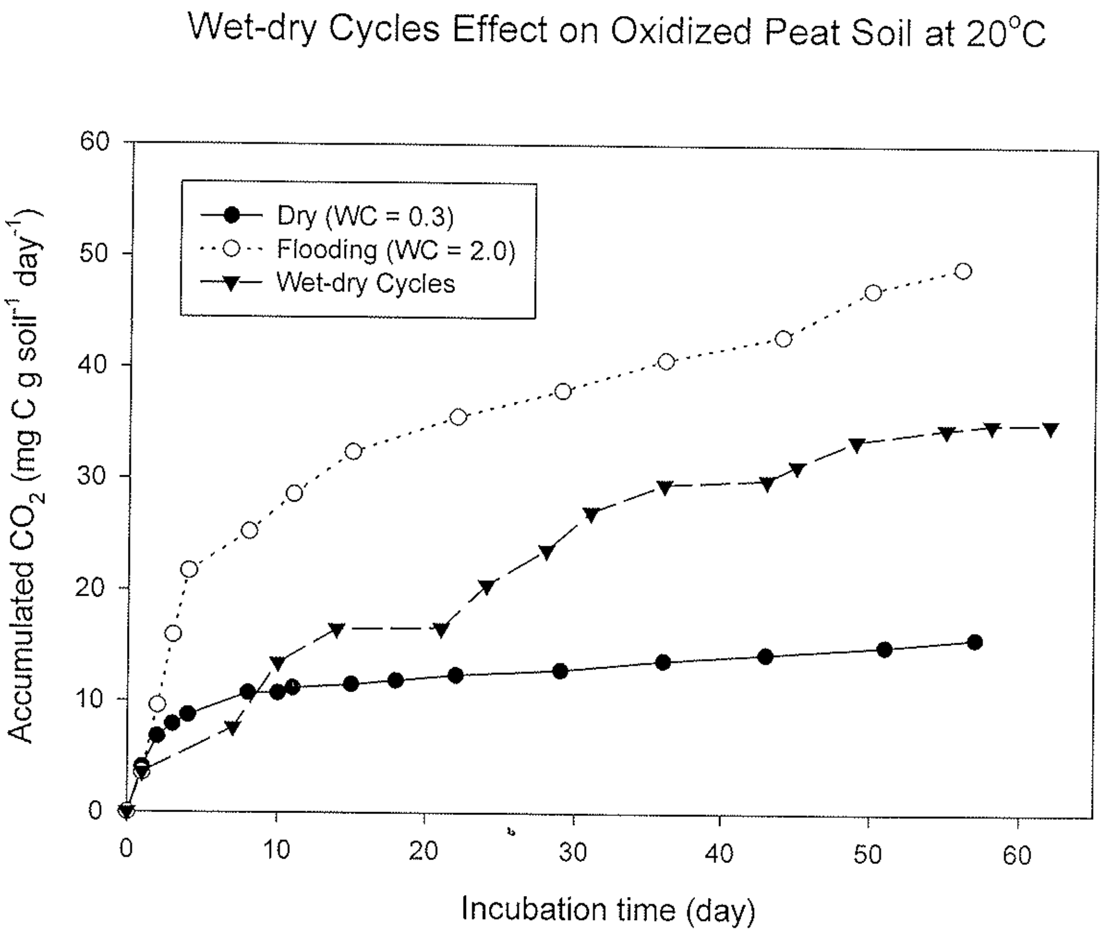


Figure 3.10. Wet-dry cycle effect on soil respiration of oxidized peat soil. The lines connected each data point are not fitting curves.

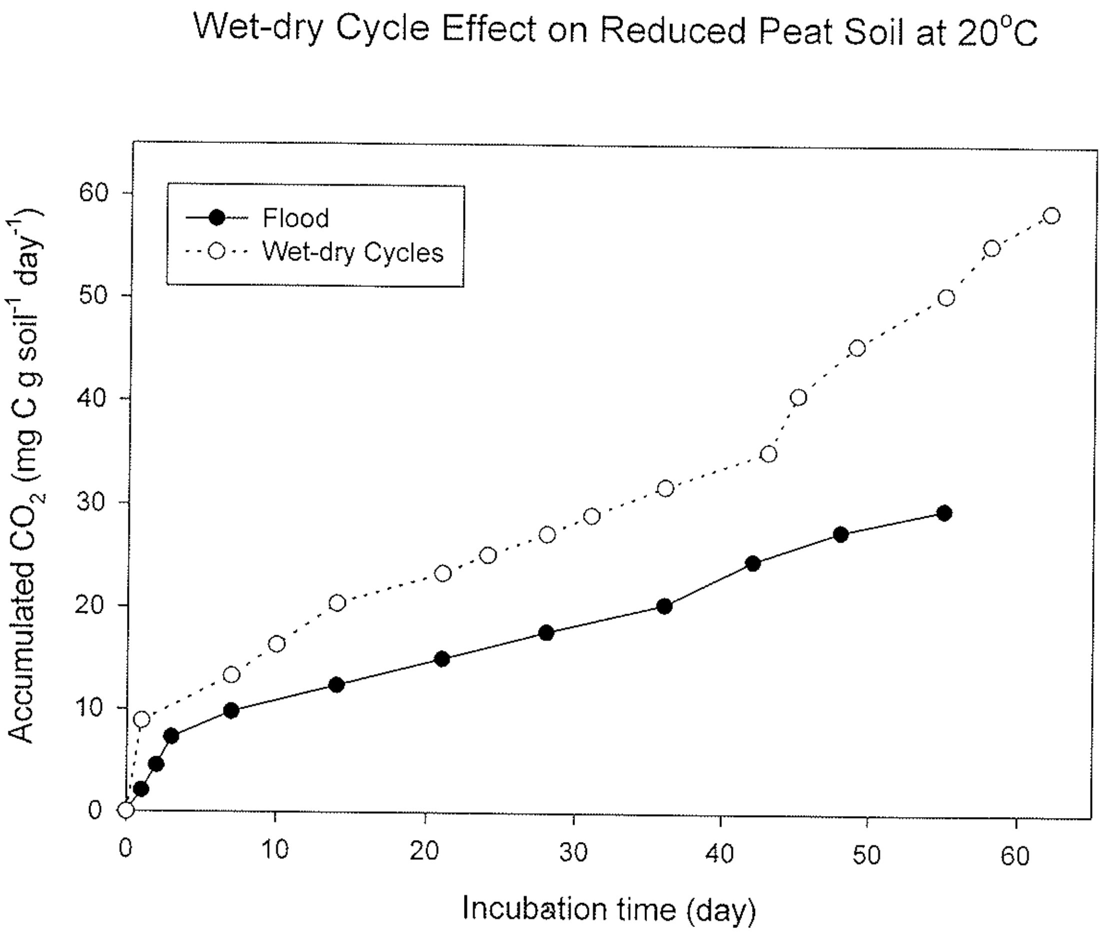


Figure 3.11. Wet-dry cycle effect on soil respiration of reduced peat soil. The lines connected data points are not fitting curves.

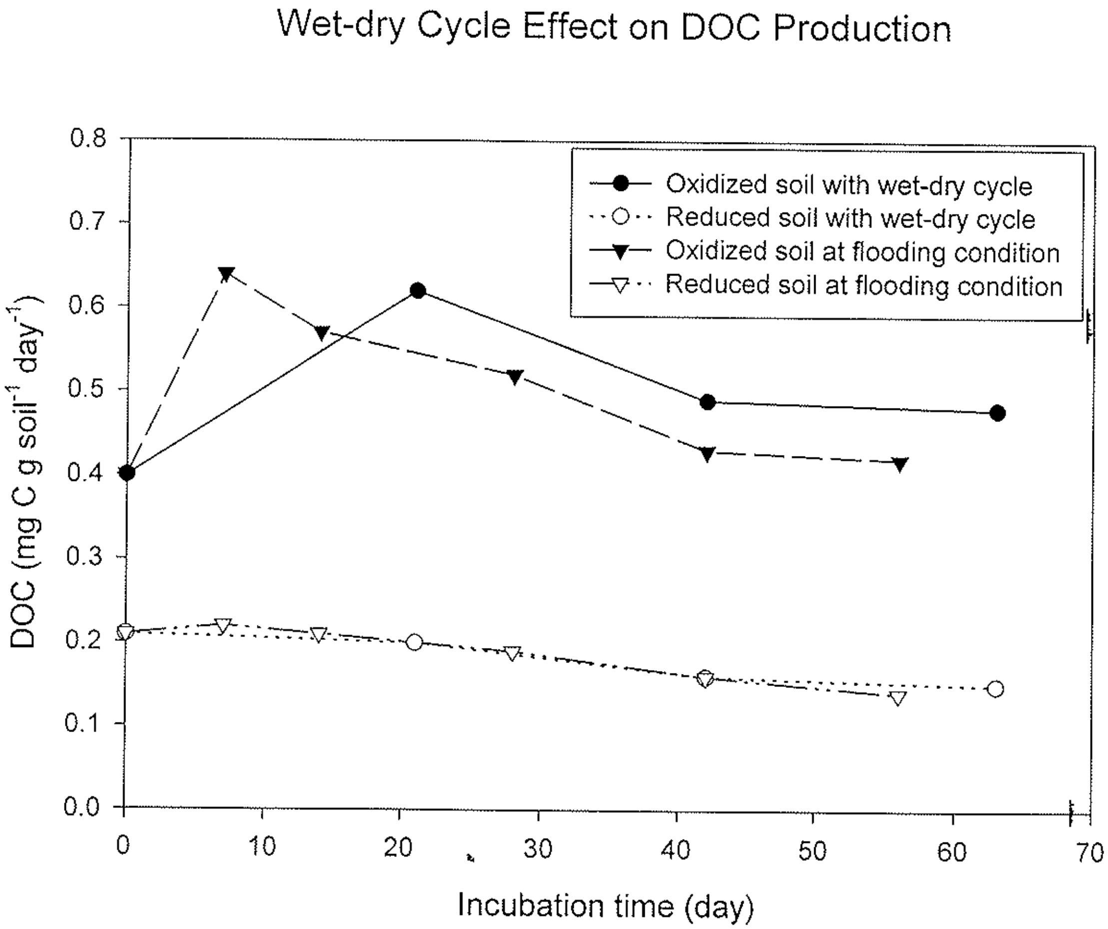


Figure 3.12. Wet-dry cycle effect on DOC production of both oxidized and reduced peat soils. The lines connected data points are not the best fitting curves.

Chapter IV - Characterization of Dissolved Organic Carbon from Peat Soils on Twitchell Island

Introduction

In finished drinking waters, there are four common trihalomethanes (THMs): trichloromethane ($CHCl_3$), dichlorobromomethane ($CHCl_2Br$), chlorodibromomethane ($CHClBr_2$) and tribromomethane ($CHBr_3$). Rook (1976) has shown that THMs are formed from the reaction of chlorine with humic substances in natural waters. Several studies have shown a linear relationship of the trihalomethane formation potential (THMFP) to the concentrations of DOC in the waters (Amy et al., 1990). Unfortunately, the slopes of each regression lines are different and these regression lines are site specific. Indeed, the yield of THMs has been shown to depend on chlorine/humic acid ratio and humic molecular weight (Rook, 1976; Oliver, 1980; Oliver and Visser, 1980). The sources and the quality of DOC can significantly affect the THMFP because the chemical and functional groups compositions of aquatic humics vary widely with source (Weber and Wilson, 1975; Oliver and Visser, 1980).

UV absorbance at 254 nm (UV_{254}) has been widely used in the water industry as a surrogate parameter to estimate the concentrations of organic carbon and THM precursors (Dobbs et al., 1972; Edzwald et al., 1985); however, the choice of wavelength is arbitrary (Eaton et al., 1992). Adsorption in the UV (200-400nm) and visible (400-800nm) is caused by atomic and electrometric vibrations, and involves elevation of electrons in σ-, π-, η-orbitals from the ground state to higher energy levels. Many scientists are of the opinion that the dark color of humic substances is due to primarily to quinone-like structures and ketonic in conjugation (Stevenson, 1996). The UV_{254} obeyed the Beer's laws and is proportional to the concentration of DOC. In addition, Oliver and Thurman (1983) postulated that the color centers in the molecular, probably both phenol groups and conjugated double bonds, were the loci for chlorine attack and subsequent trihalomethane production. Malcolm and others (1981) found that halogenated humic substances show a significant loss in color after chlorination. Furthermore, SUV_{254} is calculated by dividing UV_{254} values by the DOC concentration. This normalizes the UV_{254} data to carbon and represents the amount of aromaticity per milligram of DOC in a sample. U.S.G.S. (Fujii et al., 1998) has used the SUV_{254} in their research and they showed that the DOC from the lower soil zone had significantly higher aromacticity than the upper soil zone as measured by SUV_{254}. In addition, empirical relationships of UV_{254}, DOC and THMFP have been established for the water in the Sacramento - San Joaquin Delta (Amy et al., 1990; Hutton et al., 1992; Hutton et al., 1994; Department of Water Resources, 1994).

DOC is classified into six fractions: hydrophobic acids, bases and neutrals; and hydrophilic acids, bases and neutrals (Leenheer, 1981). XAD-8 and XAD-4 resins, which are non-ionic macroporous copolymers, have been widely used to recover and isolate these fractions from natural waters (Malcolm et al., 1978; Leenheer, 1981; Fujii et al., 1998). Sorption characteristics of XAD-8 and XAD-4 resins are dependent primarily on chemical composition, resin surface area, and resin pore size (Aiken et al., 1992). XAD-8, which is an acrylic ester, can remove hydrophobic organic acids from the water. XAD-4, which is styrene divinylbenzene, has a greater capacity for low molecular weight solutes and removes hydrophilic organic acid. The detailed description of the physical and chemical properties of these resins is given in Aiken and others (1992).

The hydrophobic and hydrophilic fractions in natural water are operationally defined. Aiken et al. (1992) defined hydrophobic acid (HPOA) "as the portion of the DOC that sorbs on a column of XAD-8 resin at pH 2 under conditions where k' is 50 for the column, and is eluted at pH 13. The capacity factor, k', is the grams of solute on resin per gram of solute in column void volume. This fraction can contain aliphatic carboxylic acids of five to nine carbons, one- and two-ring aromatic carboxylic acids, one- and two-ring phenols, and aquatic humic substances." Aiken et al. (1992) also defined hydrophilic acid (HPIA) "as that portion of the DOC contained in the XAD-8 resin effluent at pH 2 that sorbs on a column of XAD-4 resin under conditions where k' is 50 for the column, and is eluated at pH 13. This fraction can contain polyfunctional organic acids and aliphatic acids with five or fewer C atoms."

XAD-fractionation has been applied in water research and studies show that each fraction has a different formation potential to THM (Babcock and Singer, 1979; Oliver and Visser, 1980; Fujii, et al., 1998). Isolation of the HPOA (XAD-8) and HPIA (XAD-4) fractions accounted for 58 to 76 percent of the total DOC of the soil water samples from the Sacramento - San Joaqin Delta. DOC isolated in the HPOA fraction was more aromatic than that isolated in the HPIA fraction (Fujii et al., 1998). In addition, the redox status of soil can change the fractionation. Fujii et al. (1998) also showed that water samples from the zone at 4.5 to 6.5 ft (reduced layer) had greater HPOA fractions compared to those from the zone at 0.5 to 1.5 ft (oxidized layer).

UV_{254}, XAD fractionation and THMFP have been widely used to characterize the DOC from the natural waters. In order to understand the influences of the abiotic and biotic processes in the Delta on the DOC quality and the availability of THM precursors, the extracted DOC from the successive extraction experiments (Chapter II) and batch incubation experiments (Chapter III) were analyzed for these parameters. In addition, we would like to identify the major process of THM precursor production and to assess the potential formation of THM and chemical character of the hydrophobic humic acid, hydrophobic fulvic acid and hydrophilic acid fractions of the DOC produced at various soil conditions.

Materials and Experimental Methods

In order to examine both abiotic and biotic effects on the quality of DOC and THM precursors, abiotic leaching experiment and biotic incubation experiment were conducted, as described in Chapters 2 and 3. Besides the total organic carbon determinations, selected DOC samples extracted from the temperature, moisture, redox, SAR and EC experiments were then further analyzed by SUV_{254}, hydrophobic and hydrophilic fractionation and THMFP. The initial properties of the oxidized and reduced soils are given in Appendix A.

SUV_{254}. The UV absorption at 254 nm of each sample was measured by a Hewlett-Packard Model 8452 diode array UV/VIS spectrophotometer and is reported as ultraviolet absorbance at 254 mm or UV_{254}. The pH of the solution was adjusted to the range between 4 and 10 by either concentrated HCl or NaOH when necessary because UV absorption of organic matter may vary at pH values below 4 or above 10 (Eaton et al., 1992). Also, a dilution was made in order to have the UV absorption at 254 nm below 0.900 cm^{-1} (Eaton et al., 1992). The concentration of DOC was determined by UV-promoted persulfate oxidation and a DOHRMANN DC-180 carbon analyzer was used. Then the parameter SUV_{254} was obtained by taking the ratio of UV absorption at 254 nm in cm^{-1} to DOC in ppm carbon.

XAD-8 and XAD-4 fractionation. Selected samples were fractionated using XAD-8 and XAD-4 resins. Amberlite XAD-resins are nonionic macroporous copolymers with large surface areas that have been used by many investigators to sorb organic acids such as humic substances (Malcolm et al., 1978; Leenheer, 1981; Aiken et al., 1985). A method, which divides the DOC into operationally defined organic acid fractions extracted by XAD-8 and XAD- resins, is used in this study, as shown in Figure 4.1 (Aiken et al, 1992). The five fractions are hydrophobic acid (HPOA), hydrophilic acid (HPIA), hydrophobic neutrals (HPON), hydrophilic neutrals (HPIN) and low molecular weight hydrophilic acid (LMW HPIA).

The fractionation procedure has been used to study Delta soil-water by the water division of U.S.G.S. at Sacramento (Fujii et al., 1998). One liter water sample with not more than 20mg/L carbon was acidified to pH 1.9 to 2.0 and then was run through both XAD- 8 and XAD- 4 columns. An aliquot sample, 25 mL, was removed from the 1-L sample before being run on the XAD-8 column to measure the DOC concentration of the sample. The sample volume was brought back up to 1L with deionized water before being run on the XAD- 8 column. This procedure was done so that a constant volume was being run through the columns. After the sample was run through the XAD-8 column, an aliquot of the XAD-8 effluent, 25 mL, was removed so that the DOC concentration of the XAD-8 effluent could be measured. The volume of the effluent was brought back up to 1 L with deionized water before being run on the XAD-4 column. The samples were run through both columns at a rate of 4mL/min. After all the samples were run though the columns, each column was separately back eluated with 100mL of 0.1N NaOH at a rate of 2 mL/min. The eluates were collected in volumetric flasks and acidified to pH 2 with 12.1N HCl. The DOC concentration of both eluates and the XAD-4 effluent also was measured. Then, the hydrophobic and hydrophilic fraction can be calculated.

First, the total mass of C placed on the columns was calculated by multiplying the DOC concentration of the sample by the sample volume (1 L) minus the volume taken for DOC analysis. Second, the mass of the HPOA fraction was calculated by multiplying the DOC concentration of the XAD-8 eluate by its volume (0.100 L) and the mass of the HPIA fraction was calculated by multiplying the DOC concentration of the XAD-4 eluate by its volume (0.100 L). Third, the mass of the HPON fraction is calculated by subtracting the sum of the mass of C in the XAD-8 effluent and XAD-8 eluate from the mass of C put on the XAD-8 column. The mass of the HPIN fraction was calculated by subtracting the sum of the mass of C in the XAD-4 effluent and XAD-4 eluate from the mass of C put on the XAD-4 column. The mass of C put on the XAD-4 column was the product of the concentration of the XAD-8 effluent and the volume of the XAD-8 effluent collected minus the amount taken for DOC analysis. Fourth, the mass of the low molecular weight HPIA fraction was the mass of C in the XAD-4 effluent. Finally, the fractionation of the samples onto the XAD-8 and XAD-4 resins allows for a calculation of the mass of each operationally defined fraction, expressed as the percent of the original total DOC mass for a particular sample. The percent of the total mass that each fraction represents was calculated by summing the masses of each fraction for a sample and dividing the mass of each fraction by the total mass and then multiplying by 100.

THMFP. A test of Trihalomethane Formation Potential (THMFP) was carried out to estimate the potential of waters to form THM under defined conditions of chlorination and incubation. The method used in the experiment is a modified version of the procedures described in EPA Method 510.1 and EPA Method 502.2. The method is the current Standard Operation Procedure (SOP) in the water division of U.S.G.S. at Sacramento.

Extract samples are placed in three 40 mL headspace-free bottles with no more than 5 mg/L TOC. The chlorine dosing solution containing 1M H_3BO_3 and 0.11M NaOH buffer and approximately 6700 mg/L free chlorine is injected into the sample. The volume of dosing solution is calculated and it depends on the concentration of TOC and ammonia in the sample. The samples are protected from light exposure and incubated at 25 °C for 7 days. Following the incubation, pH and residual chlorine are measured on one of the aliquot bottles. The pH of incubated samples should be about 8.3 and the residual free chlorine content should be 1-5mg/L. The residual chlorine in the other two bottles is quenched with sodium thiosulfate ($Na_2S_2O_3$). A quenched sample will be analyzed for the four individual THMs ($CHCl_3$, $CHCl_2Br$, $CHBr_2Cl$ and $CHBr_3$) on a gas chromatograph equipped with an electrolytic conductivity detector. This analysis was accomplished at the U.S.G.S. Laboratory in Sacramento.

Results and Discussions

Oxidized vs. Reduced Peat Soils. Extracted DOC from oxidized and reduced peat soils are fractionated by XAD-8 and XAD-4 into 5 fractions: hydrophobic acid (HPOA), hydrophilic acid (HPIA), hydrophobic neutrals (HPON), hydrophilic neutrals (HPIN) and low molecular weight hydrophilic acid (LMW HPIA), as shown in Figure 4.2. The XAD-8 and XAD-4 resins absorbed and removed about 60% of total organic carbon from both oxidized and reduced peat soils. The HPOA, which is the major fraction in both oxidized and reduced soils, accounted for 45% and 38% and the HPIA accounted for 15% and 20% of total organic carbon in the samples, respectively. However, about 21% and 32% of the DOC in the form of LMW HPIA passed through both columns and were not absorbed.

In addition, the Specific Trihalomethane Formation Potential (STHMFP) of each fraction from oxidized peat soils is higher than reduced peat soil, as shown in Figure 4.3. STHMFP is calculated by the THMFP divided by the initial concentration of DOC in the samples. Among the fractions, the HPOA in oxidized soil has the highest STHMFP.

Salinity Effect. The effects of salinity on the aromaticity of DOC in terms of SUV_{254} are shown in Figures 4.4 to 4.5. We note that the SUV_{254} increased with number of extractions in both oxidized and reduced peat soils. The hydrophilic fraction of soil organic matters has higher water affinity. Therefore, the initial extractions contained higher fraction of small organic fragments and less aromatic compounds, which are hydrophilic, so the SUV_{254} are lower. In the later extractions, the fractions of hydrophobic compounds, which usually are aromatic, become dominant because most of the hydrophilic fractions were removed by the prior extraction. Therefore, the SUV_{254} increased with number of extractions. In addition, the solubility of hydrophobic or aromatic compounds in saline water is low. We can see that the highest salinity solutions (EC = 4dS/m) in the experiments had the lowest SUV_{254} than other solutions in both oxidized and reduced peat soils. Selected samples were analyzed for the THMFP. The results are summarized in Table 4.1. The DOC extracted by distilled water had higher STHMFP then solutions with EC =0.5 dS/m.

