Abstract

Title of Thesis: A Study Of Volatile Organic Compound Emissions In The Ambient Air Of A Sanitary Landfill In Richard W. DeKorte State Park, New Jersey.

Minsen Gao, Master of Science In Chemical Engineering, 1989

Thesis directed by:
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A study was made of 15 volatile organic compounds (VOCs) in the ambient air emissions of a sanitary landfill located at Richard W. DeKorte Park, Lyndhurst, New Jersey. The samples were collected from July 1986 to September 1987 at 10 designated landfill sites over the selected time period from 4 to 24 hours by drawing the air to be analyzed through a Tenax trap. An average 10 to 15 liters of air sample was collected each time. Sample analysis is done on a Varian Gas Chromatograph (GC) combined with a Tekmar Thermal Desorber. A standard gas mixture of the 15 VOCs and a purchased benzene standard was used to calibrate the accuracy of GC analysis on the beginning and end of each batch procedure and a precision control program was performed on selected duplicate air samples to authenticate the stability of instruments. A comparison of exposure assessment was made on six volatile compounds between several urban cities in the other states and the landfill sample data in this study. Another comparison of exposure assessment were made using the literature data on Elizabeth, New Jersey, and the landfill samples for five high ranked volatile compounds. The daily exposure dose and the carcinogen risk assessment were also calculated to show the significance of the ambient risk posed by these VOCs. An ANOVA statistical method is applied to verify the whole set of data collect and it also shows almost no difference in the data consistency between the all 15 target VOCs. These measurement of the 15 VOCs show that the exposure to the levels of VOCs detected at DeKorte Park would not increase the risk of cancer in individuals residing in the surrounding urban environment.

A Study Of Volatile Organic Compound Emissions In The Ambient Air Of A Sanitary Landfill In Richard W. DeKorte State Park, New Jersey

by

Minsen Gao

Thesis submitted to the Faculty of the Graduate school of
the New Jersey Institute of Technology in partial fulfillment of
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APPROVAL SHEET

Title Of Thesis: A Study Of Volatile Organic Compound Emissions In The Ambient Air Of A Sanitary Landfill In Richard W. DeKorte Park, New Jersey.

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1.0 Introduction

Landfill gas (LFG), composed predominantly of carbon dioxide and methane, is a by-product of the decomposition of organic wastes deposited in landfills. In addition to the major fixed gases, other trace gases are released from decomposition of the waste itself (e.g., solvents, materials of composition of the waste, hydrogen sulfide in anaerobic decomposition, etc.). Vinyl chloride, aromatic and polycyclic hydrocarbons, known human carcinogens, mutagens, and teratogens (1-6), were found to be present in the landfill gas emitted from almost all closed cells at either active or closed landfills (7-11). The sampling and analysis of these kinds of volatile organic compounds (VOCs) at ambient levels has been performed since the early to mid 1970's in a variety of urban environments (12-20).

The abundance of petrochemical industry in New Jersey has resulted in a great deal of industrial and chemical waste dumping activity over the past decades. Significant quantities of gaseous contaminants periodically accumulating in the atmosphere have been reported (21-31). In the following landfill reformation case located at DeKorte State Park, Lyndhurst, New Jersey, the final goal of the entire landfill environmental investigation and research project is to determine the possibility of transforming the vast 2000 acres landfill into a magnificent urban park. The whole design needs to deal with the potential public health risk associated with the construction of a recreational facility on an old waste disposal site.

Attention has been already focused on the need to treat leachate and render it harmless and to deal with the buildup and release of landfill gas that will be generated by the bacteriological decomposition of organic material in the buried garbage beneath the site. However, to date, the specific concerns about LFG have focused solely on the release of methane and carbon dioxide. Recent scientific findings suggest that in addition to concerns regarding methane and carbon dioxide, the release of LFG may serve as a significant source of other constituents, including a number of volatile organic compounds (VOCs). Thus it is essential that data are gathered on the release of such constituents in order to determine whether a potential public health threat exists. Concerning the matter of park air safety, there are two major considerations, which obviously have important influences in environmentally characterizing the landfills. These are the air quality and the present of any hazardous substance in the ambient air of the park. Therefore, air analysis has been undertaken to identify the volatile chemicals present in the air above the landfill. In order to monitor these low concentrations of VOCs, highly sensitive detection techniques and preconcentration steps are mandatory in monitoring a number of different sites (9,12,13,18). The method selected here is adsorption on polymer Tenax (31-36) in cartridges followed by thermal desorption (32,37), GC and GC/MS analysis (38-46).

The adsorption/thermal desorption GC and GC/MS analysis method has been found to be a very effective technique which allows both detection and confirmation of a broad range of minute contaminants in the presence of more concentrated components. This technique has been successfully utilized at the New Jersey Institute of Technology Air Pollution Laboratory for both indoor and outdoor emissions. Other advantages of using this technique are:

1.) A broad screening capability.
2.) Provide confirmation of identities of contaminants.
3.) Rapid analysis time.
4.) Absence of solvent front which allows monitoring of very volatile organics.
5.) No solvent dependent desorption.
6.) Samples sealed inside the cartridges are stable and can be stored for a few weeks.

All the air sample collection in this study was done in Dekorte Park. Most of the laboratory work was done in the Hackensack Meadowland Development Center (HMDC) within DeKorte Park and NJIT's Air Pollution Laboratory to verify the accuracy of data. This study was performed in order to determine the sources of VOCs and observe the concentration change of these chosen compounds at four landfilling areas throughout the whole park. The following study describes the collection of data on the ambient levels of primarily chlorinated and aromatic VOCs in and around the whole landfill.

2. Sample Information

2.1 Sampling Sites

The Richard W. DeKorte State Park in the Hackensack Meadowlands is about four miles west of Manhattan, New York City. It is located at the heart of New Jersey's most densely populated inner urban ring and at the doorway of the metropolitan area. This landfill has been receiving hazardous chemical waste and municipal waste containing large amounts of organic material since 1962. The whole park covers 2000 acres of which approximately 814 acre are solid waste landfill and clean landfill areas, combined with 1,186 acres of now protected tidal wetlands and bays to form a 2000-acre conservation and recreational area.

There are four major landfilling areas inside this park. They are known separately as Avon/Viola landfill (coded as Avon), Kearny (coded as 1C), Bergen County landfill (coded as BC), and Balefill landfill (coded as BF). In each area, there are several different sampling sites according to the area it covers. There are three sites in BC (coded as BC1, BC2, and BC3), two sites in 1C (coded as 1C1 and 1C2), and two sites in BF (coded as BF1 and BF2). Landfill Avon has been closed since 1985, but samples are still taken there because it lies beside location BC. There is only one sampling site inside the Avon. Samples are also taken to study the influence of convection approximately 1/2 mile north of the BC landfill area in Lyndhurst township, the downwind area. Samples collection at location BC, 1C, and BF began in July 1986, sampling at location Avon began in October 1986. Most samples are taken once every 6-9 days during the working week.

Along the boundary of the residential area and the landfills (coded as Site R or resident) the air samples were taken beginning in November 1986 to study the influence of LFG on residential areas. Another sampling site is located downwind (coded as Downwind) to study the wind effect on the LFG. There is only one sampling site for each residential area and downwind area. Information on each sampling location is shown on Table 1 and Figure 1.