SAR Effect. Sodicity or SAR also affects the quality of DOC leaching from both oxidized and reduced peat soils, as shown in Figures 4.6 and 4.7. The SUV_{254} increased with number of extractions in both oxidized and reduced peat soils. In addition, the SAR affected the aromatic content of DOC in the water. The pure NaCl solution with EC = 4 dS/m, which has SAR = $_{\infty}$, extracted more aromatic DOC from both soils, compared to the same EC solution with SAR = 0 and the solution with SAR = 5. These phenomena are possibly attributed to the dispersion and coagulation of the soil organic. The divalent calcium ions can effectively flocculate of up to 50% of the DOC originally present in the water samples (Romkens and Dolfing, 1998). Therefore, this coagulation process removed significant amount of aromatic compounds from the solution phase. On the other hand, the Na cation is ineffective as a bridging cation when compared with divalent Ca ion (Churchman, 1993). Na ions dispersed soil aggregates and exposed physically protected organic matter. In addition, these organic matters are usually highly aromatic. As a result, the SUV_{254} increased in NaCl extractions. DOC extracted from SAR = 0 and SAR = $_{\infty}$ were analyzed for the THMFP. The results are summarized in Table 4.1. We can see that the DOC from NaCl extraction (SAR = ∞) had much higher STHMFP than $CaCl_2$ extraction (SAR = 0).

Temperature Effect. The SUV_{254} produced in the incubation experiments of both oxidized and reduced peat soils are shown in Figures 4.8 and 4.9. We see that SUV_{254} increased after 8-week incubations in both soils. The increase of SUV_{254} or aromaticity of DOC is possibly due to the consumption of labile organic carbon. This carbon pool may contain compounds that are less aromatic. The aromatic compounds are more difficult for microbes to utilize because of the conjugated double bonds. Microbes use this labile carbon as food sources so that the fraction of intermediately resistant carbon increases. Therefore, the aromatic content and the SUV_{254} increased. In addition, the curves of SUV_{254} of each temperature in both soils cross each other and the temperature effect on the aromaticity of DOC is less clear. Indeed, fractionation and STHMFP do not show any clear relationship with temperature either, as shown in Figures 4.10, 4.11 and 4.12. We may conclude that the temperature effect at this moisture content ($\theta_g = 0.3$) on the DOC production and DOC quality is comparatively insignificant.

Moisture Effect and Wet-dry Cycles. The SUV_{254} produced in the incubation experiments of both oxidized and reduced peat soils under different moisture content are shown in Figures 4.13 and 4.14. The relationship of moisture content on the SUV_{254} also was not so clear in spite of the increased SUV_{254} after 8-week incubations. Moreover, the STHMFP of oxidized peat soil after wetting, flooding and wet-dry cycle incubations are lower than the original samples although the increase of SUV_{254}, as shown in Figure 4.11.

This behavior is because SUV_{254} is not a good indicator for THMFP (Fuji et al., 1998). The DOC fractionation of moisture effect is shown in Figure 4.14. Also, the moisture effect on the fractionation is not so clear.

Conclusion

Selected DOC extracted from the abiotic leaching experiments and bioitc incubation experiments are examined for SUV_{254}, XAD fractionation and THMFP. In the abiotic experiment, the experimental results showed that an increase of the salinity of soil water decreases SUV_{254} and THMFP of the leached water. Also, an increase of the SAR increases SUV_{254} and THMFP of the leached water. The biotic incubation experiments showed that microbial activities increase SUV_{254} because of the consumption of labile carbon pools. However, the THMFP of DOC extracted decreased after an 8-week incubation even though there was an increase in SUV_{254}.

Table 4.1. Results of selected samples for THMFP. DOC was extracted from the reduced peat soils.

Extracting Solution	Number of Extraction	EC (dS/m)	SUV_{254}	STHMFP (μg THMs/ mg C)
EC = 0.0 dS/m Distilled H_2O	1st	0.862	0.0257	72.89
	6th	0.048	0.0567	113.35
EC = 0.5 dS/m SAR = 5	1st	1.14	0.0248	78.74
	6th	0.61	0.0410	104.91
EC = 4 dS/m SAR = 0	1st	2.99	0.0169	72.48
	6th	4.22	0.0291	84.32
EC = 4 dS/m SAR = ∞	1st	3.11	0.0241	77.61
	6th	4.38	0.0495	105.50

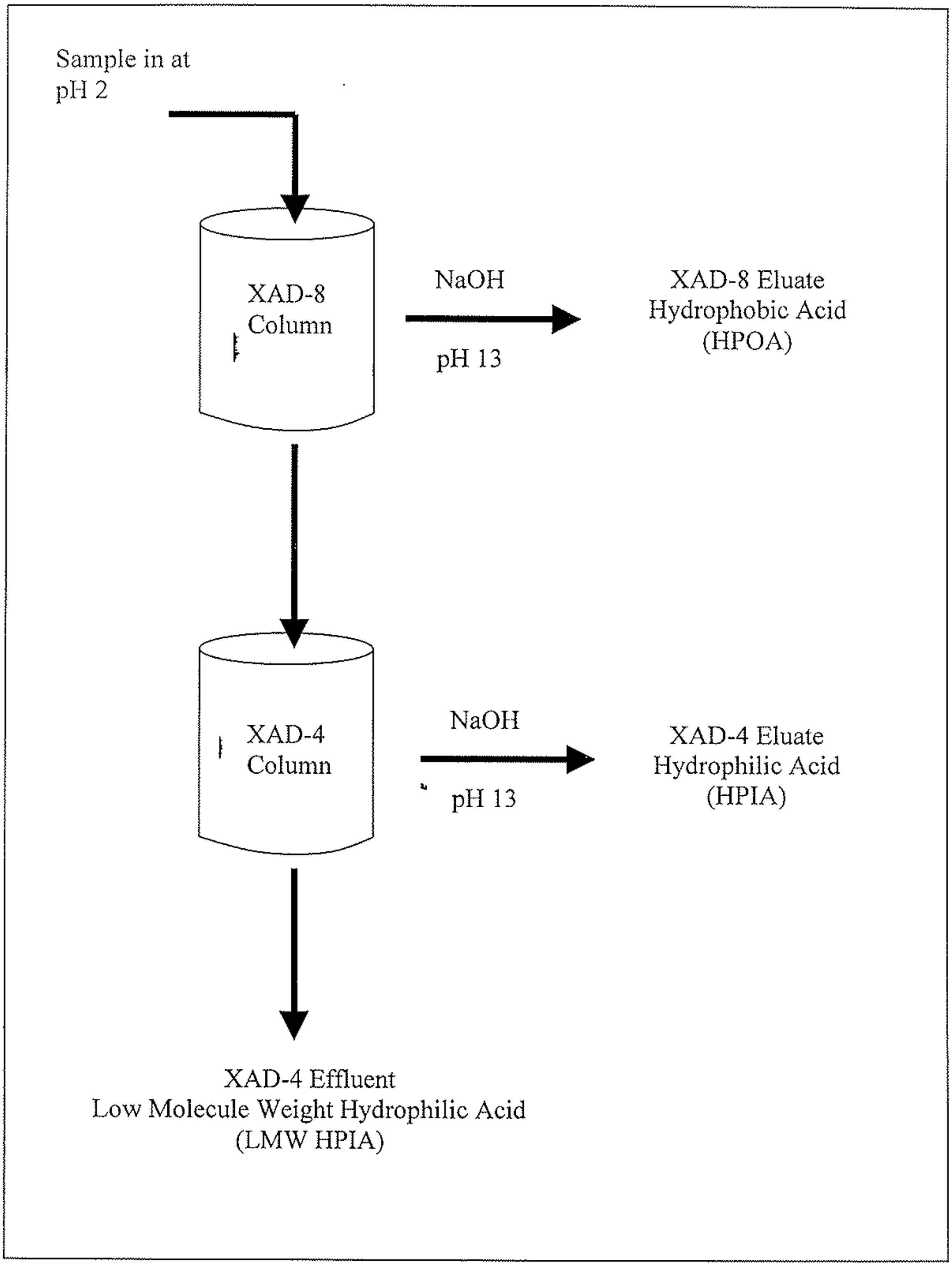


Figure 4.1. XAD isolation procedure for DOC samples is used in this study. The methodology is adopted from Aiken et al. (1992).

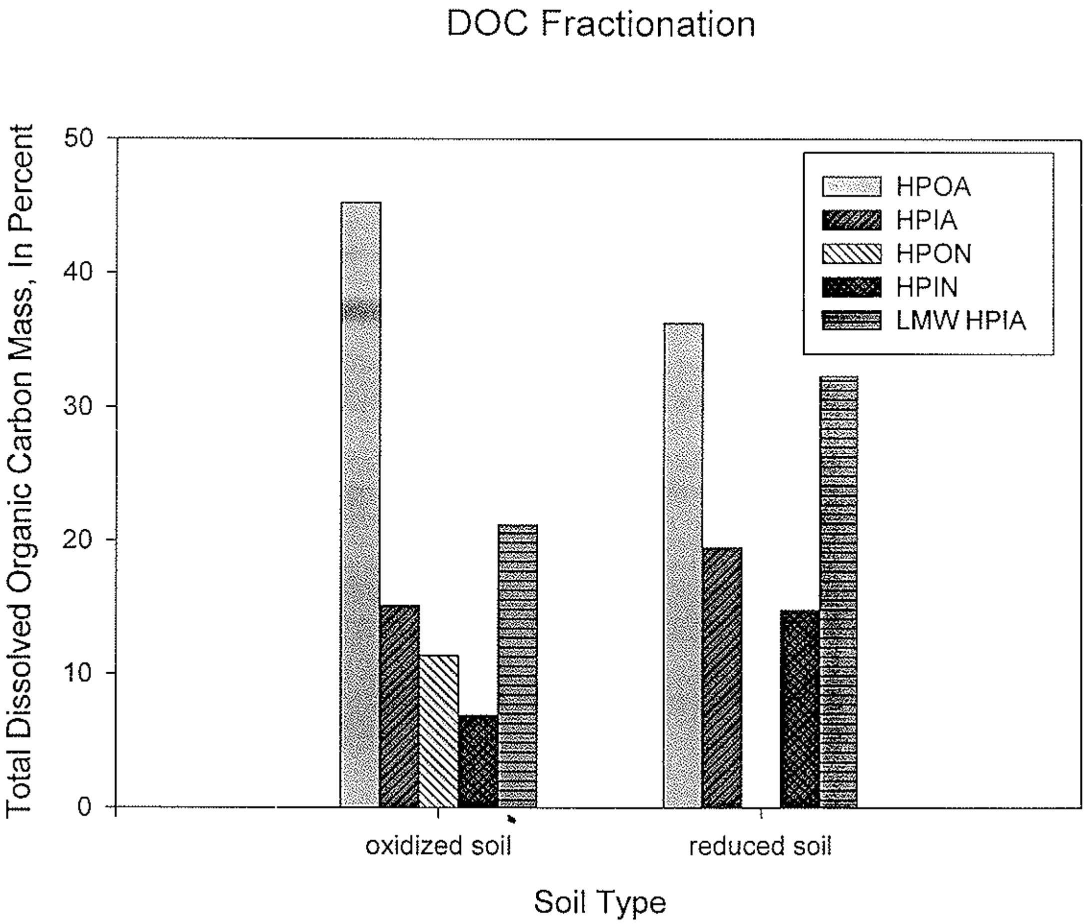


Figure 4.2. Fractionation of DOC extracted from oxidized and reduced peat soils. The DOC was extracted by EC = 0.5 dS/m and SAR = 5 solution in 1:10 soil: solution ratio.

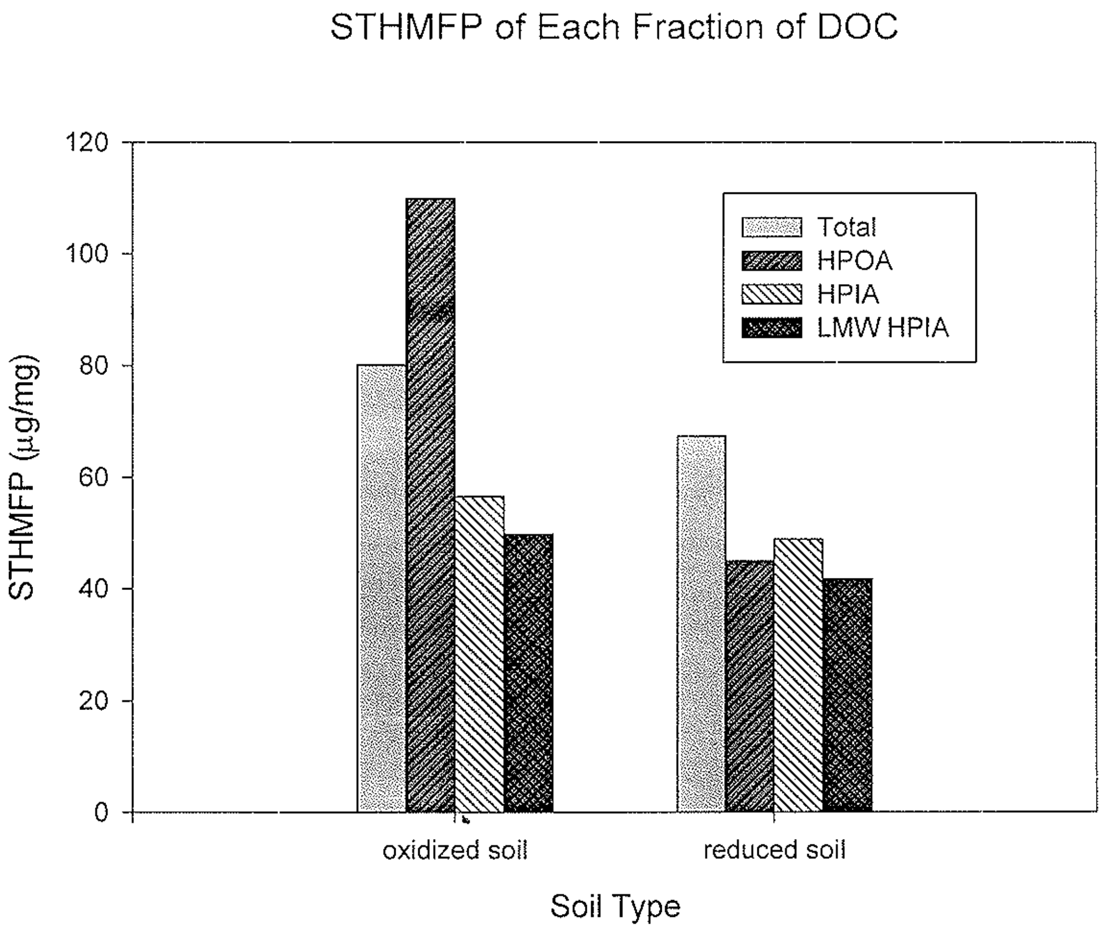


Figure 4.3. STHMFP of each DOC fraction from oxidized and reduced peal soils. The DOC was extracted by EC = 0.5 dS/m and SAR = 5 solution in 1:10 soil: solution ratio.

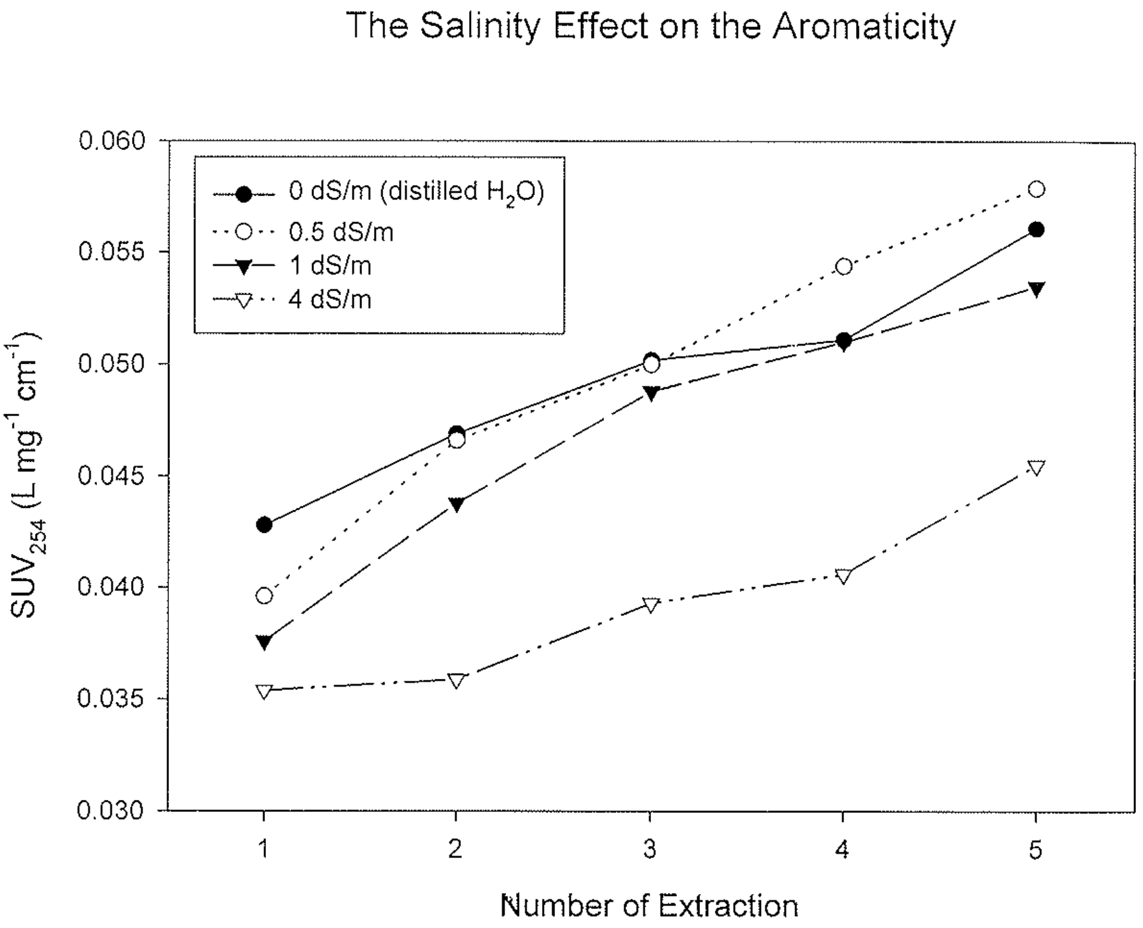


Figure 4.4. The effects of successive salinity extractions on the specific ultraviolet absorbance at 254 nm of extracted DOC from the oxidized peat soil.

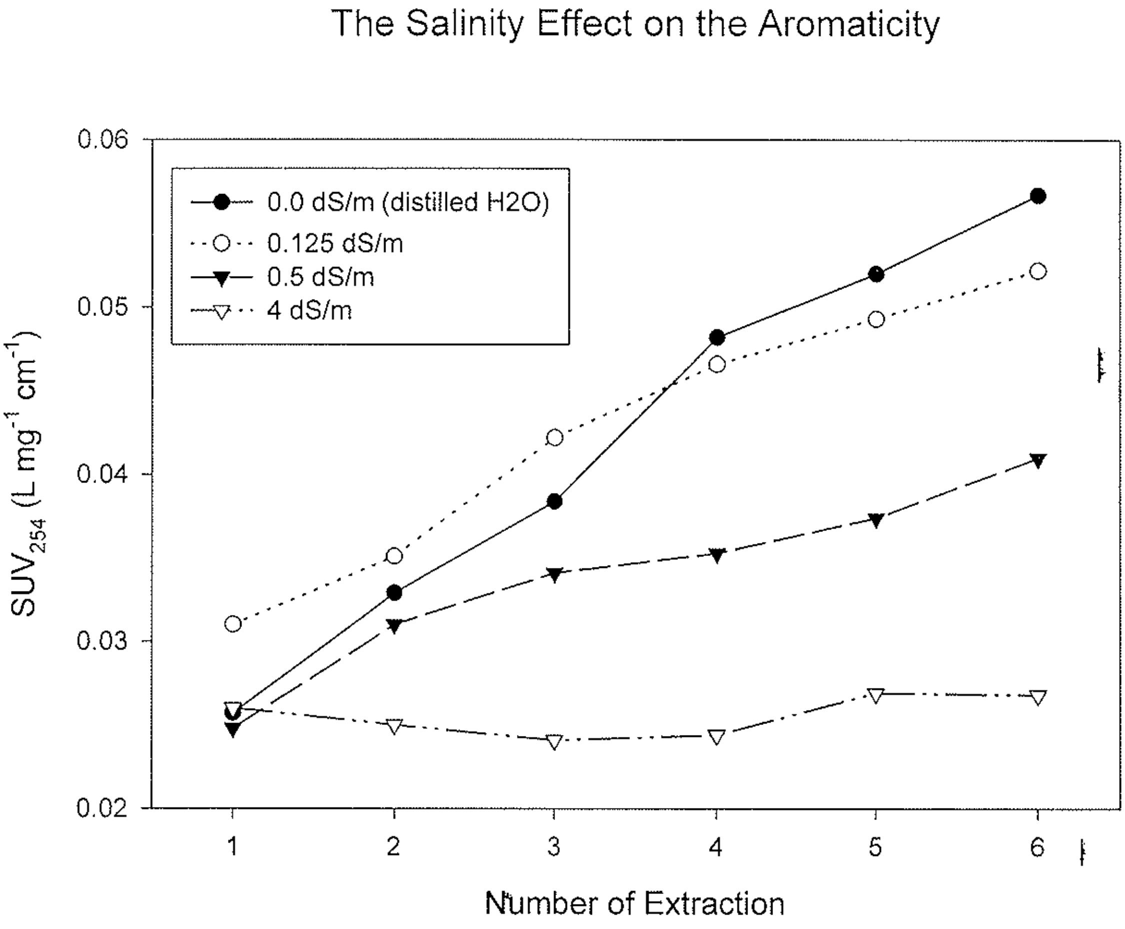


Figure 4.5. The effects of successive salinity extractions on the specific ultraviolet absorbance at 254 nm of extracted DOC from the reduced peat soil.