Table 1 Landfills Information

Landfill	Area	Sampling Sites	Status
Avon	*92 acres*	*One site only.*	*Closed on July 1985*
BC	*180 acres*	*Three Sites:* *BC1, BC2, BC3*	*Still in use*
BF	*195 acres*	*Two sites:* *BF1, BF2*	*Closed on March 1988*
1C	*212 acres*	*Two sites:* *1C1, 1C2*	*Closed on July 1987*
R	*Resident Area*	*One site only.*	
Downwind	*Downwind*	*One site only.*	

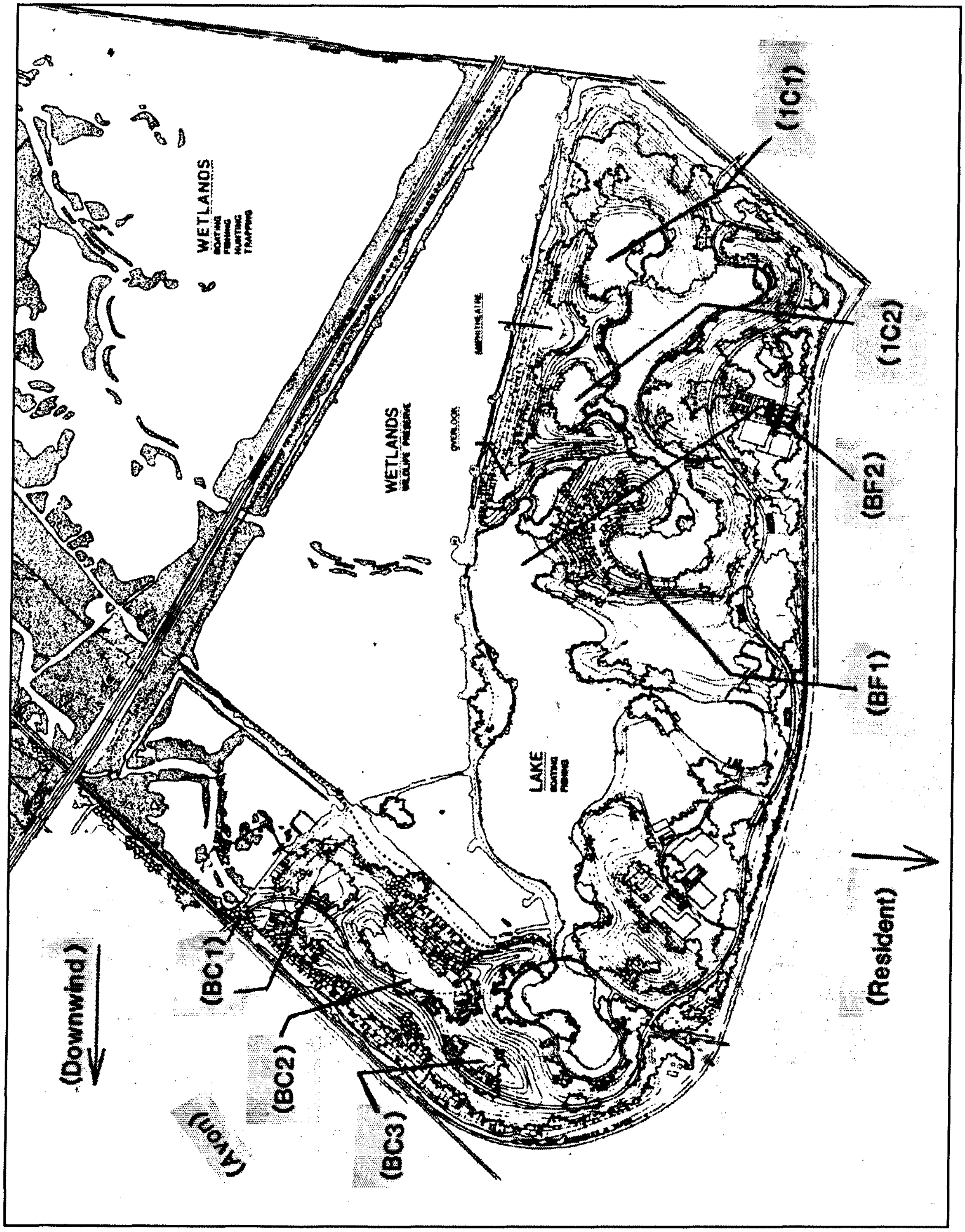


Figure 1. Landfill Sampling Sites Layout

2.2 Sampling Methodology

Air samples are collected with a custom air sampler, shown as Figure 2, which combines a sampling trap cabinet, vacuum pump, battery, gas flowmeters, and air flow valves. The sampling trap cabinet can hold two Tenax traps at a time, each trap has its own gas flow meter and needle valve to control the actual air flow. This design allows the collection of duplicate samples, or collection of a wider volatility range of compounds by using different absorbents. The flow rate of each needle valve inside the air sampler is corrected by a calibrated rotameter, which are checked against soap film flow meter and wet test meters at regular intervals. The flow rate used to calculate the total air volume is the average of the beginning and the final readings. The vacuum pumps are powered by either a regular 110 volts alternating current or rechargeable 6 volts direct current battery. The former power source can keep the air flow very stable while the latter can improve the air sampler's portability.

The air samples are taken by varying the needle valve to draw the air to be analyzed through the Tenax traps at a flow rate of 10 to 500 $^{ml}/_{min}$, collecting a total volume of approximately 10 to 15 liters. The total sampling time period ranges from 12 to 24 hours, with the time span determined by the character of specific sample desired. In order to collect the majority of the VOCs, the Tenax trap was chosen as the adsorbent. Tenax continues to be studied for an expanded range of application, as it has been shown to adsorb and release these materials by varying the operation temperature (33-35,37). The efficiency of Tenax porous polymer for collection of