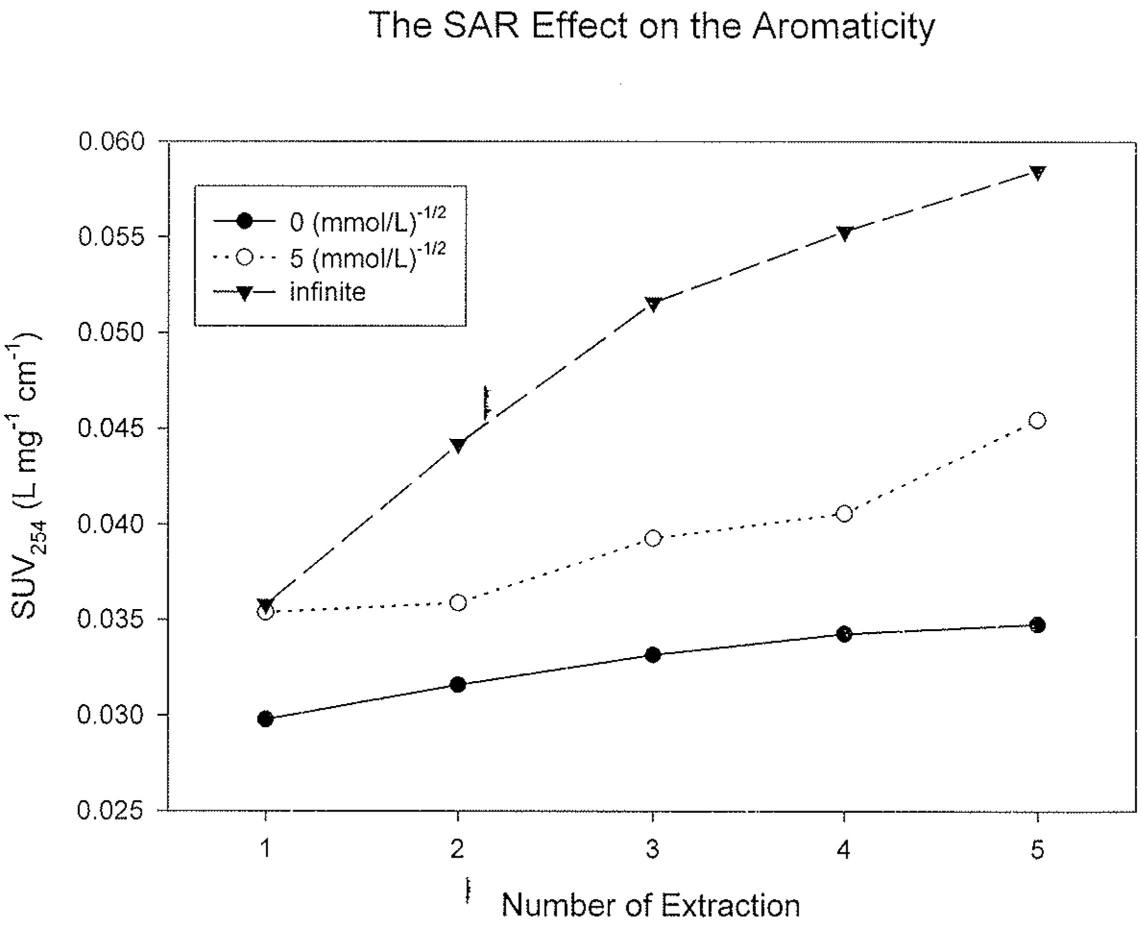


Figure 4.6. The effects of successive SAR extractions on the specific ultraviolet absorbance at 254 nm of extracted DOC from the oxidized peat soil.

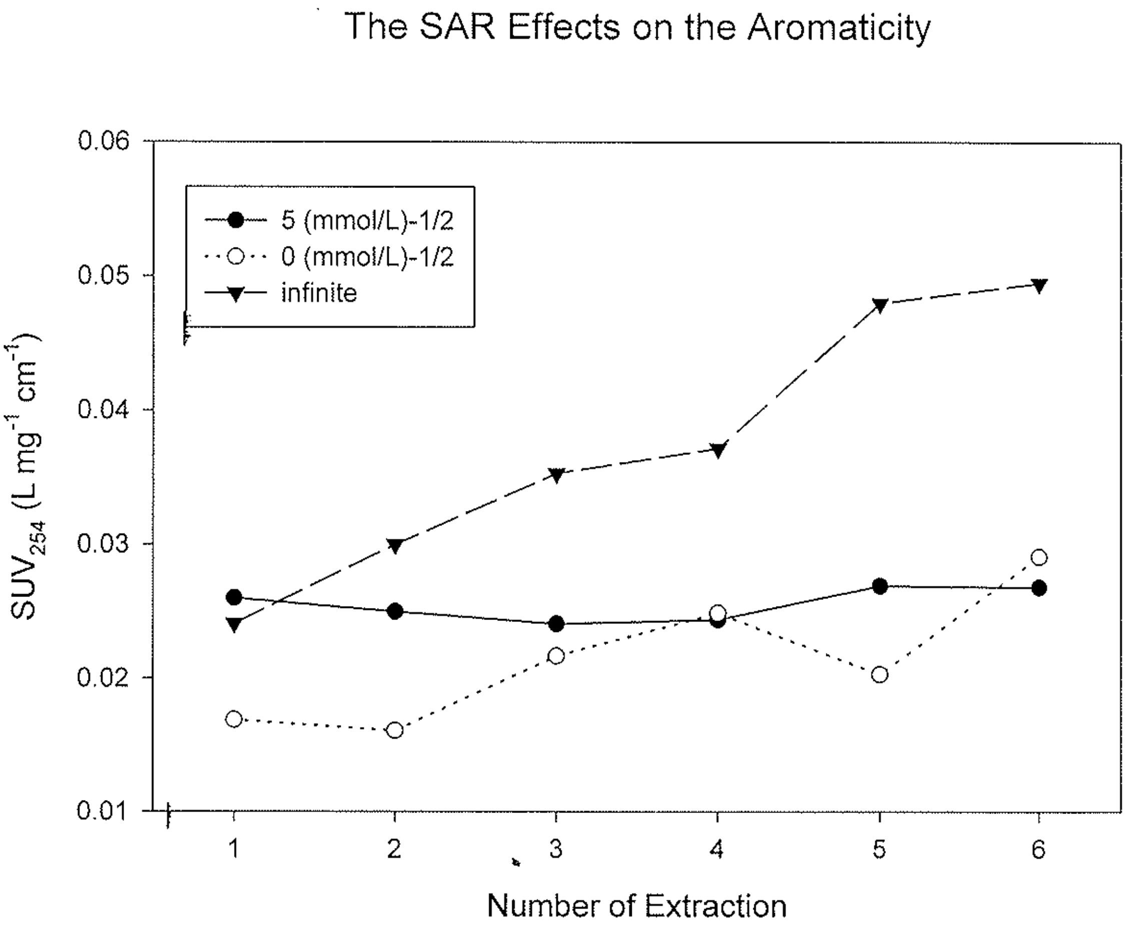


Figure 4.7. The effects of successive SAR extractions on the specific ultraviolet absorbance at 254 nm of extracted DOC from the reduced peat soil.

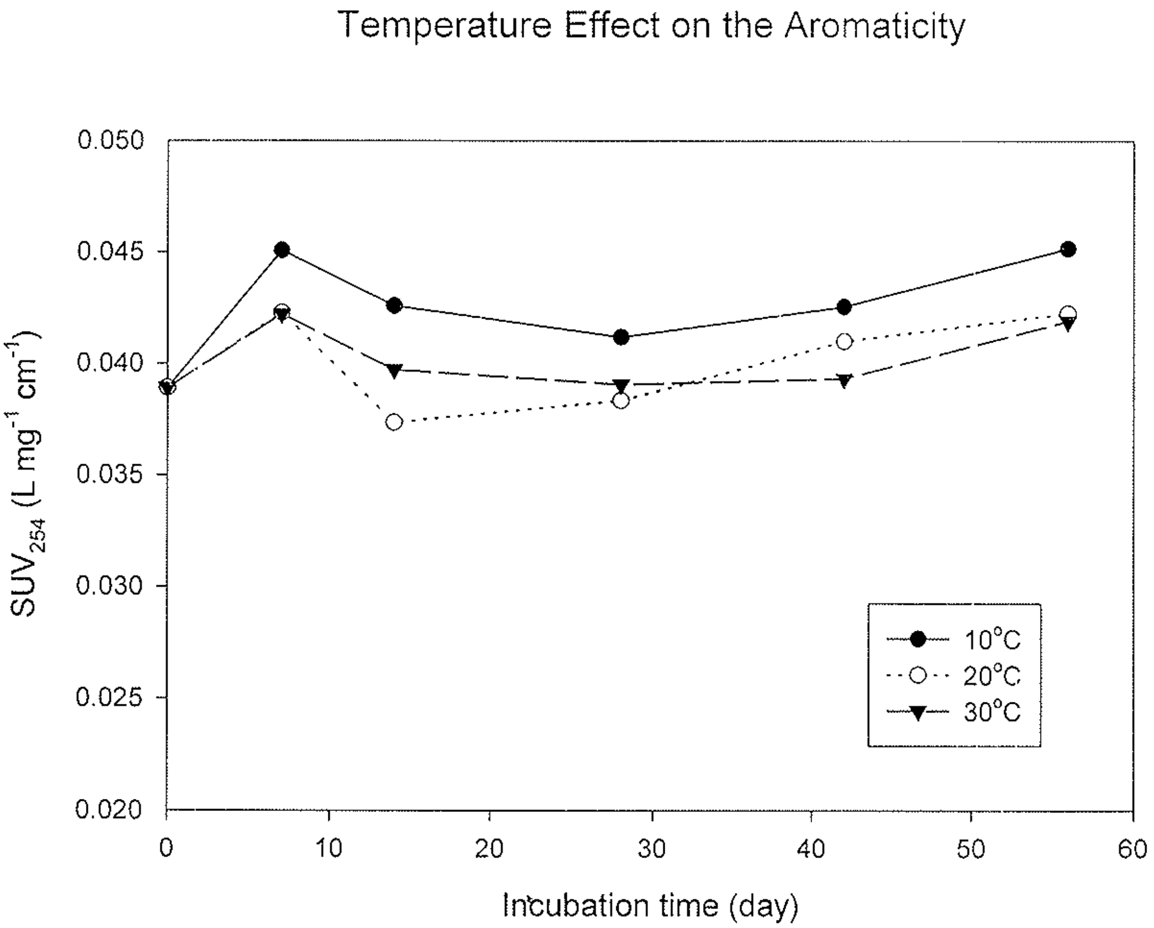


Figure 4.8. The effects of temperature incubation on the specific ultraviolet absorbance at 254 nm extracted DOC from the oxidized peat soil.

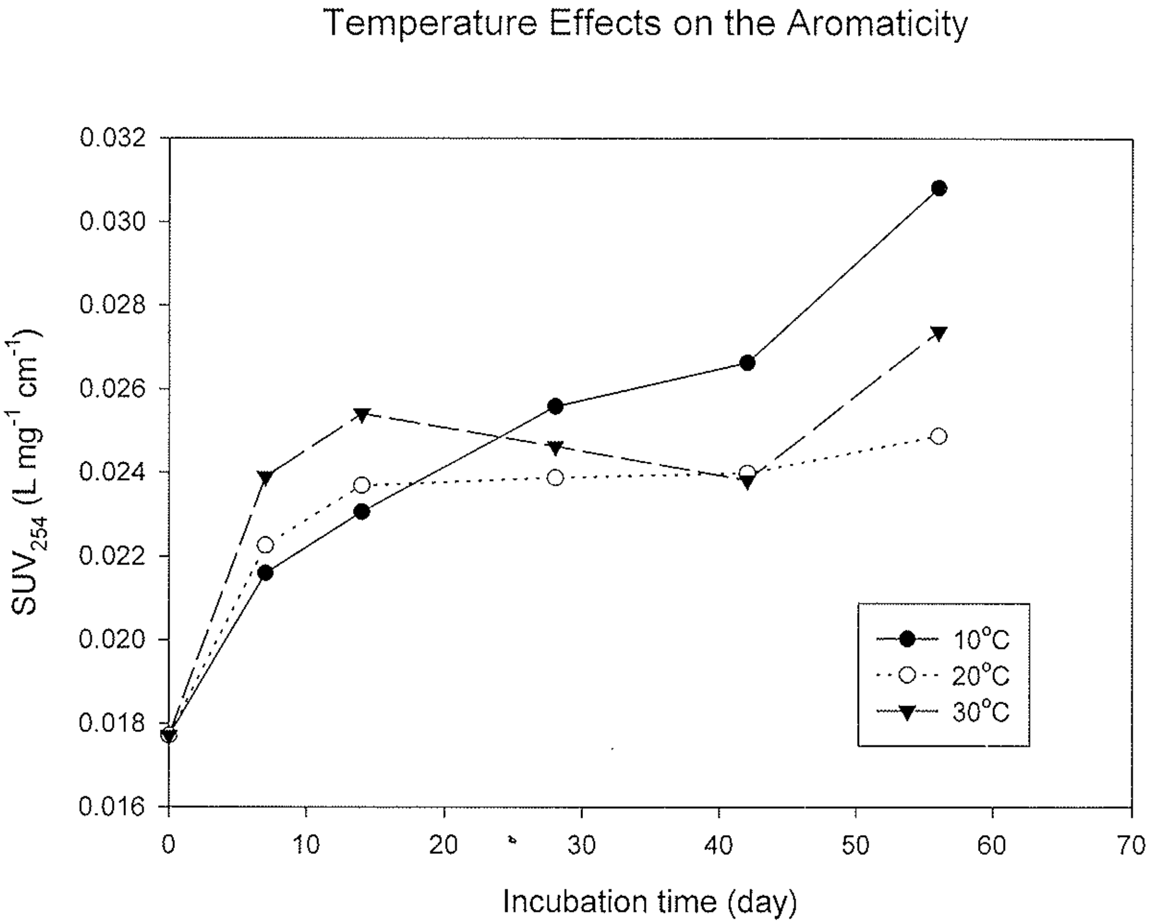


Figure 4.9. The effects of temperature incubation on the specific ultraviolet absorbance at 254 nm extracted DOC from the reduced peat soil.

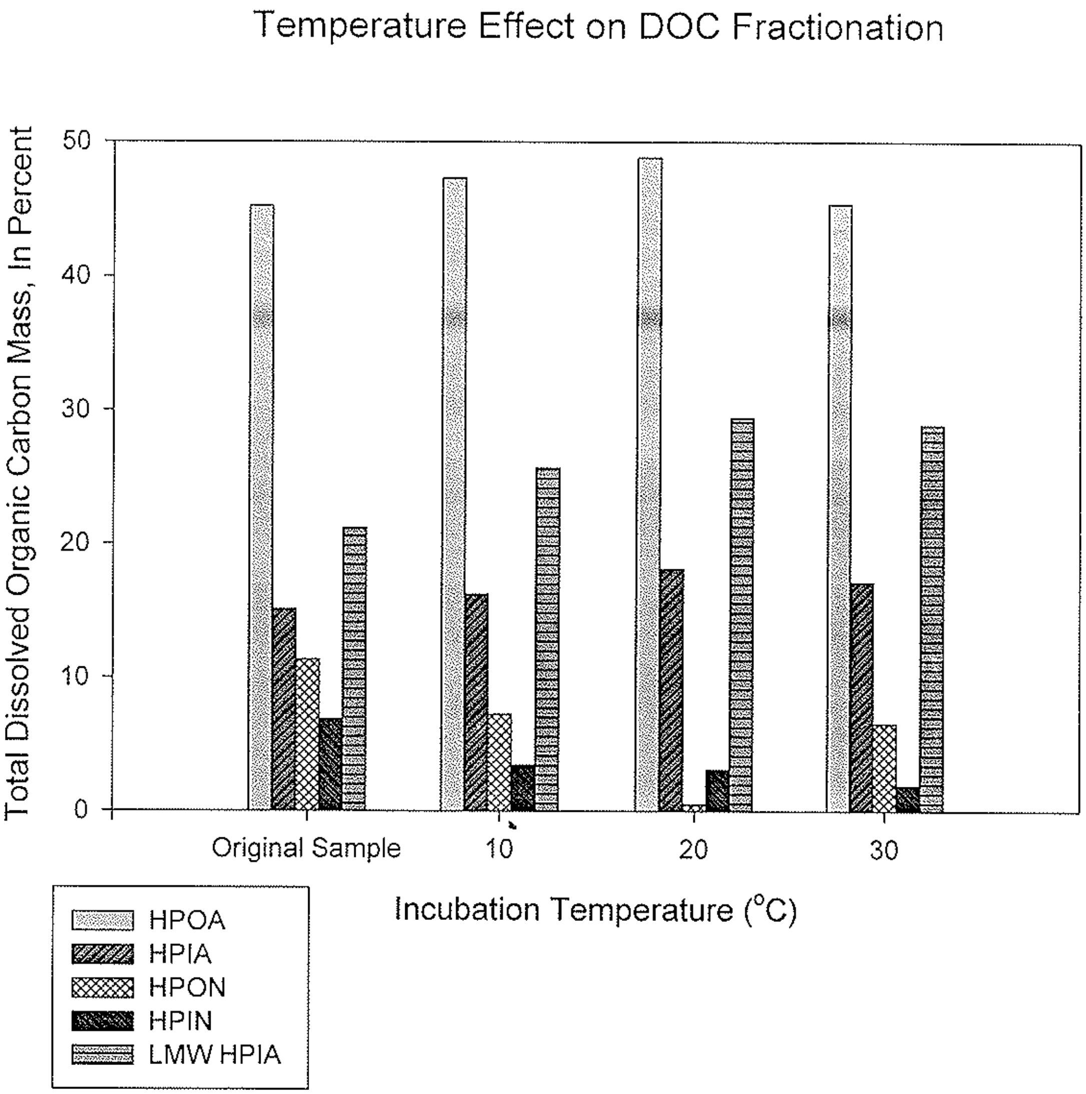


Figure 4.10. Temperature effects on the fractionation of extracted DOC from the oxidized peat soil.

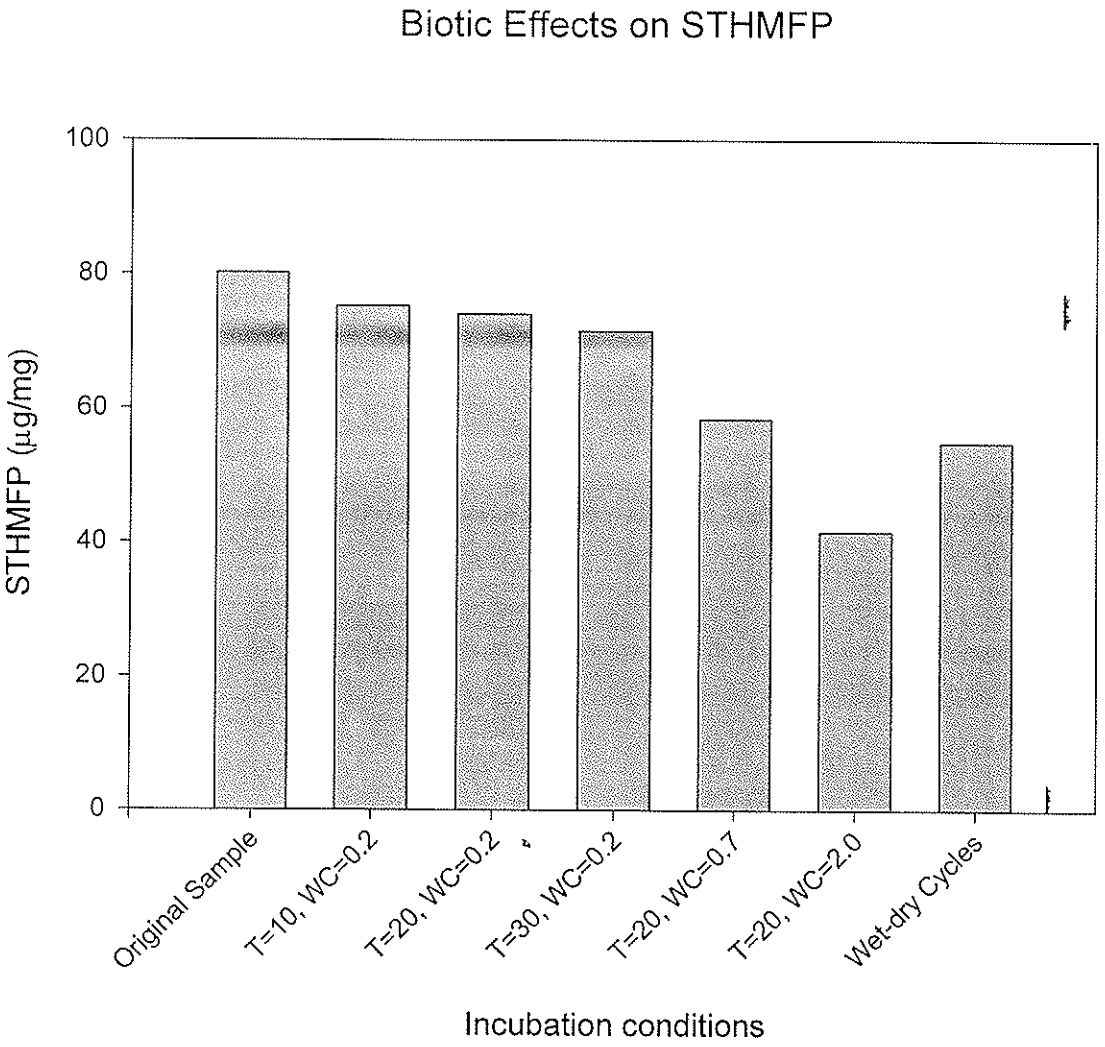


Figure 4.11. Biotic effects on STHMFP of DOC from oxidized peat soil.

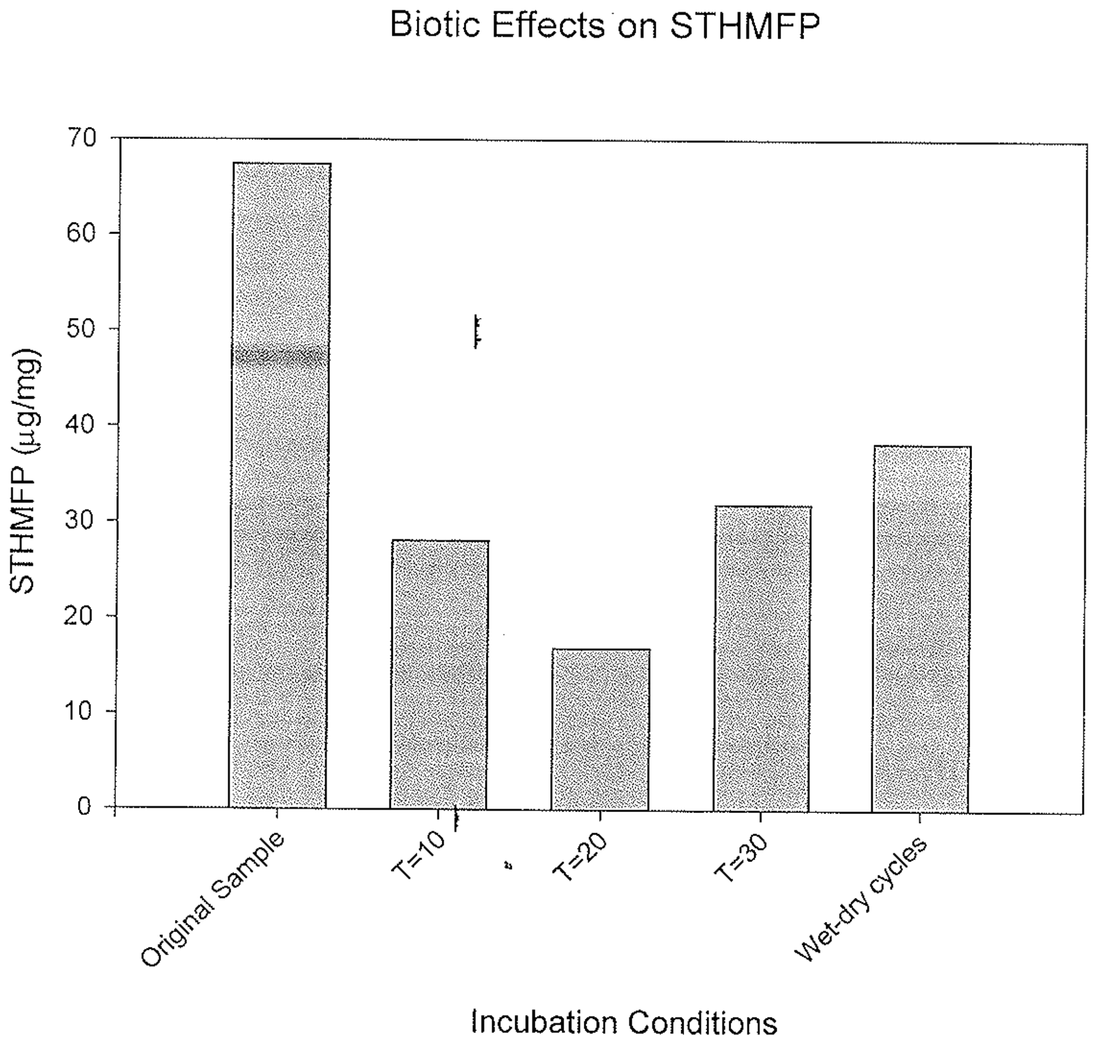


Figure 4.12. Biotic effects on STHMFP of DOC from reduced peat soil.

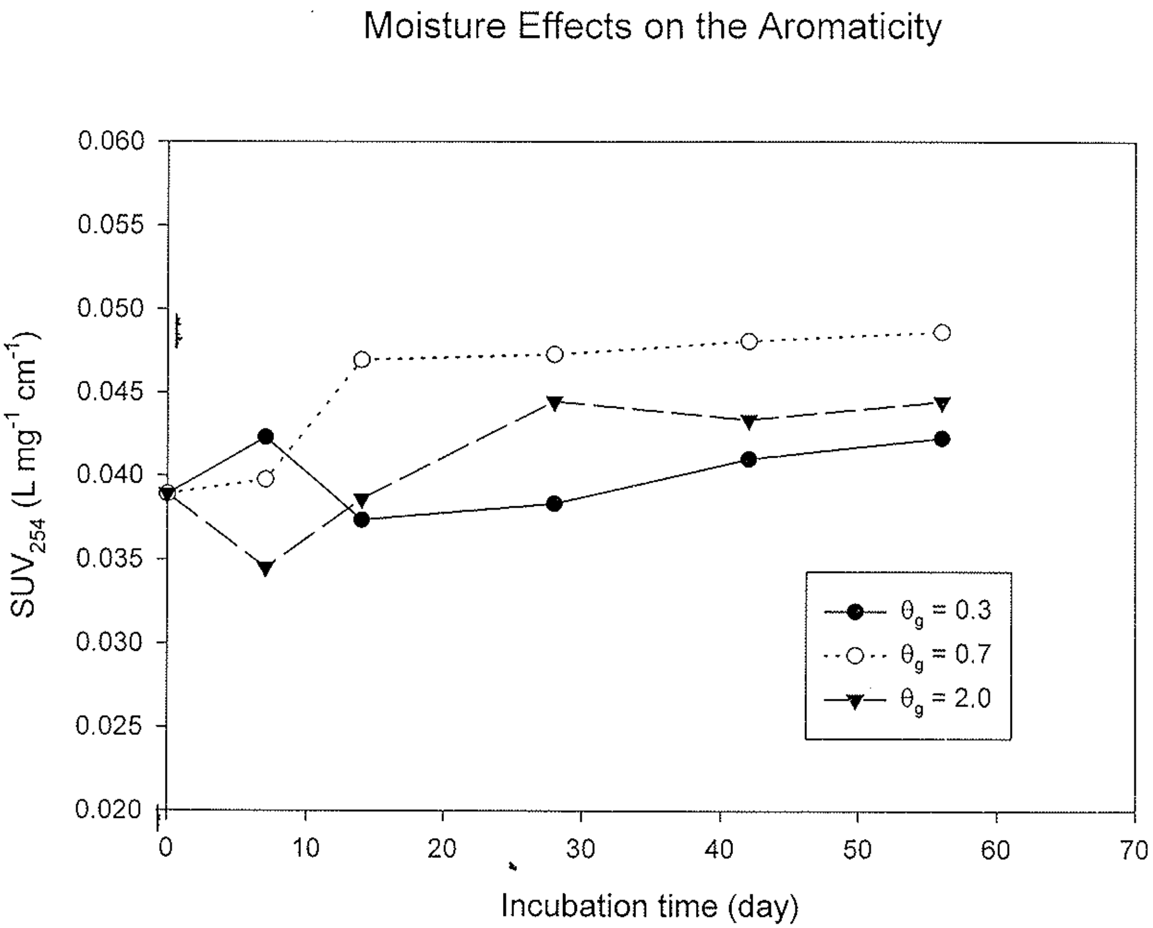


Figure 4.13. The effects of moisture incubation on the specific ultraviolet absorbance at 254 nm extracted DOC from the oxidized peat soil.

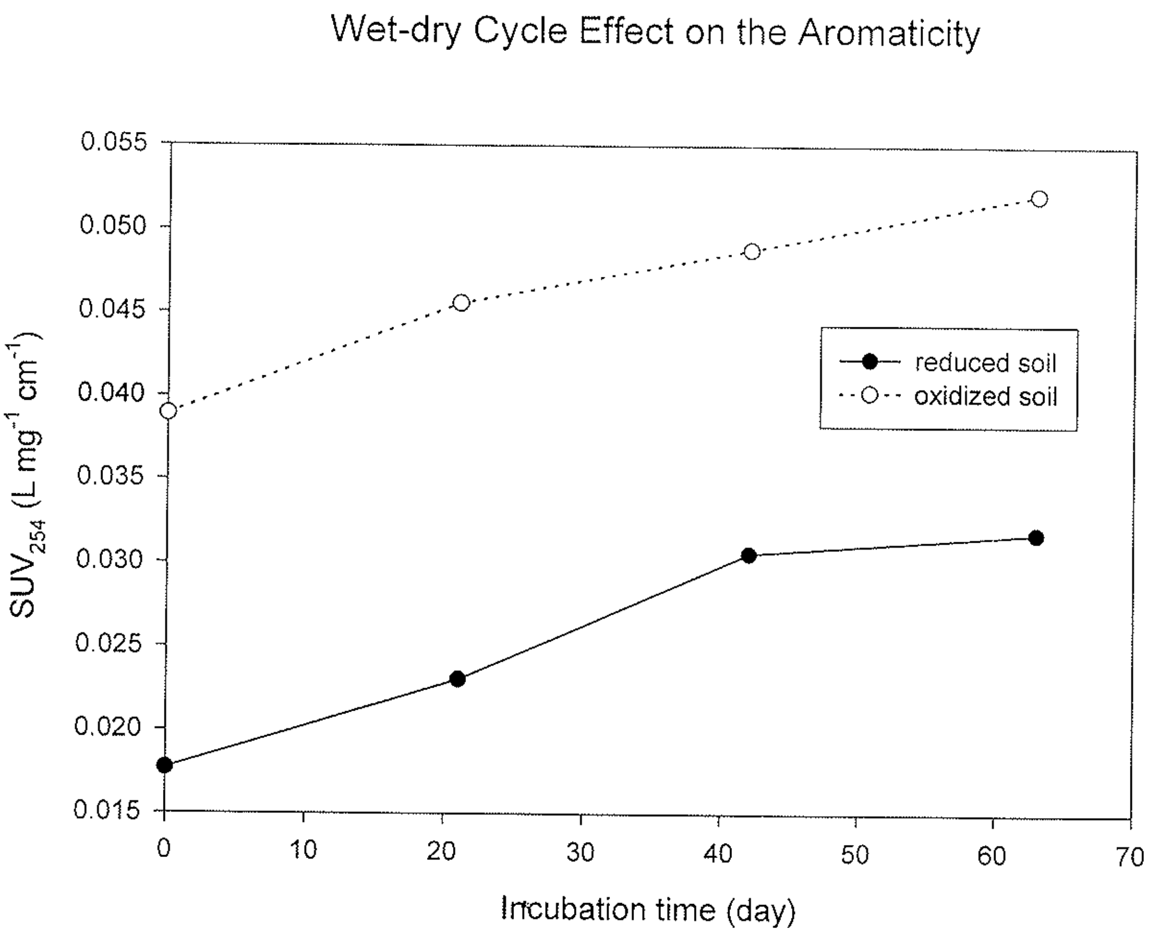


Figure 4.14. The effects of wet-dry cycle incubation on the specific ultraviolet absorbance at 254 nm extracted DOC from the oxidized peat soil and reduced peat soil.

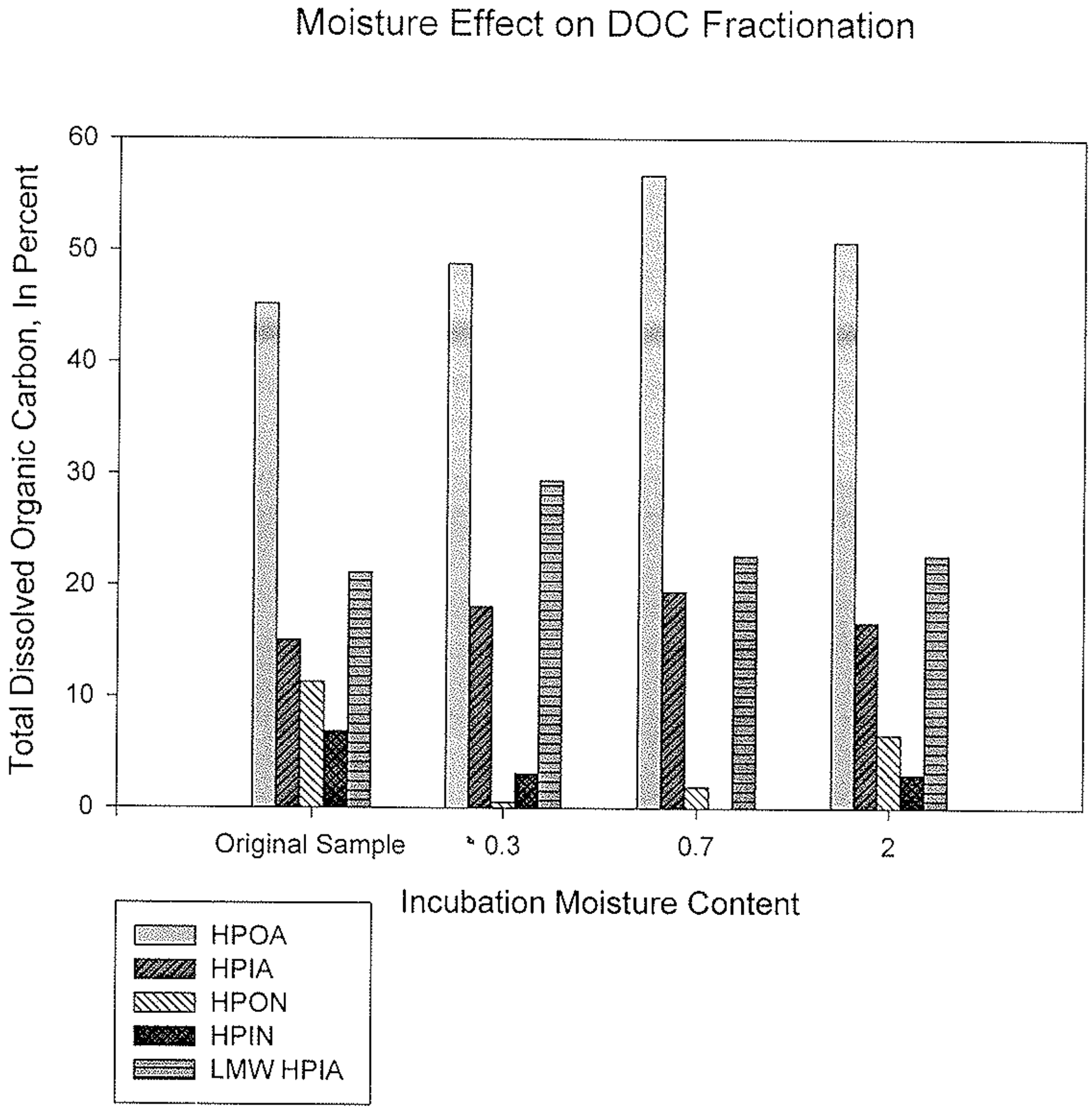


Figure 4.15. Moisture effects on the fractionation of extracted DOC from oxidized peat soils.

CHAPTER V – SUMMARY AND CONCLUSION

This study was carried out to understand the influences of the current agricultural practices on the production of DOC and THM from surface (oxidized) and subsurface (reduced) peat soil of the Sacramento-San Joaquin Delta. The current agricultural practices create seasonal wet-dry cycles in the fields so that salinity, sodicity, temperature and moisture content of soils are varied. Both abiotic and biotic are examined independently in order to identify the major DOC and THM precursors production processes.

In the abiotic experiment, the effects of salinity and SAR on the quantity and quality of DOC from both surface and subsurface are studied by successive extractions. The results showed that the increase of the soil-water salinity decreases the amount of DOC and decreases its aromaticity. A decrease of SAR also decreases the amount of DOC and decreases its aromaticity. The results of the abiotic experiment showed that the salt accumulation of the summer irrigation is not the major production of DOC; instead, the salt accumulation may reduce the DOC leaching from the peat soil, if we consider the salt effects alone.

In the biotic experiment, the effects of temperature, moisture content and wet-dry cycles on the quantity and quality of DOC from both surface and subsurface peat soils are studied by 8-week incubations. The results showed that these factors affect the microbial activities, but the flooded and the wet-dry cycle incubations increase the DOC concentration in the oxidized peat soil. However, the extracted DOC from the incubated peat soils showed lower STHMFP although there was increases in the concentration and SUV_{254}.

In summary, the current agricultural practices alter the soil salinity and create the wet-dry and flooded conditions in the fields. The summer irrigation increases the soil salinity. However, the increase of salinity decreases the DOC productions but increases the STHMFP. On the other hand, the wet-dry cycle in the summer and flooded conditions in the winter did produce the DOC, but the STHMFP of DOC produced in these conditions decreased.

REFERENCES

Aiken, G.R., D.M. McKnight, K.A. Thorn, and, E.M. Thurman. 1992. Isolation of hydrophilic organic acids from water using nonionic macroporous resins. Organic Geochemistry. 18(4): 567 – 573.

Amy, G.L., J.M. Thompson, L. Tan, M.K. Gavis, and S.W. Krasner. 1990. Evaluation of THM precursor contributions from agricultural drains. J. Am. Water Works Assoc. 82(1): 57-64.

Andersson, S., and I. Valeur. 1994. Influence of lime on soil respiration, leaching of DOC, and C/S relationships in the mor humus of a haplic podsol. Environment International. 20(1): 81– 88.

Atwater, B.F., C.W. Hedel, and E.J. Helley. 1977. Late Quaternary depositional history, holocene sea-level changes, and vertical crustal movement, southern San Francisco bay, California. U.S. Geological Survey Professional Paper 1014.

Babcock, D.B. and P.C. Singer. 1979. Chlorination and Coagulation of humic and fulvic acids. J. Am. Water Works Assoc. 71:149-152.

Bunnell, F.L. and D.E.N. Tait. 1974. Mathematical Simulation Models of Decomposition Processes. In: Holding et al. (ed.) Soil Organisms and Decomposition in Tundra. Tundra Biome Steering Committee (stockholm).

Chang, F. and M. Alexander. 1984. Effects of simulated acid precipitation on decomposition and leaching of organic carbon in forest soils. Soil Science. 138: 226-234.

Churchman, G.J., J.O. Skjemstad, and J.M. Oades. 1993. Influence of clay mineral and organic matter on effects of sodicity on soils. Australian Journal of Soil Research. 31: 779 – 800.

Cosby, S.W. 1935. Soil survey of the Sacramento-San Joaquin Delta area, California. Bureau of Plant Industry. No. 21.

Craun, G.F. 1985. Epidomiologic considerations for evaluating associations between the disinfection of drinking water and cancer in humans. p.133-144. In: R.L. Jolly et al. (ed.) Water Chlorination: Environmental Impact and Health Effects. Vol. 5. Lewis, Chelsea, Mich.

Department of Water Resources, State of California. 1993. Annual Report of the Municipal Water Quality Investigation Program. Summary of Monitoring Results. Jan. 1990-Dec. 1990.

Department of Water Resources, State of California. 1994. Five-year report of the municipal water investigations program. Summary and findings during five dry years: January 1987-December 1991.

Department of Water Resources, State of California. April, 1982. State Water Project Trihalomethane Study. Report, Central District. 54p.

Department of Water Resources, State of California. October, 1991. Trihalomethane Formation potential in the Sacramento-San Joaquin Delta Mathematical Model Development. 100p.

Department of Water Resources, State of California. June, 1990. Delta Island Drainage Investigation Report of the Interagency Delta Health Aspects Monitoring Program, A Summary of Observations During Consecutive Dry Year Conditions, Water Years 1987-1989. 118p.

Deverel S.J. and S. Rojstaczer. 1996. Subsidence of agricultural lands in the Sacramento-San Joaquin Delta, California: Role of aqueous and gaseous carbon fluxes. Water Resources Research. 32(8): 2359-2367.

Dobbs, R.A., R.H. Wise, and R.B. Dean. 1972. The use of ultra-violet absorbance for monitoring the total organic carbon content of water and wastewater. Water Res. 6:1173-1180.

Eaton, A.D., A.E. Greenberg, L.S. Clesceri, and. 1995. Standard Method for the Examination of Water and Wastewater. 19th ed. APHA/AWWA/EEF.

Edawald, J.K., W.C. Becker, and K.L. Wattier. 1985. Surrogate parameters for monitoring organic matter and THM precursors. J. Am. Water Works Assoc. 77(4): 122-132.

Eggelsmann, R.F. 1984. Subsidence of Peatland caused by drainage, evaporation, and oxidation in Land Subsidence. In: I. A. Johnson et al. (ed.) Proceedings of the third international symposium on land subsidence held in Venice, Italy, 19-25 March 1984. IAHS Publication No. 151.

Evans, A.Jr., L.W. Zelazny, and C.E. Zipper. 1988. Division S-7-forest and range soils. Solution parameters influencing dissolved organic carbon levels in three forest soils. Soil Sci. Soc. Am. J., 52: 1789-1792.

Federal Register, vol. 59, No. 145. (July 29, 1994) 38668-38817.

Forward, D.F. 1960. Effect of temperature on respiration. p.234-258. In: W. Ruhland (ed.) Encyclopedia of Plant Physiology. Volume XII. Part 2. Springer-Verlag.

Fujii, R., A.J. Ranalli, G.R. Aiken, and B.A. Bergamaschi. 1998. Dissolved organic carbon concentrations and compositions, and trihalomethane formation potentials in water from agricultural peat soils, Sacramento-San Joaquin Delta, California: Implications for drinking-water quality. U.S. Geological Survey. Water-Resources Investigation Report 98-4147.

Glenn, S., A. Heyes, and T. Moore, 1993. Carbon dioxide and methane fluxes from drained peat soils, Southern Quebec. Global Biogeochemical Cycles. 7(2): 247 – 257.

Gregory, J. 1989. Fundamentals of Flocculation. CRC Critical Reviews in Environmental Control. 19(3): 185-230.

Grieve, I.C. 1990. Seasonal, hydrogical, and land management factors controlling dissolved organic carbon concentrations in the Lock Fleet catchments, southwest Scotland. Hydrological Processes. 4: 231 – 239.

Hogg, E.H. V.J. Lieffers, and R.W. Wein. 1992. Potential carbon losses from peat profiles: Effects of temperature, drought cycles, and fire. Ecological Application 2(3): 298-306.

Horwath, W.R. and E.A. Paul. 1994. Microbial biomass. p. 753-771. In: R.W. Weaver (ed.) Methods of soil Analysis. Part 2. ASA and SSSA, Madison, WI.

Howard, D.M. and P.J.A. Howard. 1993. Relations between CO_2 evolution, moisture content and temperature for a range of soil types. Soil Biol. Biochem. 25(11): 1537-1546.

Hutton, P.H. and F.I. Chung. 1992. Simulating THM formation potential in Sacramento Delta. Part I. Journal of Water Resources Planning and Management. 118(5): 513-529.

Hutton, P.H. and F.I. Chung. 1994. Correlating trihalomethane data. Journal of Environmental Engineering. 120: 219-241.

Leenheer, J.A. 1981. Comprehensive approach to preparative isolation and fractionation of dissolved organic carbon from natural waters and wastewaters. Environmental Science and Technology. 15(5): 578 – 587.

Malcolm, R.L. E.M. Thurman, and G.R. Aiken. 1978. The concentration and fractionation of trace organic solutes from natural and polluted waters using XAD-8 , a methylmethacrylate resin. Proceedings of 11th Annual Conference Trace Substances in Environ. Health. pp.307-314.

Manahan, S.E. 1994. Environmental Chemistry. CRC Press, Inc. Boca Raton, Florida.

Muneer, M. and J.M. Oades. 1989. The role of Ca-organic interactions in soil aggregate stability. III. Mechanisms and models. Aust. J. Soil Res. 27: 411-423.

Oliver, B.G. 1980. Effect of temperature, pH and bromide concentration on the trihalomethane reaction of chlorine with aquatic humic materials. p.141-149. In: Jolley et al. (ed.) Water Chlorination: Environmental Impact and Health Effects, Vol. 3.

Oliver, B.G., and J. Lawrence. 1979. Haloforms in drinking water: A study of precursors and precursor removal. J. Am. Water Works Assoc. 71: 161 – 163.

Oliver, G. B. and S.A. Visser. 1980. Chloroform production from the chlorination of aquatic humic materials: The effect of molecular weight, environment and season. Water Res. 14: 1137-1141.

Ong, L.H., V.E. Swanson, and R.E. Bisque. 1970. Natural Organic Acids as agents of Chemical Weathering. U.S. Geol. Survey Prof. Paper 700-C, Pages C130-C137.

Ong,, L.H., and R.R. Bisque. 1968. Coagulation of Humic Colloids by Metal Ions. Soil Science. 106(3): 220-224.

Paul, E.A. and F.E. Clark. 1996. Soil Microbiology and Biochemistry. 2nd ed. Academic Press, Inc.

Rojstaczer, S. and S.J. Deverel. 1995. Land subsidence in drained Histosols and highly organic mineral soils of California. Soil Sci. Soc. Am. J. 59: 1162-1167.

Rojstaczer, S. and S.J. Deverel. 1993. Time dependence in atmospheric carbon inputs from drainage of organic soils. Geophysical Research Letters. 20(13): 1383-1386.