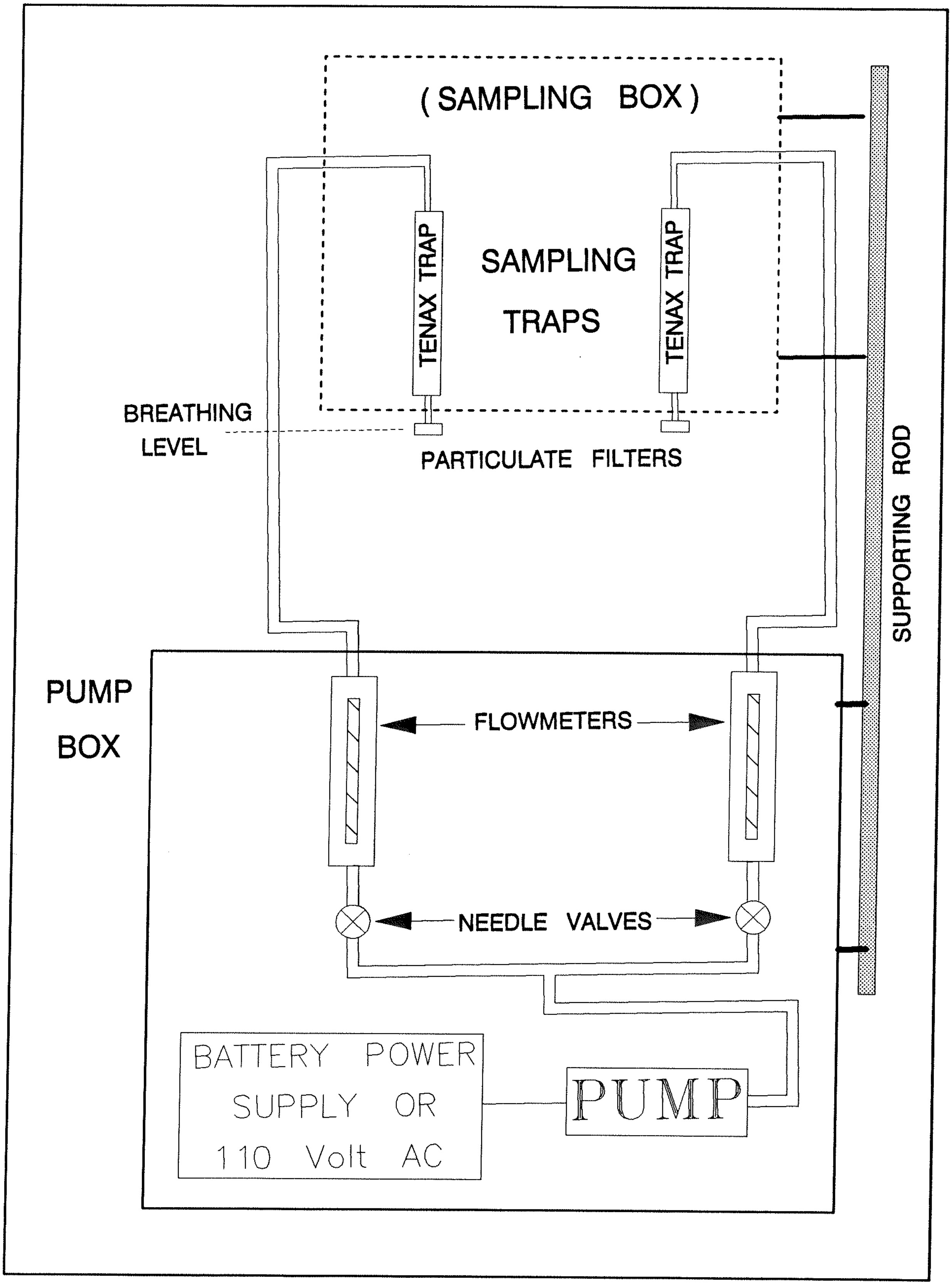


Figure 2 Vapor Sampling System

organic vapors, recovery of these vapors, and the breakthrough characteristics of the traps are discussed subsequently.

2.3 Preparation of Tenax Traps

The Tenax absorbent we used in the sample collection traps is the 60/80 mesh powder made by Chrompack company. The adsorbent is packed into traps fabricated of 1/4 inch (0.64 cm) stainless steel tubing. The traps are 15 cm in length. The packing is retained in the traps with plugs of silanized glass wool, and each contains a minimum of 0.4 grams and an average of 0.5 grams Tenax. The glass wool filter placed at both ends of each trap is to prevent particulate matter from being drawn into the traps. This filter is impregnated with sodium thiosulfate to decrease the concentration of ozone, which may be present, avoiding the oxidation of the Tenax polymer, and minimizing the formation of artifacts. Thiosulfate coated filters have been tested for this purpose and have proven to reduce the ozone interference without removing organic vapors.

The new packed traps are next cleaned by attaching them tightly to a manifold and heating to 300°C, with a purge of high purity nitrogen flowing at 10 $^{ml}/_{min}$ through each trap. This initial conditioning requires approximately 3 days to remove the extraction solvents completely, but subsequent reconditioning after field use is generally complete in 16 hours. After conditioning, the traps are tightly sealed with caps attached to the compression fittings and stored in individual glass culture tubes (sealed also). Glass wool packing is used to cushion each trap. One of these traps is taken and analyzed as a regular sample to assure the completeness of conditioning.