Rojstaczer, S.A., R.E. Hamon, S.J. Deverel, and C.A. Massey. 1991. Evaluation of selected data to assess the causes of subsidence in the Sacramento-San Joaquin Delta, California. U.S. Geological Survey Open-file report 91-193.

Romkens, P.F. and J. Dolfing. 1998. Effect of Ca on the solubility and molecular size distribution of DOC and Cu binding in soil solution samples. Environ. Sci. Technol. 32: 363-369.

Rook, J.J. 1976. Haloforms in drinking water. J. Am. Water. Works Assoc. 68: 168-172.

Schofield, R.K. 1947. A ratio law governing the equilibrium of cations in the soil solution. Proc. Int. Congr. Pure Appl. Chem. 11(3): 257-261.

Shlemon, R.J. and E.L. Begg. 1975. Late Quaternary evolution of the Sacramento-San Joaquin Delta, California. p. 259-266. In R.P. Suggate et al. (ed.) Quaternary Studies. The Royal Society of New Zealand, Wellington. Bulletin 13.

Sholkovitz, E.R. 1976. Flocculation of dissolved organic and inorganic matter during the mixing of river water and seawater. Geochimica et Cosmochimica Acta. 40: 831-845.

Sihombing, R., W.D. Johnson, M.A. Wilson, and M. Johnson. 1991. Origins of humus variation. Effects of leaching and seasonal flooding on aromaticity. Org. Geochem. 17(1): 85-91.

Sposito, G. 1989. The Chemistry of Soils. Oxford University Press, Inc.

Stevenson, F.J. and M.A. Cole. 1999. Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulfur, Micronutrients. 2nd ed. John Wiley & Sons, Inc.

Stevenson, F.L. 1994. Humus Chemistry: Genesis, Composition, Reactions. 2nd ed. John Wiley & Sons, Inc.

Stumm, W. 1992. Chemistry of the Solid-Water Interface. Johh Wiley & Sons, Inc.

Stumm, W. and J.J. Morgan. 1996. Aquatic Chemistry. 3rd ed. John Wiley & Sons, Inc.

Tanji, K.K. and L. Doneen. 1962. Salinity Investigation in the Sacramento-San Joaquin Delta Area: Salinity Survey, Permeability and Leaching Studies. Appendix E. In: L.D. Doneen (ed.) Salinity Criteria of Agricultural Waters for Peaty and Sedimentary Soils of the Lower Delta. Report from the Department of Irrigation, University of Calfornia, Davis.

Tariff, R.G. 1977. Health effects of organics: risk and hazard assessment of ingested chloroform. J. Am. Water. Works Assoc. 69: 658-661.

Tate, R.L. 1987. Soil Organic Matter: Biological and Ecological Effects. John Wiley & Sons, Inc.

Thurman, E.M. 1985. Organic Geochemistry of Natural Waters. Martinus Nijhoff/Dr W. Junk Publishers.

Weber, J.H. and S.H. Wilson. 1975. The isolation and characterization of fulvic acid and humic acid from river water. Water Res. 9: 1079-1084.

Yavitt, J.B. 1994. Carbon dynamics in Appalachian peatlands of west Virginia and western Maryland. Water, Air and Soil Pollution. 77: 271-290.

APPENDIX A - SOIL CHARACTERS OF OXIDIZED AND REDUCED PEAT SOILS

	Rep 1	Rep 2	Rep 3	Rep 4	average	mg/g dry soil
soil used (g)	250.3	249.3	249.9	250.8		
soil dry weight (g)	198.8	198.0	198.5	199.2	198.6	
water added (ml)	255	263	258	257.5		
total water (g)	306.5	314.3	309.4	309.1	309.8	
sat wc (g/g)	1.542	1.587	1.559	1.552	1.560	

pH	6.495	6.63	6.645	6.688	6.615	
EC @ 25C	4.476	4.315	4.431	4.521	4.436	
Eh (mv)	98.60	44.80	40.00	35.50	54.73	
TOC (ppm)	290.8	290.6	297.6	305.0	296.0	0.4617
IC (ppm)	15.20	18.57	19.84	20.61	18.56	0.0289
TC (ppm)	305.9	309.2	317.5	325.7	314.6	0.4907
UV254	3.240	3.246	3.212	3.228	3.231	
SUV254	0.0111	0.0112	0.0108	0.0106	0.0109	

SO4 (ppm)	914.4	865.2	895.3	914.1	897.2	1.400
Cl (ppm)	1088	1076	1101	1102	1092	1.703

Na (ppm)	525.6	486	490.8	519	505.35	0.7882
K (ppm)	12.78	12.77	12.71	13.11	12.84	0.0200
Ca (ppm)	243.73	228.4	227.73	232.6	233.1	0.3636
Mg (ppm)	170.93	177.33	175.6	176	175.0	0.2729
Mn (ppm)	2.19	2.563	2.5	2.537	2.448	0.0038
NH4 (ppm)	8.09	8.5	9.48	9.79	8.965	0.0140

anion meq/L= 49.44

cation meq/L = 48.91

Table A.1. Saturated soil paste for oxidized peat soils.

	Rep 1	Rep 2	Rep 3	Rep 4	average	mg/ g dry soil
soil used (g)	249.7	249.3	250.3	250.7		
soil dry weight (g)	41.62	41.55	41.72	41.78	41.67	
water added (ml)	137.5	178.5	145.5	157		
total water (g)	345.6	386.3	354.1	365.9	363.0	
sat wc (g/g)	8.304	9.296	8.488	8.757	8.711	

pH	6.56	6.52	6.95	6.83	6.71	
EC @ 25C	0.643	0.518	0.610	0.584	0.589	
Eh (mv)	173.0	83.7	70.4	184.7	128.0	
TOC (ppm)	23.68	17.54	22.47	21.06	21.19	0.1846
IC (ppm)	2.425	1.870	2.499	2.252	2.262	0.0197
TC (ppm)	26.10	19.41	24.97	23.31	23.45	0.2043
UV254	0.7117	0.4849	0.5911	0.5182	0.5765	
SUV254	0.0301	0.0276	0.0263	0.0246	0.0272	

SO4 (ppm)	28.8	11.76	25.87	21.21	21.91	0.1909
Cl (ppm)	180.1	152.3	168.3	167.8	167.1	1.456

Na (ppm)	71.22	54.27	66.83	61.75	63.52	0.5533
K (ppm)	6.80	5.88	6.45	6.47	6.40	0.0558
Ca (ppm)	16.55	12.75	15.32	14.00	14.66	0.1277
Mg (ppm)	13.95	10.23	13.27	11.02	12.12	0.1056
Mn (ppm)	0.267	0.237	0.28	0.267	0.26275	0.0023
NH4 (ppm)	6.30	5.41	6.28	7.74	6.43	0.0560

anion meq/L= 5.164

cation meq/L = 5.020

Table A.2. Saturated paste data for reduced peat soil.

Water Content			
Replicates	raw soil	dried soil mass (50oC)	Water Content
1	10.018g	7.897g	0.269
2	10.520g	8.337g	0.262
3	10.773g	8.597g	0.253
4	10.917g	8.992g	0.214
5	10.417g	8.613g	0.216
		Average =	0.243
		Std =	0.026

Organic Matter Content			
Replicates	dried soil mass (50°C)	dried soil mass (450°C)	% Organic Matter
1	7.897g	3.896g	49.34
2	8.337g	4.258g	51.07
3	8.597g	4.325g	50.31
4	8.992g	4.424g	49.20
5	8.613g	4.247g	49.31
		Average =	49.85
		Std =	0.82

Table A.3. Soil water content and organic matter content of oxidized peat soils. Raw soil was placed in an oven at 50°C for 48 hrs to determine the water content. Oven-dried soil then was placed in an oven at 450°C for 12 hrs to determine the loss of ignition. The loss on ignition is an approximate measure of organic matter.

Water Content			
Replicates	raw soil	dried soil mass (50°C)	Water Content
1	24.203	3.977	5.09
2	25.197	4.144	5.08
3	25.454	4.463	4.70
4	24.593	3.77	5.52
5	25.099	4.467	4.62
		Average =	5.00
		Std =	0.36

Organic Matter Content			
Replicates	dried soil mass (50°C)	dried soil mass (450°C)	% Organic Matter
1	3.977	40.233	37.94
2	4.144	38.481	39.29
3	4.463	40.748	44.30
4	3.770	46.950	36.23
5	4.467	44.782	39.00
		Average =	39.35
		std =	3.01

Table A.4. Soil water content and organic matter content of reduced peat soils. Raw soil was placed in an oven at 50°C for 48 hrs to determine the water content. Oven-dried soil then was placed in an oven at 450°C for 12 hrs to determine the loss of ignition. The loss on ignition is an approximate measure of organic matter.

APPENDIX B - RESULTS OF ABIOTIC EXPEREMENTS

		Number of Extraction				
	Replicate	1st	2nd	3rd	4th	5th
pH Before Filtration	1	NA	NA	NA	NA	NA
	2	6.012	6.166	6.099	6.358	6.438
	3	6.205	6.254	6.183	6.474	6.305
	AVG	6.109	6.210	6.141	6.416	6.372
	STDEV	0.136	0.062	0.059	0.082	0.094
pH After Filtration	1	6.471	6.673	6.776	7.027	6.75
	2	6.372	6.664	6.884	6.985	7.167
	3	6.464	6.736	6.925	7.169	7.234
	AVG	6.436	6.691	6.862	7.060	7.050
	STDEV	0.055	0.039	0.077	0.096	0.262
EC (dS/m) @25 °C	1	0.789	0.359	0.163	0.104	0.078
	2	0.792	0.348	0.172	0.104	0.076
	3	0.778	0.342	0.177	0.103	0.073
	AVG	0.786	0.350	0.170	0.104	0.076
	STDEV	0.008	0.008	0.007	0.001	0.002
UV254	1	2.615	2.729	2.921	3.015	2.982
	2	2.285	2.600	2.982	3.097	3.001
	3	2.211	2.516	2.819	2.861	2.822
	AVG	2.370	2.615	2.907	2.991	2.935
	STDEV	0.216	0.107	0.082	0.120	0.099
TOC (ppm)	1	56.04	57.91	58.07	55.63	49.42
	2	55.33	56.44	60.16	63.41	54.43
	3	54.67	53.00	55.64	56.92	53.46
	AVG	55.35	55.78	57.96	58.65	52.43
	STDEV	0.69	2.52	2.26	4.17	2.66
SUV254	1	0.047	0.047	0.050	0.054	0.060
	2	0.041	0.046	0.050	0.049	0.055
	3	0.040	0.047	0.051	0.050	0.053
	AVG	0.043	0.047	0.050	0.051	0.056
	STDEV	0.003	0.001	0.001	0.003	0.004
STOC (mg C / g soil)	1	0.280	0.290	0.290	0.278	0.247
	2	0.277	0.282	0.301	0.317	0.272
	3	0.273	0.265	0.278	0.285	0.267
	AVG	0.277	0.279	0.290	0.293	0.262
	STDEV	0.003	0.013	0.011	0.021	0.013

Table B.1. Successive extraction data for oxidized peat soils with EC = 0 dS/m.

		Number of Extraction				
	Replicate	1st	2nd	3rd	4th	5th
pH Before Filtration	1	NA	NA	NA	NA	NA
	2	5.95	6.071	5.962	6.041	6.109
	3	6.122	6.121	5.965	6.072	6.077
	AVG	6.036	6.096	5.964	6.057	6.093
	STDEV	0.122	0.035	0.002	0.022	0.023
pH After Filtration	1	6.312	6.639	6.629	6.638	6.571
	2	6.482	6.583	6.678	6.687	6.716
	3	6.427	6.559	6.548	6.704	6.79
	AVG	6.407	6.594	6.618	6.676	6.692
	STDEV	0.087	0.041	0.066	0.034	0.111
EC (dS/m) @25 °C	1	1.14	0.83	0.65	0.62	0.57
	2	1.19	0.83	0.67	0.55	0.57
	3	1.18	0.82	0.70	0.59	0.58
	AVG	1.17	0.83	0.67	0.59	0.58
	STDEV	0.02	0.00	0.03	0.03	0.01
UV254	1	1.8629	1.8451	1.7144	1.5113	1.3674
	2	1.8898	1.7637	1.6999	1.6319	1.4125
	3	1.7934	1.7226	1.5659	1.4595	1.3081
	AVG	1.849	1.777	1.660	1.534	1.363
	STDEV	0.050	0.062	0.082	0.088	0.052
TOC (ppm)	1	45.99	39.80	35.95	26.35	23.73
	2	48.03	38.27	33.05	30.39	24.05
	3	45.91	36.30	30.81	27.97	22.82
	AVG	46.64	38.12	33.27	28.23	23.53
	STDEV	1.20	1.76	2.58	2.03	0.64
SUV254	1	0.041	0.046	0.048	0.057	0.058
	2	0.039	0.046	0.051	0.054	0.059
	3	0.039	0.047	0.051	0.052	0.057
	AVG	0.040	0.047	0.050	0.054	0.058
	STDEV	0.001	0.001	0.002	0.003	0.001
STOC (mg C / g soil)	1	0.230	0.199	0.180	0.132	0.119
	2	0.240	0.191	0.165	0.152	0.120
	3	0.230	0.181	0.154	0.140	0.114
	AVG	0.233	0.191	0.166	0.141	0.118
	STDEV	0.006	0.009	0.013	0.010	0.003

Table B.2. Successive extraction data for oxidized peat soils with EC = 0.5 dS/m and SAR = 5.

		Number of Extraction				
	Replicate	1st	2nd	3rd	4th	5th
pH Before Filtration	1	NA	NA	NA	NA	NA
	2	5.873	5.96	5.722	5.913	5.941
	3	5.943	6.007	5.888	5.841	5.936
	AVG	5.908	5.984	5.805	5.877	5.939
	STDEV	0.049	0.033	0.117	0.051	0.004
pH After Filtration	1	6.233	6.802	6.391	6.426	6.44
	2	6.319	6.542	6.447	6.394	6.531
	3	6.298	6.499	6.456	6.579	6.465
	AVG	6.283	6.614	6.431	6.466	6.479
	STDEV	0.045	0.164	0.035	0.099	0.047
EC (dS/m) @25 °C	1	1.622	1.332	1.103	1.130	1.117
	2	1.675	1.308	1.158	1.070	1.070
	3	1.677	1.204	1.181	1.079	1.059
	AVG	1.658	1.281	1.147	1.093	1.082
	STDEV	0.031	0.068	0.040	0.032	0.031
UV254	1	1.5944	1.4349	1.2632	1.0194	0.9719
	2	1.5552	1.299	1.1999	1.1252	0.9701
	3	1.519	1.2441	1.1207	1.0173	0.894
	AVG	1.556	1.326	1.195	1.054	0.945
	STDEV	0.038	0.098	0.071	0.062	0.045
TOC (ppm)	1	39.87	32.56	25.08	19.60	NA
	2	42.53	30.08	24.60	22.06	17.91
	3	41.82	28.26	23.78	20.39	16.93
	AVG	41.40	30.30	24.49	20.68	17.42
	STDEV	1.38	2.16	0.66	1.26	0.69
SUV254	1	0.040	0.044	0.050	0.052	NA
	2	0.037	0.043	0.049	0.051	0.054
	3	0.036	0.044	0.047	0.050	0.053
	AVG	0.038	0.044	0.049	0.051	0.053
	STDEV	0.002	0.000	0.002	0.001	0.001
STOC (mg C / g soil)	1	0.199	0.163	0.125	0.098	NA
	2	0.213	0.150	0.123	0.110	0.090
	3	0.209	0.141	0.119	0.102	0.085
	AVG	0.207	0.152	0.122	0.103	0.087
	STDEV	0.007	0.011	0.003	0.006	0.003

Table B.3. Successive extraction data for oxidized peat soils with EC = 1 dS/m and SAR = 5.

		Number of Extraction				
	Replicate	1st	2nd	3rd	4th	5th
pH Before Filtration	1					
	2	5.648	5.713	5.543	5.584	5.615
	3	5.649	5.742	5.576	5.588	5.59
	AVG	5.649	5.728	5.560	5.586	5.603
	STDEV	0.001	0.021	0.023	0.003	0.018
pH After Filtration	1	5.969	6.016	5.929	6.052	5.969
	2	5.75	6.018	5.689	5.733	5.818
	3	5.988	6.048	6.041	5.993	5.943
	AVG	5.902	6.027	5.886	5.926	5.910
	STDEV	0.132	0.018	0.180	0.170	0.081
EC (dS/m) @25 °C	1	4.183	4.106	4.118	4.076	4.147
	2	4.198	3.984	4.148	3.957	3.994
	3	4.088	3.826	4.048	3.950	3.829
	AVG	4.156	3.972	4.105	3.994	3.990
	STDEV	0.060	0.141	0.052	0.071	0.159
UV254	1	0.978	0.724	0.592	0.467	0.431
	2	1.018	0.673	0.572	0.505	0.417
	3	0.936	0.638	0.518	0.443	0.393
	AVG	0.977	0.678	0.561	0.472	0.414
	STDEV	0.041	0.043	0.038	0.031	0.019
TOC (ppm)	1	28.20	20.47	14.60	11.25	8.97
	2	27.05	18.33	14.94	12.11	9.39
	3	27.57	17.93	13.24	11.48	8.96
	AVG	27.61	18.91	14.26	11.61	9.10
	STDEV	0.58	1.37	0.90	0.45	0.24
SUV254	1	0.035	0.035	0.041	0.042	0.048
	2	0.038	0.037	0.038	0.042	0.044
	3	0.034	0.036	0.039	0.039	0.044
	AVG	0.035	0.036	0.039	0.041	0.045
	STDEV	0.002	0.001	0.001	0.002	0.002
STOC (mg C / g soil)	1	0.141	0.102	0.073	0.056	0.045
	2	0.135	0.092	0.075	0.061	0.047
	3	0.138	0.090	0.066	0.057	0.045
	AVG	0.138	0.095	0.071	0.058	0.046
	STDEV	0.003	0.007	0.004	0.002	0.001

Table B.4. Successive extraction data for oxidized peat soils with EC = 4 dS/m and SAR = 5.

		Number of Extraction				
	Replicate	1st	2nd	3rd	4th	5th
pH Before Filtration	1	5.558	5.602	5.538	5.489	5.492
	2	5.565	5.589	5.46	5.4	5.465
	AVG	5.562	5.596	5.499	5.445	5.479
	STDEV	0.005	0.009	0.055	0.063	0.019
pH After Filtration	1	5.706	5.886	5.785	5.631	5.709
	2	5.665	5.877	5.649	5.727	5.695
	AVG	5.686	5.882	5.717	5.679	5.702
	STDEV	0.029	0.006	0.096	0.068	0.010
EC (dS/m) @25 °C	1	4.04	4.03	3.87	3.78	4.00
	2	4.10	4.09	4.10	3.88	3.86
	AVG	4.07	4.06	3.98	3.83	3.93
	STDEV	0.04	0.05	0.16	0.07	0.10
UV254	1	0.792	0.565	0.440	0.373	0.317
	2	0.776	0.552	0.404	0.344	0.300
	AVG	0.784	0.558	0.422	0.358	0.309
	STDEV	0.011	0.009	0.025	0.021	0.013
TOC (ppm)	1	27.20	17.88	13.20	11.00	9.21
	2	25.38	17.48	12.19	9.93	8.53
	AVG	26.29	17.68	12.70	10.46	8.87
	STDEV	1.29	0.28	0.71	0.76	0.48
SUV254	1	0.029	0.032	0.033	0.034	0.034
	2	0.031	0.032	0.033	0.035	0.035
	AVG	0.0298	0.0316	0.0332	0.0343	0.0348
	STDEV	0.0010	0.0000	0.0001	0.0005	0.0005
STOC (mg C/ g soil)	1	0.136	0.089	0.066	0.055	0.046
	2	0.127	0.087	0.061	0.050	0.043
	AVG	0.131	0.088	0.063	0.052	0.044
	STDEV	0.006	0.001	0.004	0.004	0.002

Table B.5. Successive extraction data for oxidized peat soils with EC = 4 dS/m and SAR = 0.

		Number of Extraction				
	Replicate	1st	2nd	3rd	4th	5th
pH Before Filtration	1	NA	NA	NA	NA	NA
	2	5.8	5.898	5.85	5.886	5.983
	3	5.778	5.94	5.849	5.907	5.959
	AVG	5.789	5.919	5.850	5.897	5.971
	STDEV	0.016	0.030	0.001	0.015	0.017
pH After Filtration	1	6.206	6.161	6.401	6.178	6.422
	2	6.08	6.523	6.324	6.339	6.495
	3	6.255	6.2911	6.187	6.396	6.586
	AVG	6.180	6.325	6.304	6.304	6.501
	STDEV	0.090	0.183	0.108	0.113	0.082
EC (dS/m) @25 °C	1	4.33	4.14	3.71	4.12	4.19
	2	4.13	3.97	3.97	3.96	4.05
	3	4.34	3.88	4.27	4.08	3.91
	AVG	4.27	3.99	3.98	4.05	4.05
	STDEV	0.12	0.13	0.28	0.08	0.14
UV254	1	1.506	1.434	1.403	1.313	1.435
	2	1.045	1.272	1.348	1.439	1.397
	3	1.417	1.244	1.271	1.277	1.283
	AVG	1.323	1.316	1.341	1.343	1.372
	STDEV	0.244	0.102	0.066	0.085	0.079
TOC (ppm)	1	38.97	32.46	25.08	23.48	23.88
	2	36.54	28.75	27.71	25.59	24.42
	3	35.40	28.07	25.37	23.73	22.03
	AVG	36.97	29.76	26.05	24.27	23.44
	STDEV	1.82	2.37	1.44	1.15	1.26
SUV254	1	0.039	0.044	0.056	0.056	0.060
	2	0.029	0.044	0.049	0.056	0.057
	3	0.040	0.044	0.050	0.054	0.058
	AVG	0.036	0.044	0.052	0.055	0.059
	STDEV	0.006	0.000	0.004	0.001	0.001
STOC (mg C / g soil)	1	0.195	0.162	0.125	0.117	0.119
	2	0.183	0.144	0.139	0.128	0.122
	3	0.177	0.140	0.127	0.119	0.110
	AVG	0.185	0.149	0.130	0.121	0.117
	STDEV	0.009	0.012	0.007	0.006	0.006

Table B.6. Successive extraction data for oxidized peat soils with EC = 4 dS/m and SAR = ∞.

		Number of Extraction					
	Replicate	1st	2nd	3rd	4th	5th	6th
pH Before Filtration	1	5.523	5.616	5.772	6.033	5.999	6.031
	2	5.51	5.639	5.779	6.007	6.099	6.175
	3	5.547	5.642	5.807	5.966	6.053	6.009
	AVG	5.527	5.632	5.786	6.002	6.050	6.072
	STDEV	0.019	0.014	0.019	0.034	0.050	0.090
pH After Filtration	1	6.531	6.828	6.895	6.969	7.423	7.344
	2	6.469	6.73	6.713	6.898	7.252	7.275
	3	6.548	6.529	6.838	6.946	7.319	6.978
	AVG	6.516	6.696	6.815	6.938	7.331	7.199
	STDEV	0.042	0.152	0.093	0.036	0.086	0.194
EC (dS/m) @25 °C	1	0.894	0.502	0.270	0.134	0.078	0.052
	2	0.853	0.474	0.263	0.125	0.070	0.042
	3	0.838	0.480	0.268	0.142	0.086	0.050
	AVG	0.862	0.485	0.267	0.134	0.078	0.048
	STDEV	0.029	0.015	0.004	0.009	0.008	0.005
UV254	1	0.423	0.486	0.537	0.752	0.925	1.037
	2	0.402	0.461	0.561	0.800	0.966	1.098
	3	0.403	0.453	0.529	0.762	0.996	1.187
	AVG	0.409	0.467	0.542	0.771	0.962	1.107
	STDEV	0.012	0.017	0.017	0.026	0.035	0.076
TOC (ppm)	1	15.99	13.58	15.17	15.64	17.90	18.50
	2	16.70	14.59	14.01	16.30	17.45	19.20
	3	15.12	14.52	13.26	16.02	20.35	20.88
	AVG	15.94	14.23	14.15	15.99	18.57	19.53
	STDEV	0.79	0.56	0.96	0.33	1.56	1.22
SUV254	1	0.026	0.036	0.035	0.048	0.052	0.056
	2	0.024	0.032	0.040	0.049	0.055	0.057
	3	0.027	0.031	0.040	0.048	0.049	0.057
	AVG	0.026	0.033	0.038	0.048	0.052	0.057
	STDEV	0.001	0.003	0.003	0.001	0.003	0.001
STOC (mgC/g soil)	1	0.160	0.136	0.152	0.156	0.179	0.185
	2	0.167	0.146	0.140	0.163	0.175	0.192
	3	0.151	0.145	0.133	0.160	0.204	0.209
	AVG	0.159	0.142	0.141	0.160	0.186	0.195
	STDEV	0.008	0.006	0.010	0.003	0.016	0.012

Table B.7. Successive extraction data for reduced peat soil with EC = 0 dS/m.

		Number of Extraction					
	Replicate	1st	2nd	3rd	4th	5th	6th
pH Before Filtration	1	5.443	5.636	5.751	5.702	5.91	6.288
	2	5.469	5.635	5.715	5.64	5.875	6.194
	3	5.406	5.598	5.67	5.74	5.894	6.118
	AVG	5.439	5.623	5.712	5.694	5.893	6.200
	STDEV	0.032	0.022	0.041	0.050	0.018	0.085
pH After Filtration	1	6.525	6.325	6.548	6.219	7.365	6.549
	2	6.562	6.154	6.145	6.3	7.177	6.404
	3	6.466	5.996	6.741	6.433	7.145	6.685
	AVG	6.518	6.158	6.478	6.317	7.229	6.546
	STDEV	0.048	0.165	0.304	0.108	0.119	0.141
EC (dS/m) @25 °C	1	0.95	0.63	0.40	0.27	0.22	0.21
	2	0.97	0.63	0.39	0.27	0.21	0.19
	3	1.00	0.64	0.37	0.28	0.22	0.19
	AVG	0.97	0.63	0.39	0.27	0.22	0.20
	STDEV	0.03	0.01	0.01	0.01	0.01	0.01
UV254	1	0.428	0.420	0.459	0.517	0.554	0.681
	2	0.430	0.423	0.517	0.528	0.586	0.604
	3	0.461	0.429	0.468	0.500	0.531	0.626
	AVG	0.440	0.424	0.481	0.515	0.557	0.637
	STDEV	0.018	0.005	0.031	0.014	0.027	0.039
TOC (ppm)	1	13.77	11.90	11.29	11.11	10.87	12.91
	2	14.84	11.90	11.73	11.26	12.02	11.64
	3	14.03	12.41	11.15	10.82	11.02	12.04
	AVG	14.21	12.07	11.39	11.06	11.30	12.20
	STDEV	0.56	0.29	0.30	0.22	0.63	0.65
SUV254	1	0.031	0.035	0.041	0.047	0.051	0.053
	2	0.029	0.036	0.044	0.047	0.049	0.052
	3	0.033	0.035	0.042	0.046	0.048	0.052
	AVG	0.0310	0.0351	0.0422	0.0466	0.0493	0.0522
	STDEV	0.0019	0.0005	0.0017	0.0003	0.0015	0.0004
STOC (mgC/g soil)	1	0.138	0.119	0.113	0.111	0.109	0.129
	2	0.148	0.119	0.117	0.113	0.120	0.116
	3	0.140	0.124	0.112	0.108	0.110	0.120
	AVG	0.142	0.121	0.114	0.111	0.113	0.122
	STDEV	0.006	0.003	0.003	0.002	0.006	0.006

Table B.8 Successive extraction for reduced peat soil with EC = 0.125 dS/m and SAR =5.

		Number of Extraction					
	Replicate	1st	2nd	3rd	4th	5th	6th
pH Before Filtration	1	5.476	5.488	5.548	5.534	5.587	5.613
	2	5.477	5.529	5.562	5.525	5.584	5.545
	3	5.475	5.504	5.559	5.572	5.615	5.595
	AVG	5.476	5.507	5.556	5.544	5.595	5.584
	STDEV	0.001	0.021	0.007	0.025	0.017	0.035
pH After Filtration	1	6.614	6.781	6.765	6.439	6.612	7.007
	2	6.526	6.931	6.801	6.543	6.485	6.713
	3	6.35	6.812	6.692	6.553	6.317	6.784
	AVG	6.497	6.841	6.753	6.512	6.471	6.835
	STDEV	0.134	0.079	0.056	0.063	0.148	0.153
EC (dS/m) @25 °C	1	1.14	0.93	0.75	0.69	0.66	0.61
	2	1.14	0.93	0.78	0.69	0.65	0.62
	3	1.13	0.91	0.77	0.69	0.65	0.61
	AVG	1.14	0.92	0.77	0.69	0.65	0.61
	STDEV	0.00	0.01	0.02	0.00	0.00	0.01
UV254	1	0.359	0.375	0.342	0.351	0.332	0.296
	2	0.362	0.386	0.335	0.331	0.310	0.288
	3	0.367	0.378	0.362	0.344	0.324	0.294
	AVG	0.363	0.380	0.346	0.342	0.322	0.293
	STDEV	0.004	0.006	0.014	0.010	0.011	0.004
TOC (ppm)	1	14.66	12.00	10.05	9.30	8.41	7.21
	2	14.58	12.17	10.06	10.97	7.56	7.25
	3	14.71	12.60	10.34	9.07	10.18	6.96
	AVG	14.65	12.26	10.15	9.78	8.71	7.14
	STDEV	0.07	0.31	0.16	1.04	1.34	0.16
SUV254	1	0.024	0.031	0.034	0.038	0.040	0.041
	2	0.025	0.032	0.033	0.030	0.041	0.040
	3	0.025	0.030	0.035	0.038	0.032	0.042
	AVG	0.025	0.031	0.034	0.035	0.037	0.041
	STDEV	0.000	0.001	0.001	0.004	0.005	0.001
STOC (mgC/g soil)	1	0.147	0.120	0.101	0.093	0.084	0.072
	2	0.146	0.122	0.101	0.110	0.076	0.072
	3	0.147	0.126	0.103	0.091	0.102	0.070
	AVG	0.147	0.123	0.102	0.098	0.087	0.071
	STDEV	0.001	0.003	0.002	0.010	0.013	0.002

Table B.9. Successive extractions for reduced peat soil with EC = 0.5 dS/m and SAR =5.

		Number of Extraction					
	Replicate	1st	2nd	3rd	4th	5th	6th
pH Before Filtration	1	5.172	5.071	5.201	5.132	5.131	5.263
	2	5.17	5.064	5.163	5.122	5.13	5.226
	3	5.174	5.099	5.141	5.154	5.142	5.222
	AVG	5.172	5.078	5.168	5.136	5.134	5.237
	STDEV	0.002	0.019	0.030	0.016	0.007	0.023
pH After Filtration	1	6.543	5.321	5.2	5.278	5.201	5.221
	2	6.513	5.28	5.154	5.296	5.209	5.237
	3	6.51	5.309	5.146	5.232	5.191	5.256
	AVG	6.522	5.303	5.167	5.269	5.200	5.238
	STDEV	0.018	0.021	0.029	0.033	0.009	0.018
EC (dS/m) @25 °C	1	3.01	3.57	3.96	4.12	4.06	4.21
	2	3.03	3.52	3.98	4.10	3.88	4.01
	3	2.96	3.45	3.85	4.16	3.94	4.11
	AVG	3.00	3.51	3.93	4.13	3.96	4.11
	STDEV	0.04	0.06	0.07	0.03	0.09	0.10
UV254	1	0.254	0.222	0.156	0.129	0.113	0.088
	2	0.270	0.207	0.159	0.130	0.108	0.112
	3	0.385	0.204	0.156	0.111	0.112	0.103
	AVG	0.303	0.211	0.157	0.123	0.111	0.101
	STDEV	0.071	0.010	0.002	0.010	0.003	0.012
TOC (ppm)	1	11.44	8.30	6.24	4.97	4.43	3.66
	2	11.63	8.62	6.71	5.05	4.01	3.62
	3	11.81	8.43	6.67	5.13	3.98	4.01
	AVG	11.63	8.45	6.54	5.05	4.14	3.76
	STDEV	0.19	0.16	0.26	0.08	0.25	0.21
SUV254	1	0.022	0.027	0.025	0.026	0.026	0.024
	2	0.023	0.024	0.024	0.026	0.027	0.031
	3	0.033	0.024	0.023	0.022	0.028	0.026
	AVG	0.0260	0.0250	0.0241	0.0244	0.0269	0.0268
	STDEV	0.0057	0.0015	0.0009	0.0024	0.0013	0.0035
STOC (mgC/g soil)	1	0.114	0.083	0.062	0.050	0.044	0.037
	2	0.116	0.086	0.067	0.050	0.040	0.036
	3	0.118	0.084	0.067	0.051	0.040	0.040
	AVG	0.116	0.085	0.065	0.050	0.041	0.038
	STDEV	0.002	0.002	0.003	0.001	0.003	0.002

Table B.10. Successive extraction data for reduced peat soil with EC = 4 dS/m and SAR = 5.

		Number of Extraction					
	Replicate	1st	2nd	3rd	4th	5th	6th
pH Before Filtration	1	5.117	5.101	5.023	5.18	5.121	4.989
	2	5.087	5.024	5.024	5.138	5.138	5.006
	3	5.083	5.032	5.033	5.125	5.108	5.01
	AVG	5.096	5.052	5.027	5.148	5.122	5.002
	STDEV	0.019	0.042	0.006	0.029	0.015	0.011
pH After Filtration	1	5.947	6.127	5.955	5.28	5.212	5.344
	2	6.239	5.981	5.885	5.273	5.232	5.324
	3	6.357	5.796	5.782	5.247	5.512	5.369
	AVG	6.181	5.968	5.874	5.267	5.319	5.346
	STDEV	0.211	0.166	0.087	0.017	0.168	0.023
EC (dS/m) @25 °C	1	2.97	3.51	3.78	3.90	4.16	4.19
	2	3.00	3.30	3.80	3.96	4.15	4.19
	3	2.99	3.41	3.82	3.95	4.15	4.27
	AVG	2.99	3.41	3.80	3.94	4.15	4.22
	STDEV	0.02	0.11	0.02	0.03	0.01	0.04
UV254	1	0.208	0.163	0.185	0.127	0.095	0.108
	2	0.216	0.158	0.146	0.096	0.088	0.098
	3	0.205	0.146	0.145	0.151	0.088	0.106
	AVG	0.210	0.156	0.159	0.125	0.090	0.104
	STDEV	0.006	0.009	0.023	0.027	0.004	0.005
TOC (ppm)	1	11.73	10.77	8.02	5.14	4.64	3.51
	2	12.86	10.08	6.88	4.87	4.36	3.63
	3	12.70	8.39	6.97	4.98	4.29	3.58
	AVG	12.43	9.75	7.29	5.00	4.43	3.57
	STDEV	0.61	1.22	0.63	0.13	0.19	0.06
SUV254	1	0.018	0.015	0.023	0.025	0.020	0.031
	2	0.017	0.016	0.021	0.020	0.020	0.027
	3	0.016	0.017	0.021	0.030	0.020	0.030
	AVG	0.0169	0.0161	0.0217	0.0249	0.0203	0.0291
	STDEV	0.0008	0.0012	0.0012	0.0053	0.0002	0.0019
STOC (mgC/g soil)	1	0.117	0.108	0.080	0.051	0.046	0.035
	2	0.129	0.101	0.069	0.049	0.044	0.036
	3	0.127	0.084	0.070	0.050	0.043	0.036
	AVG	0.124	0.097	0.073	0.050	0.044	0.036
	STDEV	0.006	0.012	0.006	0.001	0.002	0.001

Table B. 11. Successive extraction data for reduced peat soil with EC = 4 dS/m and SAR = 0.

		Number of Extraction					
	Replicate	1st	2nd	3rd	4th	5th	6th
pH Before Filtration	1	5.376	5.389	5.378	5.556	5.616	5.514
	2	5.429	5.367	5.378	5.534	5.596	5.501
	3	5.346	5.35	5.374	5.52	5.565	5.547
	AVG	5.384	5.369	5.377	5.537	5.592	5.521
	STDEV	0.042	0.020	0.002	0.018	0.026	0.024
pH After Filtration	1	7.167	6.603	6.172	6.422	6.436	6.446
	2	6.5	6.361	6.033	6.214	6.369	6.36
	3	6.604	6.247	6.231	6.121	6.369	6.452
	AVG	6.757	6.404	6.145	6.252	6.391	6.419
	STDEV	0.359	0.182	0.102	0.154	0.039	0.051
EC (dS/m) @25 °C	1	3.20	3.68	3.89	4.12	4.02	4.37
	2	3.06	3.79	4.04	4.15	4.17	4.30
	3	3.08	3.70	3.98	4.10	4.07	4.46
	AVG	3.11	3.72	3.97	4.12	4.09	4.38
	STDEV	0.08	0.06	0.08	0.03	0.07	0.08
UV254	1	0.417	0.315	0.309	0.308	0.334	0.409
	2	0.360	0.322	0.321	0.306	0.337	0.373
	3	0.341	0.320	0.319	0.309	0.483	0.362
	AVG	0.373	0.319	0.317	0.307	0.385	0.381
	STDEV	0.040	0.004	0.007	0.001	0.085	0.025
TOC (ppm)	1	22.42	10.57	8.735	8.19	7.911	7.87
	2	13.42	10.84	9.255	8.064	7.839	7.611
	3	12.65	10.53	8.94	8.553	8.193	7.633
	AVG	16.163	10.647	8.977	8.269	7.981	7.705
	STDEV	5.432	0.169	0.262	0.254	0.187	0.144
SUV254	1	0.019	0.030	0.035	0.038	0.042	0.052
	2	0.027	0.030	0.035	0.038	0.043	0.049
	3	0.027	0.030	0.036	0.036	0.059	0.047
	AVG	0.024	0.030	0.035	0.037	0.048	0.049
	STDEV	0.005	0.000	0.001	0.001	0.009	0.002
STOC (mgC/g soil)	1	0.224	0.106	0.087	0.082	0.079	0.079
	2	0.134	0.108	0.093	0.081	0.078	0.076
	3	0.127	0.105	0.089	0.086	0.082	0.076
	AVG	0.162	0.106	0.090	0.083	0.080	0.077
	STDEV	0.054	0.002	0.003	0.003	0.002	0.001

Table B. 12. Successive extraction data for reduced peat soil with EC = 4 dS/m and SAR = ∞.

APPENDIX C - WASH PROCEDURE AND ANALYTICAL RESULTS OF THE REMOVAL INITIAL DOC OF OXIDIZED PEAT SOIL

A scheme as shown in Figure C.1 was used to wash out the initial DOC that accumulated in the surface peat soil. This procedure is necessary because our preliminary study showed that the background DOC in the soil was high such that the increases of DOC from two-month incubation experiment were relative small and the biotic effects from the experiments were difficult to evaluate. As shown, the setup included a 10L plastic bucket with a 0.004-inche diameter stainless steel screen at the bottom. A 27 cm, which is exactly the same diameter of the bucket, Whatman #1 filter paper was placed inside the bucket before 5.5 kg air dried surface soil was packed. Then, the bucket was placed inside a 18"x12"x12" high-density-polyethylene (HDPE) regular tank. A synthesized carbon free solution with EC = 0.5 dS/m and SAR = 5 was filled the tank such that the water level was just above the soil surface. An inverted glass funnel, which wide mouth is also 27 cm, with 0.004-inch diameter stainless steel screen at the wide mouth was placed on the top of the soil column. Water can seepage through the bottom and the water was slowly pumped from the inverted funnel on the top of the soil column. The flow rate was controlled by a peristaltic pump at about 0.1 L/min. The water level in the regular tank was maintained at a constant level by a constant head device. In addition, four glass air bubbling tubes are installed at each corner of the water tank so that the water was saturated with air to avoid the reduced condition developing in the soil column. Dissolved Oxygen (DO) was continually measured at effluent from the soil column. The DO was not less than 5 ppm through the whole course of the washing procedure. Thus, the oxic environment in the soil column could be maintained. This washing procedure was ended when UV254 and EC of effluents were not changed significantly. Total 275L synthesized solutions flowed through the soil column and total wash time was about 50 hours. All the equipment was acid-washed before use. After the wash, the soils were then air dried and stored in 4°C before use. The analysis of the leaching water for TOC and UV_{254} were summarized in Figure C.2.

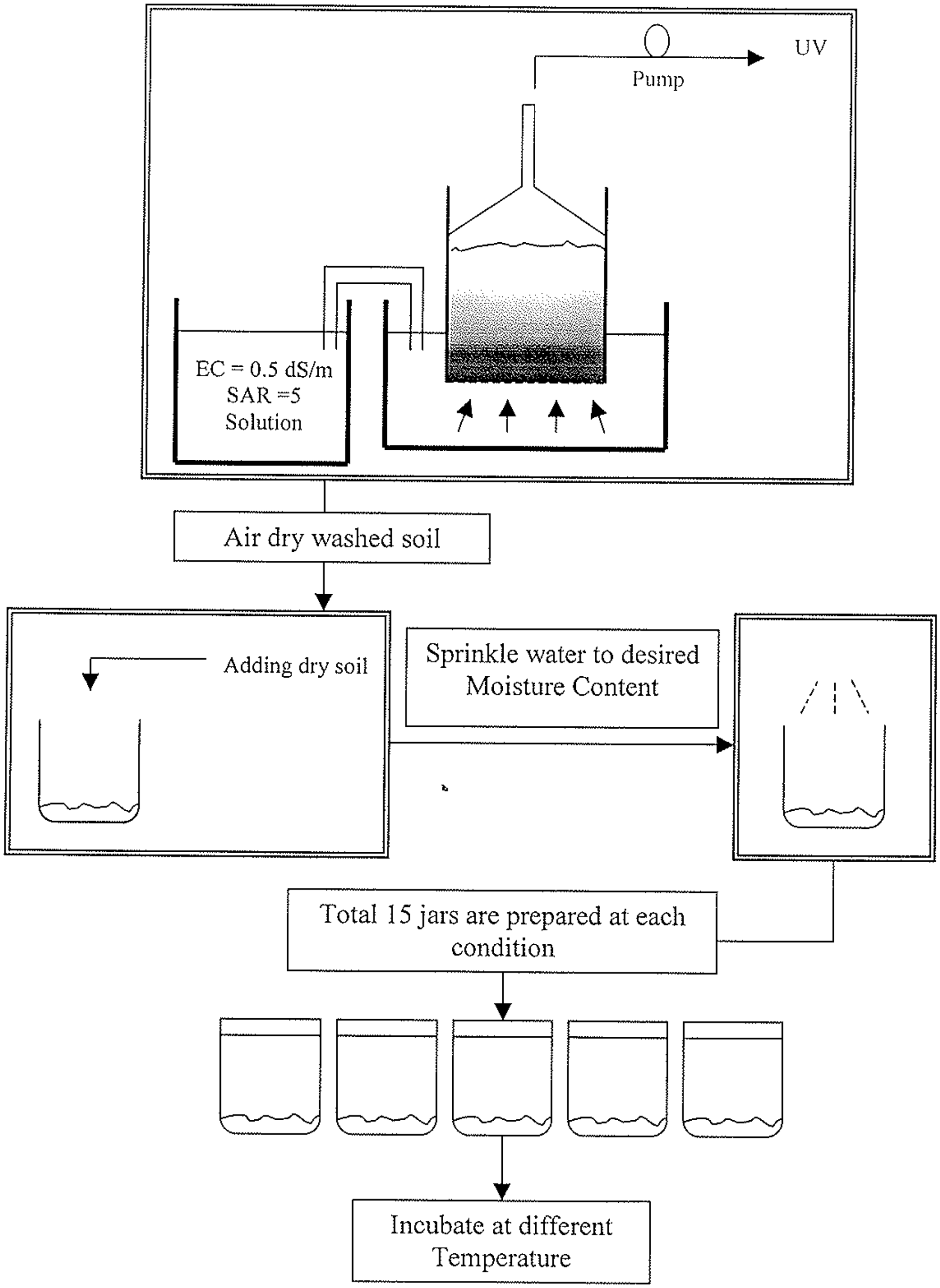


Figure C.1. The scheme of soil wash and incubation of the oxidized peat soil.

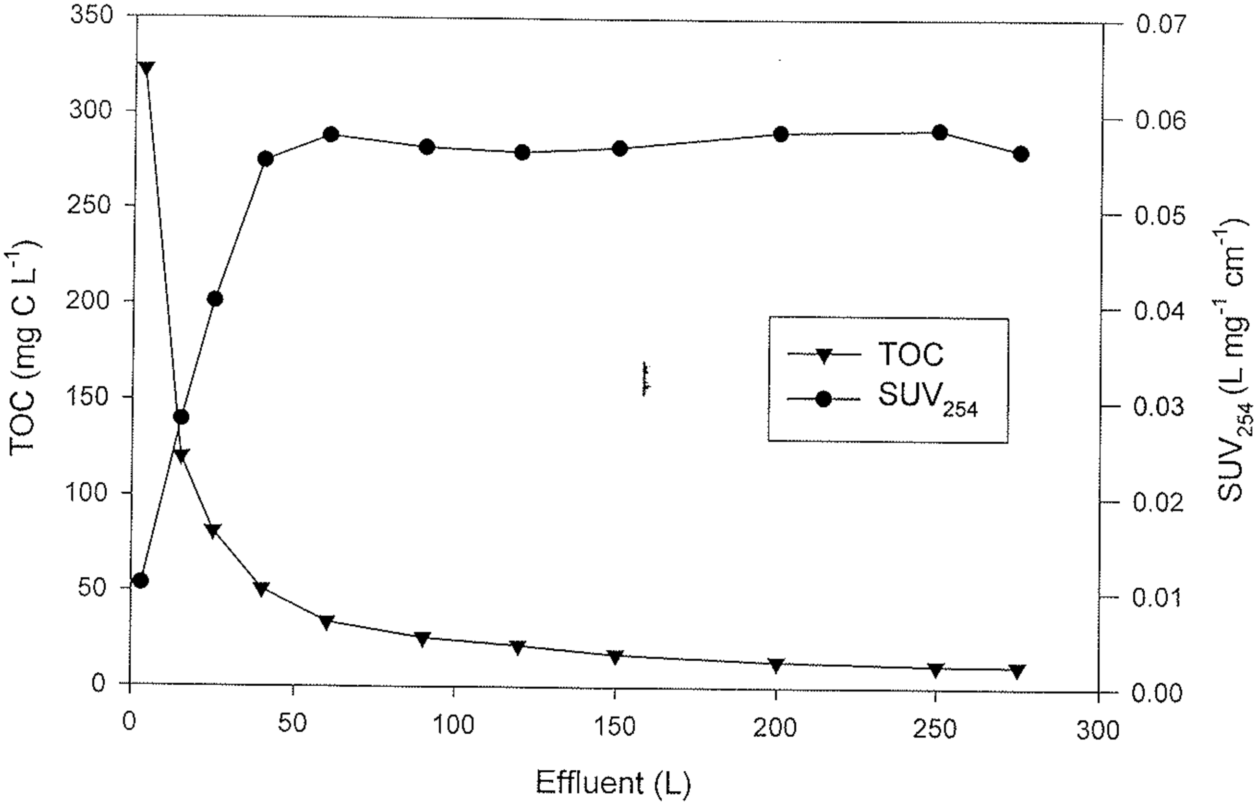


Figure C.2. The TOC and SUV$_{254}$ of effluent of soil wash for the oxidized peat soil.