After one cycle of sample collection and desorption, a trap is reconditioned for 16 hours as mentioned above for further use. Up now there are no signs to show reduced trapping capacity following recycling of the Tenax used in our study, but after 40 - 50 cycles the tubes are removed from service. At that point the traps are emptied and repacked with fresh Tenax. The development of channels in the packing is prevented by this repacking of the traps. Traps which become channelled or plugged are discovered in the cleaning process, when the flow of gas is measured at each trap. Any trap which is more or less permeable than average is removed from service, and repacked as in the above procedure.

2.4 Sample Desorption For GC

The air sample collected was stored in a sealed glass tube or stainless steel cylinder and kept in a refrigerator or a cool area to prevent loss and contamination. When the sample was brought back to the laboratory, it was determined to be a GC or a GC/MS sample and different desorption method are followed. For GC analysis, a Tekmar 5000 automatic desorber was connected to the Varian GC. For the GC/MS side, the sample is desorbed into a 10 milliliter gas cylinder from which one can perform multiple analyses on each sample.

In both the NJIT Air Pollution Research Laboratory and the HMDC laboratory, there is a Tekmar 5000 automatic desorber connected to the Varian 3700 gas chromatograph. This system consists of one small sample oven and double cryofocusing traps with liquid nitrogen coolant. This Tekmar desorber, shown as Figure 3, has three built-in procedures with programmable operation variables in each procedure to allow the user to optimize desorption conditions.