APPENDIX D

RESULTS OF SPECIATION OF TRIHALOMETHANE FORMATION POTENTIAL AND ASSOCIATED PARAMETERS

Table D.1. Results of speciation of trihalomethane formation potential and associated parameters for oxidized peat soil from the Sacramento-San Joaquin Delta.

	samples	Replicates	DOC	$CHCl_3$	$CHCl_2Br$	$CHBr_2Cl$	$CHBr_3$	THMFP	STHMFP
oxidized soil	XAD-8 Eluate	1	0.79	87.12	4.18	0.95	2.01	94.26	119.62
		2	0.96	91.34	3.68	0.76	2.00	97.79	101.54
		3	0.86	87.35	3.61	0.77	2.00	93.73	108.54
		average	0.87	88.60	3.83	0.83	2.00	95.26	109.90
		std	0.09	2.38	0.31	0.11	0.00	2.20	9.11
	XAD-4 Eluate	1	0.96	54.51	7.00	1.41	2.03	64.94	67.69
		2	0.98	42.46	3.63	1.18	2.07	49.33	50.11
		3	0.80	35.66	3.11	0.92	2.03	41.72	51.98
		average	0.92	44.21	4.58	1.17	2.04	52.00	56.59
		std	0.10	9.55	2.11	0.24	0.02	11.84	9.66
	XAD-4 Effluent	1	0.89	31.69	2.44	0.81	1.09	36.04	40.37
		2	0.74	28.64	6.76	1.68	1.02	38.10	51.63
		3	0.75	31.97	7.97	2.22	1.04	43.20	57.63
		average	0.79	30.77	5.72	1.57	1.05	39.11	49.88
		std	0.09	1.85	2.91	0.71	0.04	3.69	8.76

Table D.2. Results of speciation of trihalomethane formation potential and associated parameters for reduced peat soil from the Sacramento-San Joaquin Delta.

	samples	Replicates	DOC	$CHCl_3$	$CHCl_2Br$	$CHBr_2Cl$	$CHBr_3$	THMFP	STHMFP
Reduced soil	XAD-8 Eluate	1	0.85	32.57	0	0	0	32.57	38.51
		2	0.98	50.74	0	0	0	50.74	51.56
		average	0.91	41.65	0	0	0	41.65	45.04
		std	0.10	12.85	0	0	0	12.85	9.23
	XAD-4 Eluate	1	0.84	31.15	6.71	0	0	37.86	45.19
		2	1.09	50.54	7.13	0	0	57.67	52.72
		average	0.97	40.84	6.92	0	0	47.76	48.96
		std	0.18	13.71	0.30	0	0	14.01	5.33
	XAD-4 Effluent	1	0.84	12.67	10.65	2.24	0	25.56	30.56
		2	0.71	20.45	12.12	5.24	0	37.81	53.05
		average	0.77	16.56	11.39	3.74	0	31.69	41.81
		std	0.09	5.50	1.04	2.13	0	8.66	15.90

Table D.3. Results of speciation of trihalomethane formation potential and associated parameters for salinity successive extractions of the reduced peat soils from the Sacramento-San Joaquin Delta.

Solution Used	Samples	Replicates	DOC	$CHCl_3$	$CHCl_2Br$	$CHBr_2Cl$	$CHBr_3$	THMFP	STHMFP
Distilled Water	1st extraction	1	1.60	86.95	2.10	0	0	89.05	55.69
		2	1.67	109.97	4.82	0	0	114.79	68.74
		3	1.51	132.73	9.77	0	0	142.50	94.25
		average	1.59	109.88	5.56	0	0	115.45	72.89
		std	0.08	22.89	3.89	0	0	26.73	19.61
Distilled Water	6th extraction	1	1.85	181.20	0	0	0	181.20	97.95
		2	1.92	230.23	0	0	0	230.23	119.91
		3	2.09	255.13	0	0	0	255.13	122.19
		average	1.95	222.19	0	0	0	222.19	113.35
		std	0.12	37.61	0	0	0	37.61	13.39
EC=0.5dS/m SAR=5	1st extraction	1	1.83	132.30	4.79	0	0	137.09	74.79
		2	1.82	127.29	7.13	0	0	134.42	73.73
		3	1.84	147.30	13.99	0	0	161.29	87.71
		average	1.83	135.63	8.64	0	0	144.27	78.74
		std	0.01	10.41	4.78	0	0	14.80	7.78
EC=0.5dS/m SAR=5	6th extraction	1	1.80	180.70	0	0	0	180.70	100.22
		2	1.81	165.36	1.23	0	0	166.59	91.94
		3	1.74	211.25	2.05	0	0	213.30	122.59
		average	1.79	185.77	1.09	0	0	186.86	104.91
		std	0.04	23.36	1.03	0	0	23.96	15.85

Table D.4. Results of speciation of trihalomethane formation potential and associated parameters for SAR successive extractions of the reduced peat soils from the Sacramento-San Joaquin Delta.

Solution Used	Samples	Replicates	DOC	$CHCl_3$	$CHCl_2Br$	$CHBr_2Cl$	$CHBr_3$	THMFP	STHMFP
EC=4dS/m SAR = 0	1st extraction	1	1.96	120.06	15.29	0	0	135.35	69.23
		2	2.14	126.83	17.67	1.21	0	145.71	68.09
		3	2.12	142.88	25.06	1.90	0	169.84	80.11
		average	2.07	129.92	19.34	1.04	0	150.30	72.48
		std	0.10	11.72	5.10	0.96	0	17.70	6.64
EC=4dS/m SAR = 0	6th extraction	1	1.76	98.16	32.27	3.31	0	133.74	76.21
		2	1.82	87.81	29.57	6.31	0	123.69	68.15
		3	1.79	141.49	41.15	11.73	0	194.38	108.59
		average	1.79	109.16	34.33	7.11	0	150.60	84.32
		std	0.03	28.48	6.06	4.27	0	38.24	21.41
EC=4dS/m SAR=infinite	1st extraction	1	2.24	96.53	11.60	0	0.32	108.45	48.35
		2	2.24	160.68	19.15	0.03	0	179.86	80.40
		3	2.11	190.25	28.74	0.37	0	219.37	104.06
		average	2.20	149.15	19.83	0.13	0.11	169.22	77.61
		std	0.08	47.91	8.59	0.20	0.19	56.22	27.96
EC=4dS/m SAR=infinite	6th extraction	1	1.97	169.61	17.78	0	0	187.39	95.22
		2	1.90	174.59	19.50	0	0	194.08	102.04
		3	1.91	198.18	29.31	0	0	227.49	119.23
		average	1.93	180.79	22.20	0	0	202.99	105.50
		std	0.04	15.26	6.22	0	0	21.48	12.37

Table D.5. Results of speciation of trihalomethane formation potential and associated parameters for oxidized and reduced peat soils from the Sacramento-San Joaquin Delta

	samples	Replicates	DOC	$CHCl_3$	$CHCl_2Br$	$CHBr_2Cl$	$CHBr_3$	THMFP	STHMFP
Before Incubation	oxidized soil	1	0.79	71.03	0	0	0	71.03	90.45
		2	0.79	53.16	0	0	0	53.16	67.50
		3	0.83	63.45	0	0	0	63.45	76.33
		4	0.76	65.53	0	0	0	65.53	86.49
		average	0.79	63.29	0	0	0	63.29	80.19
		std	0.03	7.47	0	0	0	7.47	10.34
Before Incubation	reduced soil	1	1.06	55.09	7.28	1.55	2.03	65.96	62.28
		2	1.11	59.71	7.34	1.62	2.04	70.70	63.42
		3	1.03	56.67	8.17	8.87	9.81	83.53	80.98
		4	1.06	57.19	6.35	1.22	2.03	66.79	63.19
		average	1.07	57.17	7.28	3.31	3.98	71.74	67.47
		std	0.04	1.92	0.74	3.71	3.89	8.12	9.02

Table D.6. Results of speciation of trihalomethane formation potential and associated parameters for temperature effect incubation experiments for the oxidized peat soils from the Sacramento-San Joaquin Delta.

	samples	Replicates	DOC	$CHCl_3$	$CHCl_2Br$	$CHBr_2Cl$	$CHBr_3$	THMFP	STHMFP
After	T=10°C	1	2.20	149.80	0	0	0	149.80	68.12
8-week	θ_g =0.3	2	2.18	166.54	0	0	0	166.54	76.33
Incubation		3	2.11	170.84	0	0	0	170.84	81.12
		average	2.16	162.39	0	0	0	162.39	75.19
		std	0.05	11.12	0	0	0	11.12	6.57
After	T=20°C	1	2.23	162.86	0	0	0	162.86	73.19
8-week	θ_g =0.3	2	2.19	155.86	0	0	0	155.86	71.07
Incubation		3	2.19	170.16	0	0	0	170.16	77.77
		average	2.20	162.96	0	0	0	162.96	74.01
		std	0.02	7.15	0	0	0	7.15	3.42
After	T=30°C	1	2.41	171.80	0	0	0	171.80	71.17
8-week	θ_g =0.3	2	2.46	171.15	0	0	0	171.15	69.60
Incubation		3	2.56	189.05	0	0	0	189.05	73.76
		average	2.48	177.33	0	0	0	177.33	71.51
		std	0.08	10.16	0	0	0	10.16	2.10

Table D.7. Results of speciation of trihalomethane formation potential and associated parameters for moisture effect incubation experiments for the oxidized peat soils from the Sacramento-San Joaquin Delta.

	samples	Replicates	DOC	$CHCl_3$	$CHCl_2Br$	$CHBr_2Cl$	$CHBr_3$	THMFP	STHMFP
After	T=20°C	1	1.78	103.40	0	0	0	103.40	58.22
8-week	θ_g =0.7	2	1.76	100.84	0	0	0	100.84	57.46
Incubation		3	1.79	106.55	0	0	0	106.55	59.53
		average	1.77	103.60	0	0	0	103.60	58.40
		std	0.02	2.86	0	0	0	2.86	1.05
After	T=20°C	1	1.64	81.34	2.07	0	0	83.41	50.99
8-week	θ_g =2.0	2	1.61	80.13	2.50	0	0	82.63	51.39
Incubation		3	1.82	40.67	0	0	0	40.67	22.39
		average	1.69	67.38	1.52	0	0	68.90	41.59
		std	0.11	23.14	1.34	0	0	24.46	16.62
After	T=20°C	1	1.88	100.25	0	0	0	100.25	53.24
8-week	wet-dry	2	1.92	105.83	0	0	0	105.83	55.01
Incubation	cycles	3	2.00	112.78	0	0	0	112.78	56.45
		average	1.94	106.29	0	0	0	106.29	54.90
		std	0.06	6.28	0	0	0	6.28	1.61

Table D.8. Results of speciation of trihalomethane formation potential and associated parameters for temperature and wet-dry cycle effect incubation experiments for the reduced peat soils from the Sacramento-San Joaquin Delta.

	samples	Replicates	DOC	$CHCl_3$	$CHCl_2Br$	$CHBr_2Cl$	$CHBr_3$	THMFP	STHMFP
After	T=10°C	1	1.75	44.26	0	0	0	44.26	25.36
8-week	θ_g =5	2	1.72	53.27	0	0	0	53.27	30.91
Incubation		average	1.73	48.76	0	0	0	48.76	28.14
		std	0.02	6.37	0	0	0	6.37	3.93
After	T=20°C	1	1.58	35.54	0	0	0	35.54	22.57
8-week	θ_g =5	2	1.53	17.40	0	0	0	17.40	11.36
Incubation		average	1.55	26.47	0	0	0	26.47	16.96
		std	0.03	12.83	0	0	0	12.83	7.93
After	T=30°C	1	1.64	48.90	0	0	0	48.90	29.87
8-week	θ_g =5	2	1.76	59.69	0	0	0	59.69	34.01
Incubation		average	1.70	54.29	0	0	0	54.29	31.94
		std	0.08	7.63	0	0	0	7.63	2.93
After	T=20°C	1	1.54	63.93	0	0	0	63.93	41.54
8-week	wet-dry	2	1.52	55.68	0	0	0	55.68	36.53
Incubation	cycle	3	1.50	55.25	0	0	0	55.25	36.96
		average	1.52	58.29	0	0	0	58.29	38.34
		std	0.02	4.89	0	0	0	4.89	2.77

APPENDIX E - ANALYTICAL RESULTS OF WATER EXTRACTS IN THE BIOTIC EXPERIMENTS

Table E.1. Results of batch incubation for oxidized peat soil at T =10°c and $\theta_g = 0.3$.

pH before filtration						
Week	R1	R2	R3	R4	average	std
t=0	6.27	6.24	6.25	6.24	6.25	0.01
t=1	6.27	6.26	NA	NA	6.26	0.01
t=2	6.17	6.17	6.18	NA	6.17	0.01
t=4	6.10	6.11	6.16	NA	6.13	0.03
t=6	6.32	6.32	6.33	NA	6.32	0.01
t=8	6.16	6.19	6.16	NA	6.17	0.02

TOC (mg/L)						
Week	R1	R2	R3	R4	average	std
t=0	39.45	39.40	41.57	37.93	39.59	1.50
t=1	27.05	27.42	27.33	NA	27.27	0.19
t=2	26.20	28.34	28.86	NA	27.80	1.41
t=4	24.91	25.88	25.53	NA	25.44	0.49
t=6	23.47	23.05	23.24	NA	23.25	0.21
t=8	21.99	21.82	21.06	NA	21.62	0.50

SUV254 (L mg^{-1} cm^{-1})						
Week	R1	R2	R3	R4	average	std
t=0	0.0398	0.0393	0.0370	0.0396	0.0389	0.0013
t=1	0.0470	0.0442	0.0441	NA	0.0451	0.0017
t=2	0.0451	0.0414	0.0413	NA	0.0426	0.0022
t=4	0.0404	0.0416	0.0416	NA	0.0412	0.0007
t=6	0.0429	0.0423	0.0425	NA	0.0426	0.0003
t=8	0.0467	0.0445	0.0443	NA	0.0452	0.0013

Table E.2. Results of batch incubation for oxidized peat soil at $T = 20^{o}$c and $\theta_g = 0.3$.

pH before filtration						
Week	R1	R2	R3	R4	average	std
t=0	6.27	6.24	6.25	6.24	6.25	0.01
t=1	6.20	6.21	6.21	NA	6.21	0.01
t=2	6.27	6.27	6.30	NA	6.28	0.02
t=4	6.18	6.20	6.17	NA	6.18	0.02
t=6	6.16	6.13	6.13	NA	6.14	0.02
t=8	6.23	6.23	6.23	NA	6.23	0.00

TOC (mg/L)						
Week	R1	R2	R3	R4	average	std
t=0	39.45	39.40	41.57	37.93	39.59	1.50
t=1	26.03	24.59	24.91	NA	25.18	0.75
t=2	26.06	26.28	26.61	NA	26.32	0.28
t=4	24.10	23.58	23.42	NA	23.70	0.35
t=6	20.15	21.50	21.21	NA	20.95	0.71
t=8	22.25	21.93	21.88	NA	22.02	0.20

SUV254 (L mg^{-1} cm^{-1})						
Week	R1	R2	R3	R4	average	std
t=0	0.040	0.039	0.037	0.040	0.039	0.001
t=1	0.042	0.043	0.042	NA	0.042	0.001
t=2	0.036	0.038	0.038	NA	0.037	0.001
t=4	0.038	0.038	0.039	NA	0.038	0.001
t=6	0.042	0.041	0.040	NA	0.041	0.001
t=8	0.044	0.041	0.042	NA	0.042	0.001

Table E.3. Results of batch incubation for the oxidized peat soil at T =30°c and $\theta_g = 0.3$.

pH before filtration						
Week	R1	R2	R3	R4	average	std
t=0	6.27	6.24	6.25	6.24	6.25	0.01
t=1	6.17	6.28	6.31	NA	6.25	0.08
t=2	6.17	6.19	6.19	NA	6.18	0.01
t=4	6.12	6.17	6.16	NA	6.15	0.02
t=6	6.31	6.29	6.30	NA	6.30	0.01
t=8	6.15	6.18	6.19	NA	6.17	0.02

TOC (mg/L)						
Week	R1	R2	R3	R4	average	std
t=0	39.45	39.40	41.57	37.93	39.59	1.50
t=1	25.12	24.39	23.66	NA	24.39	0.73
t=2	26.57	25.40	25.85	NA	25.94	0.59
t=4	25.40	25.39	25.32	NA	25.37	0.04
t=6	24.52	24.84	24.53	NA	24.63	0.18
t=8	24.14	24.59	25.63	NA	24.79	0.76

SUV254 (L mg^{-1} cm^{-1})						
Week	R1	R2	R3	R4	average	std
t=0	0.040	0.039	0.037	0.040	0.039	0.001
t=1	0.044	0.041	0.042	NA	0.042	0.001
t=2	0.038	0.041	0.040	NA	0.040	0.001
t=4	0.039	0.039	0.039	NA	0.039	0.000
t=6	0.039	0.039	0.039	NA	0.039	0.000
t=8	0.042	0.042	0.042	NA	0.042	0.000

Table E.4. Results of batch incubation for the oxidized peat soil at T =20°c and $\theta_g = 0.7$.

pH before filtration						
Week	R1	R2	R3	R4	average	std
t=0	6.27	6.24	6.25	6.24	6.25	0.01
t=1	6.22	6.15	6.21	NA	6.19	0.03
t=2	6.15	6.19	6.19	NA	6.18	0.02
t=4	6.09	5.98	6.01	NA	6.03	0.06
t=6	5.87	6.01	5.94	NA	5.94	0.07
t=8	5.76	5.91	5.78	NA	5.82	0.08

TOC (mg/L)						
Week	R1	R2	R3	R4	average	std
t=0	39.45	39.40	41.57	37.93	39.59	1.50
t=1	29.82	32.24	29.66	NA	30.57	1.45
t=2	24.19	24.96	26.46	NA	25.21	1.16
t=4	19.92	19.96	19.64	NA	19.84	0.17
t=6	19.05	19.65	19.38	NA	19.36	0.30
t=8	17.76	17.55	17.90	NA	17.74	0.18

SUV254 (L mg^{-1} cm^{-1})						
Week	R1	R2	R3	R4	average	std
t=0	0.040	0.039	0.037	0.040	0.039	0.001
t=1	0.041	0.038	0.040	NA	0.040	0.002
t=2	0.050	0.047	0.044	NA	0.047	0.003
t=4	0.047	0.047	0.048	NA	0.047	0.000
t=6	0.050	0.046	0.048	NA	0.048	0.002
t=8	0.049	0.049	0.049	NA	0.049	0.000

Table E.5. Results of batch incubation for oxidized peat soil at T =20°c and θ_g = 2.0.

pH before filtration						
Week	R1	R2	R3	R4	average	std
t=0	6.27	6.24	6.25	6.24	6.25	0.01
t=1	6.27	6.27	NA	NA	6.27	0.00
t=2	6.29	6.33	NA	NA	6.31	0.03
t=4	6.33	6.29	6.29	NA	6.30	0.02
t=6	6.29	6.27	6.25	NA	6.27	0.02
t=8	6.20	6.12	6.18	NA	6.17	0.04

TOC (mg/L)						
Week	R1	R2	R3	R4	average	std
t=0	39.45	39.40	41.57	37.93	39.59	1.50
t=1	64.10	62.95	NA	NA	63.52	0.81
t=2	59.28	54.09	NA	NA	56.69	3.67
t=4	55.13	51.07	49.74	NA	51.98	2.81
t=6	43.38	43.57	42.12	NA	43.02	0.79
t=8	40.90	40.21	45.41	NA	42.17	2.82

SUV254 (L mg^{-1} cm^{-1})						
Week	R1	R2	R3	R4	average	std
t=0	0.040	0.039	0.037	0.040	0.039	0.001
t=1	0.036	0.033	NA	NA	0.035	0.002
t=2	0.039	0.038	NA	NA	0.039	0.001
t=4	0.043	0.045	0.045	NA	0.044	0.001
t=6	0.043	0.044	0.043	NA	0.043	0.000
t=8	0.045	0.044	0.044	NA	0.044	0.001

Table E.6. Results of batch incubation for oxidized peat soil at T =20°c with wet-dry cycles.

pH before filtration						
Week	R1	R2	R3	R4	average	std
t=0	6.27	6.24	6.25	6.24	6.25	0.01
t=3	6.14	6.16	6.17	NA	6.16	0.01
t=6	6.21	6.13	6.17	NA	6.17	0.04
t=9	6.04	6.16	6.15	NA	6.12	0.06

TOC (mg/L)						
Week	R1	R2	R3	R4	average	std
t=0	39.45	39.40	41.57	37.93	39.59	1.50
t=3	61.79	63.09	61.89		62.25	0.72
t=6	54.79	44.14	48.70		49.21	5.34
t=9	47.07	48.11	49.95		48.38	1.46

SUV254 (L mg^{-1} cm^{-1})						
Week	R1	R2	R3	R4	average	std
t=0	0.040	0.039	0.037	0.040	0.039	0.001
t=3	0.044	0.047	0.046		0.046	0.001
t=6	0.049	0.049	0.049		0.049	0.000
t=9	0.052	0.052	0.052		0.052	0.000

Table E.7. Results of batch incubation for the reduced peat soil at T =10°c and $\theta_g = 5$.

pH before filtration						
Week	R1	R2	R3	R4	average	std
t=0	5.65	5.76	5.82	5.79	5.75	0.07
t=1	5.34	5.36	5.33	NA	5.34	0.01
t=2	5.39	5.42	5.48	NA	5.43	0.04
t=4	5.52	5.49	5.53	NA	5.51	0.02
t=6	5.40	5.40	5.49	NA	5.43	0.05
t=8	5.33	5.38	NA	NA	5.35	0.03

TOC (mg/L)						
Week	R1	R2	R3	R4	average	std
t=0	21.181	22.296	20.629	21.138	21.311	0.703
t=1	22.554	21.172	17.384	NA	20.37	2.6766
t=2	20.242	19.04	20.546	NA	19.942	0.7964
t=4	17.38	18.74	18.48	NA	18.2	0.7219
t=6	17.35	16.75	17.8	NA	17.3	0.5268
t=8	17.45	17.23	15.75	NA	16.81	0.9246