After the air sample collection procedure, the sample cartridge is put into the trap furnace, located at the upper-right of the Tekmar desorber, and the furnace is sealed tightly. In our procedure, the desorber is heated to +240 °C and the desorbing helium carrier gas flow rate is controlled at 10 $^{ml}/_{min}$. Before any desorption activity takes place, the first cool trap, which is located at the exit of the main desorber furnace, is cooled down to -150 °C by a liquid nitrogen stream. Concurrently a second cool trap, which is located at the inlet of the gas chromatograph, is cooled down to -150 °C by the liquid nitrogen. The reasons why the second cold trap is needed to refocus the sample are: 1) the main desorber combines some moving parts and also has a bigger heating/cooling device, hence it is designed to sit a little distance from the GC because of its size, 2.) to obtain a better sample consistency -- compounds can be desorbed at different rates. 3.) reduction of the distance the focused sample must travel before entering the GC column for analysis.

The first desorbing time is 8 minutes. After this desorption, the air sample is totally transferred from the Tenax cartridge to the first trapping volume. Then the first focusing volume is quickly heated from -150 ° C to +240 ° C. The sample is transferred from the first chamber into the second and smaller one; as mentioned before, this area is always held at -150 ° C, so the air sample is focused again here. In this second focusing procedure, the air sample is concentrated inside the capillary column at the inlet of gas chromatograph in the equivalent of less than 0.1 sec carrier gas flow distance. Heating this area will cause releasing the sample to the gas chromatograph column/oven, starting the separation and analysis.

3. Chromatographic Analysis

3.1 Gas Chromatographic Analysis

The analysis of the air samples was done on a Varian 3700 gas chromatograph as shown in Figure 4. The air sample desorbed from the Tekmar automatic desorber is focussed at the sample inlet area of the gas chromatograph. To achieve the highest possible resolution, a fused silica crosslinked methylsilicone capillary column, 0.22 millimeter ID, with a coating thickness of 0.5 micrometer, and 50 meters in length is used. This column has given superior separations and has made it possible to reduce the number of connections in the sample stream. By attaching the head of the column directly to the gas sampling valve inlet by using graphite ferrule, the air samples are run with helium carrier gas at a flow of 1.0 $^{ml}/_{min}$.

The temperature in the gas chromatograph is maintained at 35 ° C at the beginning. When the analysis starts, the temperature of the sample in the Tekmar second chamber is raised from -150 ° C to +250 ° C and held for 10 minutes. At the same time the gas chromatograph is maintained at 35 ° C for 5 minutes and then heated at 10 ° C per minute up to 190 ° C. The entire run from sample desorption to finishing GC analysis takes 55 minutes.

The detectors used inside the Varian GC are the Flame Ionization Detector (FID) and the Electron Capture Detector (ECD). To prevent peak broadening in the detectors, at the end of the capillary column, a nitrogen make-up gas is added to the sample flow at the rate of 30 $^{ml}/_{min}$. The column effluent is split into two portions, the ECD receiving approximately 5 percent of the total column flow and the FID receiving most of the column flow. The detector signals are integrated and the sample concentrations are calculated using a Vista 402 multichannel integrator interfaced with an IBM PC/XT microcomputer. Data are also output to a dual pen recorder. The 5 halocarbons and other electronegative species to which the ECD responds form a small subset of the 20 to 30 pollutant species usually detected by the FID. These ECD peaks then serve as easily identifiable markers, which provide convenient and positive references for qualitative identification of many of the FID peaks. A resulting chromatogram is shown as Figure 5. On this figure, the FID peaks are shown on the left hand side while the ECD peaks are on the right hand side. This parallel detector system also permits peak ratioing of compounds to which both the ECD and FID detectors are sensitive, for more positive identification.