SUV254 (L mg^{-1} cm^{-1})						
Week	R1	R2	R3	R4	average	std
t=0	0.018	0.016	0.019	0.018	0.018	0.001
t=1	0.021	0.020	0.024	NA	0.022	0.002
t=2	0.025	0.024	0.020	NA	0.023	0.002
t=4	0.024	0.025	0.028	NA	0.026	0.002
t=6	0.027	0.028	0.025	NA	0.027	0.002
t=8	0.033	0.029	NA	NA	0.031	0.002

Table E.8. Results of batch incubation for reduced peat soil at T =20°c and $\theta_g = 5$.

pH before filtration						
Week	R1	R2	R3	R4	average	std
t=0	5.65	5.76	5.82	5.79	5.75	0.07
t=1	5.33	5.33	5.31	NA	5.32	0.01
t=2	5.44	5.42	5.44	NA	5.44	0.01
t=4	5.50	5.52	5.52	NA	5.51	0.01
t=6	5.43	5.42	5.43	NA	5.42	0.00
t=8	5.42	5.44	5.41	NA	5.42	0.02

TOC (mg/L)						
Week	R1	R2	R3	R4	average	std
t=0	21.18	22.30	20.63	21.14	21.31	0.70
t=1	22.86	22.85	20.43	NA	22.05	1.40
t=2	20.33	21.52	21.75	NA	21.20	0.76
t=4	19.67	18.88	18.08	NA	18.88	0.80
t=6	15.76	16.02	15.66	NA	15.81	0.19
t=8	15.75	15.32	16.00	NA	15.69	0.34

SUV254 (L mg^{-1} cm^{-1})						
Week	R1	R2	R3	R4	average	std
t=0	0.018	0.016	0.019	0.018	0.018	0.001
t=1	0.021	0.022	0.024	NA	0.022	0.001
t=2	0.024	0.024	0.024	NA	0.024	0.000
t=4	0.023	0.024	0.025	NA	0.024	0.001
t=6	0.025	0.025	0.023	NA	0.024	0.001
t=8	0.024	0.025	0.025	NA	0.025	0.001

Table E.9. Results of batch incubation for reduced peat soil at T =30°c and $\theta_g = 5$.

pH before filtration						
Week	R1	R2	R3	R4	average	std
t=0	5.65	5.76	5.82	5.79	5.75	0.07
t=1	5.35	5.37	5.38	NA	5.37	0.01
t=2	5.44	5.47	5.50	NA	5.47	0.03
t=4	5.53	5.52	5.53	NA	5.53	0.01
t=6	5.49	5.45	5.45	NA	5.46	0.02
t=8	5.45	5.46	5.53	NA	5.48	0.05

TOC (mg/L)						
Week	R1	R2	R3	R4	average	std
t=0	21.18	22.30	20.63	21.14	21.31	0.70
t=1	26.49	24.24	22.63	NA	24.45	1.94
t=2	24.51	21.26	23.17	NA	22.98	1.63
t=4	19.94	20.21	20.40	NA	20.18	0.23
t=6	20.32	17.57	18.70	NA	18.86	1.38
t=8	16.37	17.55	21.93	NA	18.62	2.93

SUV254 (L mg^{-1} cm^{-1})						
Week	R1	R2	R3	R4	average	std
t=0	0.018	0.016	0.019	0.018	0.018	0.001
t=1	0.024	0.023	0.025	NA	0.024	0.001
t=2	0.027	0.025	0.024	NA	0.025	0.002
t=4	0.024	0.024	0.026	NA	0.025	0.001
t=6	0.027	0.024	0.020	NA	0.024	0.003
t=8	0.024	0.025	0.033	NA	0.027	0.005

Table E.10. Results of batch incubation for reduced peat soil at T =20°c with wet-dry cycles.

pH before filtration						
Week	R1	R2	R3	R4	average	std
t=0	5.65	5.76	5.82	5.79	5.75	0.073
t=3	5.50	5.48	5.46	NA	5.48	0.019
t=6	5.45	5.40	5.48	NA	5.44	0.041
t=9	5.59	5.63	5.61	NA	5.61	0.022

TOC (mg/L)						
Week	R1	R2	R3	R4	average	std
t=0	21.18	22.30	20.63	21.14	21.31	0.70
t=3	19.31	21.42	20.29	NA	20.34	1.05
t=6	14.83	15.44	16.45	NA	15.57	0.82
t=9	15.39	15.24	14.95	NA	15.19	0.22

SUV254 (L mg^{-1} cm^{-1})						
Week	R1	R2	R3	R4	average	std
t=0	0.018	0.016	0.019	0.018	0.018	0.001
t=3	0.024	0.023	0.022	NA	0.023	0.001
t=6	0.033	0.030	0.029	NA	0.031	0.002
t=9	0.033	0.029	0.033	NA	0.032	0.002

APPENDIX F - RESULTS OF CARBON MINERALIZATION OF BATCH INCUBATION EXPERIMENT

Table F.1. Carbon dioxide measurement of incubation experiment of oxidized peat soil at T= 10°C and $\theta_g = 0.3$.

	total closing time		CO_2 production rate (mg C g soil^{-1} day^{-1})				Accumulated CO_2 (mg C g soil^{-1})				
Day	day	hours	R1	R2	R3	Average	R1	R2	R3	Average	Std
0							0.00	0.00	0.00	0.00	0.00
1	1	24.50	1.854	1.384	2.258	1.832	1.85	1.38	2.26	1.83	0.44
2	1	22.27	0.725	0.699	0.827	0.750	2.58	2.08	3.09	2.58	0.50
3	1	23.10	0.552	0.432	0.608	0.530	3.13	2.52	3.69	3.11	0.59
7	1	23.17	1.006	0.177	1.159	0.780	4.14	2.69	4.85	3.89	1.10
8	1	23.00	-0.021	0.063	0.147	0.063	4.11	2.76	5.00	3.96	1.13
10	1	23.67	0.084	0.084	0.092	0.087	4.20	2.84	5.09	4.04	1.13
14	1	22.92	0.054	0.020	0.189	0.088	4.25	2.86	5.28	4.13	1.22
17	1	24.58	0.034	0.049	0.104	0.062	4.29	2.91	5.38	4.19	1.24
21	1	22.33	0.017	0.042	0.034	0.031	4.30	2.95	5.42	4.22	1.24
28	1	23.20	0.152	0.161	0.263	0.192	4.46	3.11	5.68	4.42	1.28
35	1	22.88	0.075	0.092	0.413	0.194	4.53	3.20	6.09	4.61	1.45
42	1	22.75	0.288	0.105	0.498	0.297	4.82	3.31	6.59	4.91	1.64
50	1	24.23	0.238	0.139	0.305	0.227	5.06	3.45	6.90	5.13	1.73
56	1	23.20	0.214	0.131	0.235	0.193	5.27	3.58	7.13	5.33	1.78

Table F.2. Carbon dioxide measurement of incubation experiment of oxidized peat soil at T= 20°C and $\theta_g = 0.3$.

	total closing time		CO_2 production rate (mg C g soil^{-1} day^{-1})				Accumulated CO_2 (mg C g soil^{-1})				
Day	day	hours	R1	R2	R3	Average	R1	R2	R3	Average	Std
0							0.00	0.00	0.00	0.00	0.000
1	1	24.25	4.014	4.032	4.050	4.032	4.01	4.03	4.05	4.03	0.018
2	1	23.25	2.636	2.966	2.686	2.763	6.65	7.00	6.74	6.79	0.181
3	1	22.00	1.066	1.190	1.116	1.124	7.72	8.19	7.85	7.92	0.243
4	1	23.62	0.801	0.861	0.846	0.836	8.52	9.05	8.70	8.75	0.271
8	1	23.33	2.006	2.091	1.929	2.009	10.52	11.14	10.63	10.76	0.331
10	1	22.75	0.028	-0.014	-0.014	0.000	10.55	11.13	10.61	10.76	0.316
11	1	23.50	0.457	0.490	0.408	0.452	11.01	11.62	11.02	11.21	0.348
15	1	22.33	0.305	0.389	0.305	0.333	11.31	12.01	11.33	11.55	0.396
18	1	23.50	0.420	0.365	0.302	0.363	11.73	12.37	11.63	11.91	0.402
22	1	22.50	0.503	0.479	0.479	0.487	12.24	12.85	12.11	12.40	0.397
29	1	22.75	0.684	0.334	0.425	0.481	12.92	13.18	12.53	12.88	0.327
36	1	22.83	0.777	1.079	0.794	0.884	13.70	14.26	13.33	13.76	0.471
43	1	22.90	0.554	0.621	0.621	0.598	14.25	14.88	13.95	14.36	0.477
51	1	24.62	0.685	0.764	0.701	0.717	14.94	15.65	14.65	15.08	0.514
57	1	24.00	0.703	0.761	0.732	0.732	15.64	16.41	15.38	15.81	0.535

Table F.3. Carbon dioxide measurement of incubation experiment of oxidized peat soil at T= 30°C and $\theta_g = 0.3$.

Day	total closing time		CO_2 production rate (mg C g soil^{-1} day^{-1})				Accumulated CO_2 (mg C g soil^{-1})				
	day	hours	R1	R2	R3	Average	R1	R2	R3	Average	Std
0							0.00	0.00	0.00	0.00	0.000
1	1	24.50	4.839	5.066	4.869	4.924	4.84	5.07	4.87	4.92	0.123
2	1	22.17	2.194	2.115	2.035	2.115	7.03	7.18	6.90	7.04	0.138
3	1	23.30	1.288	1.110	1.251	1.216	8.32	8.29	8.16	8.26	0.088
7	1	23.42	3.866	4.327	4.423	4.205	12.19	12.62	12.58	12.46	0.238
8	1	23.25	0.866	0.858	0.874	0.866	13.05	13.48	13.45	13.33	0.238
10	1	23.42	1.236	1.197	1.419	1.284	14.29	14.67	14.87	14.61	0.296
14	1	22.83	1.004	0.901	0.885	0.930	15.29	15.57	15.76	15.54	0.233
17	1	24.25	0.697	0.638	0.645	0.660	15.99	16.21	16.40	16.20	0.205
21	1	22.33	0.948	0.972	1.043	0.988	16.94	17.18	17.44	17.19	0.253
28	1	23.12	0.730	0.770	0.881	0.794	17.67	17.95	18.32	17.98	0.329
35	1	23.60	1.896	1.175	1.520	1.530	19.57	19.13	19.84	19.51	0.362
42	1	22.95	0.914	0.874	0.963	0.917	20.48	20.00	20.81	20.43	0.406
50	1	24.30	0.865	0.857	0.919	0.880	21.34	20.86	21.73	21.31	0.435
56	1	23.82	1.807	2.920	2.081	2.269	23.15	23.78	23.81	23.58	0.370

Table F.4. Carbon dioxide measurement of incubation experiment of oxidized peat soil at T= 20°C and $\theta_g = 0.7$.

	total closing time		CO_2 production rate (mg C g soil^{-1} day^{-1})				Accumulated CO_2 (mg C g soil^{-1})				
Day	day	hours	R1	R2	R3	Average	R1	R2	R3	Average	Std
0							0.00	0.00	0.00	0.00	0.000
1	1	24.50	12.156	11.924	12.079	12.053	12.16	11.92	12.08	12.05	0.118
2	1	22.47	5.639	5.464	5.314	5.472	17.79	17.39	17.39	17.53	0.233
3	1	22.58	4.361	4.294	4.167	4.274	22.16	21.68	21.56	21.80	0.315
4	1	23.50	3.666	3.479	3.340	3.495	25.82	25.16	24.90	25.29	0.475
8	1	24.33	2.556	2.463	2.324	2.448	28.38	27.62	27.22	27.74	0.586
11	1	23.75	2.444	2.382	2.210	2.345	30.82	30.01	29.43	30.09	0.697
15	1	22.53	2.203	2.195	2.211	2.203	33.03	32.20	31.65	32.29	0.694
22	1	22.28	2.027	1.873	1.797	1.899	35.05	34.07	33.44	34.19	0.811
29	1	23.10	1.655	1.639	1.556	1.617	36.71	35.71	35.00	35.81	0.858
36	1	23.02	1.610	1.694	1.802	1.702	38.32	37.41	36.80	37.51	0.764
44	1	24.25	1.361	1.450	1.498	1.436	39.68	38.86	38.30	38.94	0.694
50	1	23.83	2.978	3.368	3.309	3.219	42.66	42.22	41.61	42.16	0.527
56	1	24.88	1.351	1.379	1.324	1.351	44.01	43.60	42.93	43.51	0.544

Table F.5. Carbon dioxide measurement of incubation experiment of oxidized peat soil at T= 20°C and $\theta_g = 2.0$.

Day	total closing time		CO_2 production rate (mg C g soil^{-1} day^{-1})				Accumulated CO_2 (mg C g soil^{-1})				
	day	hours	R1	R2	R3	Average	R1	R2	R3	Average	Std
0							0.00	0.00	0.00	0.00	0.00
1	1	24.50	3.361	3.703	3.486	3.517	3.36	3.70	3.49	3.52	0.17
2	1	22.22	5.818	6.376	6.049	6.081	9.18	10.08	9.54	9.60	0.45
3	1	22.50	6.179	6.517	6.380	6.359	15.36	16.60	15.92	15.96	0.62
4	1	23.33	5.775	5.697	5.783	5.752	21.13	22.29	21.70	21.71	0.58
8	1	22.33	3.416	3.608	3.560	3.528	24.55	25.90	25.26	25.24	0.68
11	1	23.67	3.278	3.486	3.360	3.375	27.83	29.39	28.62	28.61	0.78
15	1	22.53	4.058	3.866	3.405	3.776	31.89	33.25	32.02	32.39	0.75
22	1	22.08	2.968	3.221	3.351	3.180	34.85	36.47	35.37	35.57	0.83
29	1	23.20	2.363	2.355	2.418	2.379	37.22	38.83	37.79	37.95	0.82
36	1	22.93	2.297	2.638	3.393	2.776	39.51	41.47	41.19	40.72	1.06
44	1	24.17	2.038	2.229	2.206	2.157	41.55	43.70	43.39	42.88	1.16
50	1	23.95	3.871	4.312	4.450	4.211	45.42	48.01	47.84	47.09	1.45
56	1	24.77	1.878	2.081	2.090	2.016	47.30	50.09	49.93	49.11	1.57

Table F.6. Carbon dioxide measurement of incubation experiment of oxidized peat soil at T= 20°C with wet-dry cycles.

Day	total closing time		CO_2 production rate (mg C g soil^{-1} day^{-1})				Accumulated CO_2 (mg C g soil^{-1})				
	day	hours	R1	R2	R3	Average	R1	R2	R3	Average	Std
0							0.000	0.000	0.000	0.000	0.000
1	1	23.17	3.552	3.537	3.568	3.552	3.552	3.537	3.568	3.552	0.015
7	1	22.58	4.033	4.191	4.025	4.083	7.586	7.728	7.593	7.636	0.080
10	1	23.83	6.346	5.638	5.571	5.852	13.932	13.366	13.165	13.487	0.398
14	1	22.42	3.106	3.121	2.951	3.059	17.037	16.487	16.116	16.547	0.464
21	1	22.58	0.104	0.112	0.088	0.101	17.141	16.599	16.204	16.648	0.471
24	1	23.08	4.016	3.936	3.655	3.869	21.157	20.534	19.858	20.517	0.650
28	1	22.62	2.963	3.284	3.268	3.171	24.119	23.818	23.126	23.688	0.509
31	1	22.53	2.526	3.837	3.828	3.397	26.645	27.655	26.954	27.085	0.518
36	1	23.05	2.695	2.470	2.208	2.458	29.340	30.125	29.163	29.543	0.512
43	1	24.45	0.428	0.383	0.503	0.438	29.768	30.508	29.666	29.981	0.459
45	1	23.17	1.318	1.407	1.221	1.315	31.086	31.915	30.887	31.296	0.545
49	1	23.87	2.047	2.370	2.333	2.250	33.132	34.284	33.220	33.546	0.641
55	1	24.75	0.884	0.877	1.483	1.081	34.017	35.161	34.703	34.627	0.576
58	1	23.82	0.328	0.580	0.429	0.446	34.345	35.741	35.132	35.073	0.700
62	1	24.00	0.106	-0.020	0.048	0.045	34.451	35.722	35.180	35.117	0.638

Table F.7. Carbon dioxide measurement of incubation experiment of reduced peat soil at T= 10°C with $\theta_g = 5.0$.

Day	total closing time		CO_2 production rate (mg C g soil^{-1} day^{-1})				Accumulated CO_2 (mg C g soil^{-1})				
	day	hours	R1	R2	R3	Average	R1	R2	R3	Average	Std
0							0.00	0.00	0.00	0.00	0.00
1	1	23.17	0.371	0.511	0.371	0.418	0.37	0.51	0.37	0.42	0.08
2	1	23.75	0.916	0.557	0.650	0.708	1.29	1.07	1.02	1.13	0.14
3	1	24.58	1.006	0.837	0.824	0.889	2.29	1.90	1.84	2.01	0.24
7	1	22.33	1.128	0.987	0.860	0.992	3.42	2.89	2.70	3.01	0.37
14	1	22.70	1.197	1.010	0.851	1.019	4.62	3.90	3.56	4.02	0.54
21	1	22.97	1.319	1.190	-1.130	0.460	5.94	5.09	2.43	4.48	1.83
28	1	22.92	1.779	1.620	1.735	1.711	7.72	6.71	4.16	6.20	1.83
36	1	24.33	1.803	1.665	1.527	1.665	9.52	8.38	5.69	7.86	1.97
42	1	23.22	2.946	1.945	2.773	2.554	12.46	10.32	8.46	10.42	2.00
48	1	24.92	1.390	1.087	1.087	1.188	13.85	11.41	9.55	11.60	2.16
55	1	24.17	1.457	1.195	0.635	1.096	15.31	12.60	10.18	12.70	2.56

Table F.8. Carbon dioxide measurement of incubation experiment of reduced peat soil at T= 20°C with $\theta_g = 5.0$.

	total closing time		CO_2 production rate (mg C g soil^{-1} day^{-1})				Accumulated CO_2 (mg C g soil^{-1})				
Day	day	hours	R1	R2	R3	Average	R1	R2	R3	Average	Std
0							0.00	0.00	0.00	0.00	0.00
1	1	21.25	2.041	2.115	2.085	2.080	2.04	2.11	2.09	2.08	0.04
2	1	23.58	2.259	2.711	2.388	2.453	4.30	4.83	4.47	4.53	0.27
3	1	24.00	2.783	2.834	2.680	2.766	7.08	7.66	7.15	7.30	0.31
7	1	22.50	2.474	2.636	2.460	2.523	9.56	10.30	9.61	9.82	0.41
14	1	22.17	2.625	2.611	2.525	2.587	12.18	12.91	12.14	12.41	0.43
21	1	23.30	2.927	2.448	2.530	2.635	15.11	15.35	14.67	15.04	0.35
28	1	23.05	2.611	2.805	2.513	2.643	17.72	18.16	17.18	17.69	0.49
36	1	24.33	2.648	2.768	2.741	2.719	20.37	20.93	19.92	20.41	0.50
42	1	24.08	5.314	4.848	2.566	4.243	25.68	25.78	22.49	24.65	1.87
48	1	24.87	2.639	3.132	2.880	2.884	28.32	28.91	25.37	27.53	1.90
55	1	24.33	2.421	1.783	2.270	2.158	30.74	30.69	27.64	29.69	1.78

Table F.9. Carbon dioxide measurement of incubation experiment of reduced peat soil at T= 30°C with $\theta_g = 5.0$.

Day	total closing time		CO_2 production rate (mg C g soil^{-1} day^{-1})				Accumulated CO_2 (mg C g soil^{-1})				
	day	hours	R1	R2	R3	Average	R1	R2	R3	Average	Std
0							0.000	0.000	0.000	0.000	0.000
1	1	23.42	5.283	5.347	3.084	4.572	5.283	5.347	3.084	4.572	1.288
2	1	23.92	4.143	4.493	4.184	4.273	9.426	9.840	7.269	8.845	1.381
3	1	24.25	4.535	5.077	4.769	4.793	13.961	14.917	12.038	13.638	1.466
7	1	22.33	3.846	3.688	3.951	3.828	17.807	18.604	15.989	17.467	1.341
14	1	22.83	3.857	4.045	4.179	4.027	21.664	22.649	20.167	21.493	1.250
21	1	22.88	3.759	3.624	3.624	3.669	25.423	26.273	23.791	25.162	1.261
28	1	23.33	3.953	3.980	4.351	4.095	29.376	30.253	28.142	29.257	1.060
36	1	24.35	4.040	4.014	4.516	4.190	33.416	34.267	32.659	33.447	0.805
42	1	23.98	10.435	10.388	9.139	9.987	43.850	44.655	41.798	43.434	1.473
48	1	24.97	4.337	4.277	4.559	4.391	48.187	48.932	46.357	47.825	1.325
55	1	24.42	4.224	3.772	4.240	4.079	52.411	52.704	50.598	51.904	1.141

Table F.10. Carbon dioxide measurement of incubation experiment of reduced peat soil at T= 30°C with wet-dry cycles.

Day	total closing time		CO_2 production rate (mg C g soil^{-1} day^{-1})				Accumulated CO_2 (mg C g soil^{-1})				
	day	hours	R1	R2	R3	Average	R1	R2	R3	Average	Std
0							0.00	0.00	0.00	0.00	0.00
1	1	23.08	9.147	8.863	8.621	8.877	9.15	8.86	8.62	8.88	0.26
7	1	22.42	4.624	4.456	4.205	4.429	13.77	13.32	12.83	13.31	0.47
10	1	23.92	3.167	2.806	3.154	3.042	16.94	16.13	15.98	16.35	0.52
14	1	22.42	4.505	3.311	4.342	4.053	21.44	19.44	20.32	20.40	1.01
21	1	22.48	2.982	2.982	2.968	2.977	24.42	22.42	23.29	23.38	1.01
24	1	23.00	1.505	2.099	1.787	1.797	25.93	24.52	25.08	25.17	0.71
28	1	22.70	2.189	2.132	1.809	2.043	28.12	26.65	26.89	27.22	0.79
31	1	22.62	1.789	1.850	1.850	1.829	29.91	28.50	28.74	29.05	0.75
36	1	23.92	2.747	2.732	2.854	2.778	32.65	31.23	31.59	31.82	0.74
43	1	24.50	3.596	3.278	3.292	3.389	36.25	34.51	34.88	35.21	0.92
45	1	23.08	5.892	4.993	5.607	5.497	42.14	39.50	40.49	40.71	1.33
49	1	23.70	2.411	3.620	8.519	4.850	44.55	43.12	49.01	45.56	3.07
55	1	24.67	6.651	4.974	3.250	4.958	51.20	48.10	52.26	50.52	2.16
58	1	23.98	5.713	5.854	3.002	4.856	56.92	53.95	55.26	55.38	1.49
62	1	24.00	3.437	3.658	2.569	3.222	60.35	57.61	57.83	58.60	1.53