Co-eluting compounds are indicated when the computer or manual verification indicate that the ratio of peaks is not similar to that for a single compound in the standard. If the co-eluting peak is or has been identified by the mass spectroscopy analysis, quantitation on both species can readily be performed using two linear equations, where the unknowns are the concentrations of the two eluting species. These two linear equations are:

$$R_{F1} \times C_1 + R_{F2} \times C_2 = A_{FID} \quad (1)$$

$$R_{E1} \times C_1 + R_{E2} \times C_2 = A_{ECD} \quad (2)$$

where:

A_{FID}, A_{ECD}	is the area of peak from FID and ECD detector
F1, F2	represent FID detector
E1, E2	represent ECD detector
R	is experimentally determined response factor
C_1, C_2	is the concentration of compound 1 and 2

3.2 Calibration of the GC By Benzene Standard

Each time, before and after analysis of Tenax samples, the gas chromatograph was calibrated with a purchased 10 ppb gaseous benzene standard. This standard was guaranteed by the manufacturer to be accurate within 2%. This is within an order of magnitude of the concentration of the desorbed samples, and well within the linear range of the FID. The calibration factor is compared with the running average and entered on the control chart. If the value is out of control limits, the run is repeated, after the flows of air and hydrogen to the detector have been checked, and readjusted if necessary. The running average is updated, and the benzene factor is entered into the computer calculation as a factor to multiply each peak area. The relative response factors (RRF), mentioned latter at section 3.4, for the individual compounds are permanently stored in the computer analysis file.

3.3 Calibration Of The GC By Standard Gas Mixture

In our first GC/MS qualitative analysis of the landfill sample, we chose 15 of the most obvious compounds to be our target VOC. The mixed gas standard is then prepared from the 15 chosen VOCs and used to update retention times. The quantities of the halogenated compounds found by this method are used to calibrate the ECD. Gaseous standards have been prepared which contain approximately 5 parts per million (PPM) of each of the compounds being determined. Before preparing the standard gas mixture, a liquid mixture is gravimetrically prepared containing each target compound. Two tenths of a milliliter of the liquid mixture is injected through a septum into an evacuated 13 liter stainless steel high pressure gas cylinder. The cylinder is evacuated before use. The fittings containing the septum and cylinder inlet are warmed to insure rapid evaporation of the mixture. High purity helium (99.99%) is filled into the cylinder to form a 1000 PSI gas mixture. The cylinder is kept warm and allowed to equilibrate for two days, and the mixture is then analyzed for benzene against a trace-level benzene standard mixture, as mentioned in the previous section.

It was found there were two problems associated with the mixed gas standard. The first one comes from the heating and inner wall of the cylinder. When the standard gas mixture is drawn from a room temperature cylinder, the less volatile compounds show reduced concentrations, indicating some adsorption of these on the cylinder walls. These losses may be as high as 50% if heating is neglected. Some compounds, which have been tested, show a tendency to decline in concentration over a period of several weeks, probably due to reactions or adsorptions on the cylinder walls. Therefore, it is necessary to check the stability of each compound added to the mixture. This problem has been solved by some gas companies nowadays by putting a special coating on the inner wall of the gas cylinder. An alternative way is to heat the cylinder to increase the activity of gas mixture in order to reduce the adsorption on the inner wall. Hence, keeping the gas standard at a constant temperature is still the best way to get the better replicate results. In our process, the standard gas mixture cylinder was kept heated to 60 °C, and a resulting FID chromatogram of the standard gas mixture is shown as Figure 6, while a resulting GC/MS chromatograph is shown as Figure 7.

The second problem is that it is difficult to make reproducible injections of the standard for some of the compounds. Passage of the vapor through tubing has the effect of removing some of the compounds from the stream. In addition there may be problems of changing concentrations due to diffusion effects which take place when a mixture of gases flows down a tube.

Due to these problems, the standard gas mixture therefore continued to be used for determining retention times and column performance and for spiking samples (mentioned latter at section 3.5).

3.4 Relative Response Factors

Relative response factors (RRF) were developed to calculate the relative concentration for each compound is detected on the FID detector, by using benzene as the reference. These factors were obtained at the very beginning of the entire project by the following method. Standard mixtures are gravimetrically prepared from reagent grade liquids diluted in phenylether solvent. Compounds which are not completely separated in the chromatogram are prepared in separate mixtures, to avoid integration errors. A 0.05 microliter portion of the liquid standard mixture is injected onto the GC column and the response ratios of the target compounds, normalized to benzene with a response of 1.0, are calculated. These are determined from the area generated from each compound, relative to the benzene area. The gas phase benzene standard is run on the chromatograph every time before and after the analysis of air sample to generate a benzene calibration factor as mentioned in section 3.2. Each response ratio is multiplied by this daily factor to give a calibration factor for each compound. The calculations are outlined in the following equations:

$$\text{Conc(I)}_{\text{sample}} = \text{Area(I)}_{\text{sample}} \times \text{RRF} \times \text{Benzene Factor}$$

where:

$$RRF = [X_I \times Area_I] / [X_b \times Area_b]$$

[Determined from liquid inject]

X_I = Molar fraction of compound I in liquid mixture

X_b = Molar fraction of benzene in liquid mixture

$$\text{Benzene Factor} = \frac{\text{Conc. of Benzene Gas Standard}}{\text{Area of Benzene Gas Standard}}$$

[Determined by daily calibration]

3.5 Identification Of Peaks in the Chromatogram

In order to help identify the sample peaks in the complex chromatograms obtained from the air sample analysis, a spiking method was developed. After the air sample is analyzed, a duplicate sample is spiked with a small quantity of the standard gas mixture as mentioned in Section 3.3 and the whole desorption and chromatograph analysis procedure is repeated. The resulting chromatogram is then compared with that from the standard gas mixture. The increase in the peak height or the appearance of new peaks shows the target compounds of interest.

The method is developed to compensate for instrumental errors due to the change of peripherals such as the drop of the carrier or make-up gas flows. Because within an area, compound peaks may vary in size from day to day, but the general pattern of substances present in the chromatogram changes very little. Spiked samples were run at a regular intervals, especially when the sampling location was changed or the gases used in the gas chromatograph were changed.

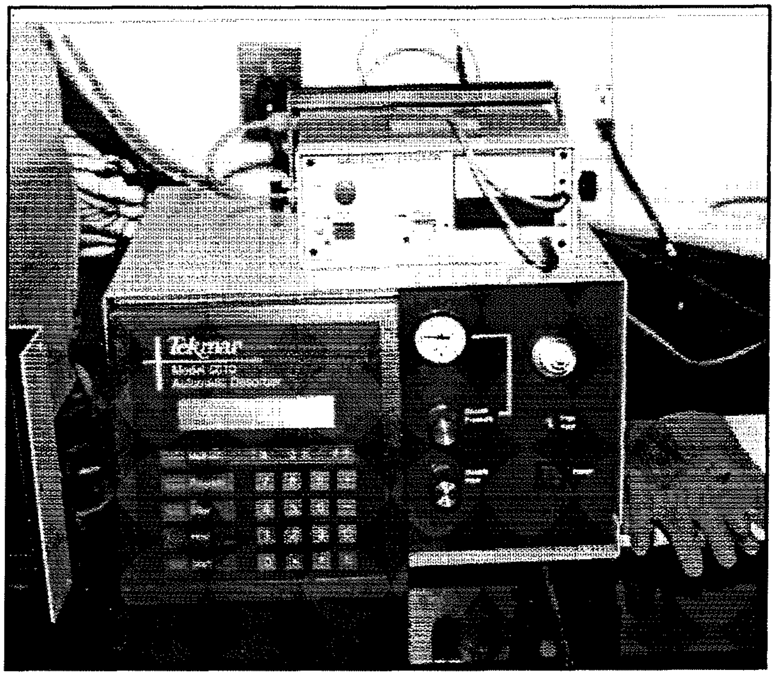


Figure 3 Tekmar Desorber

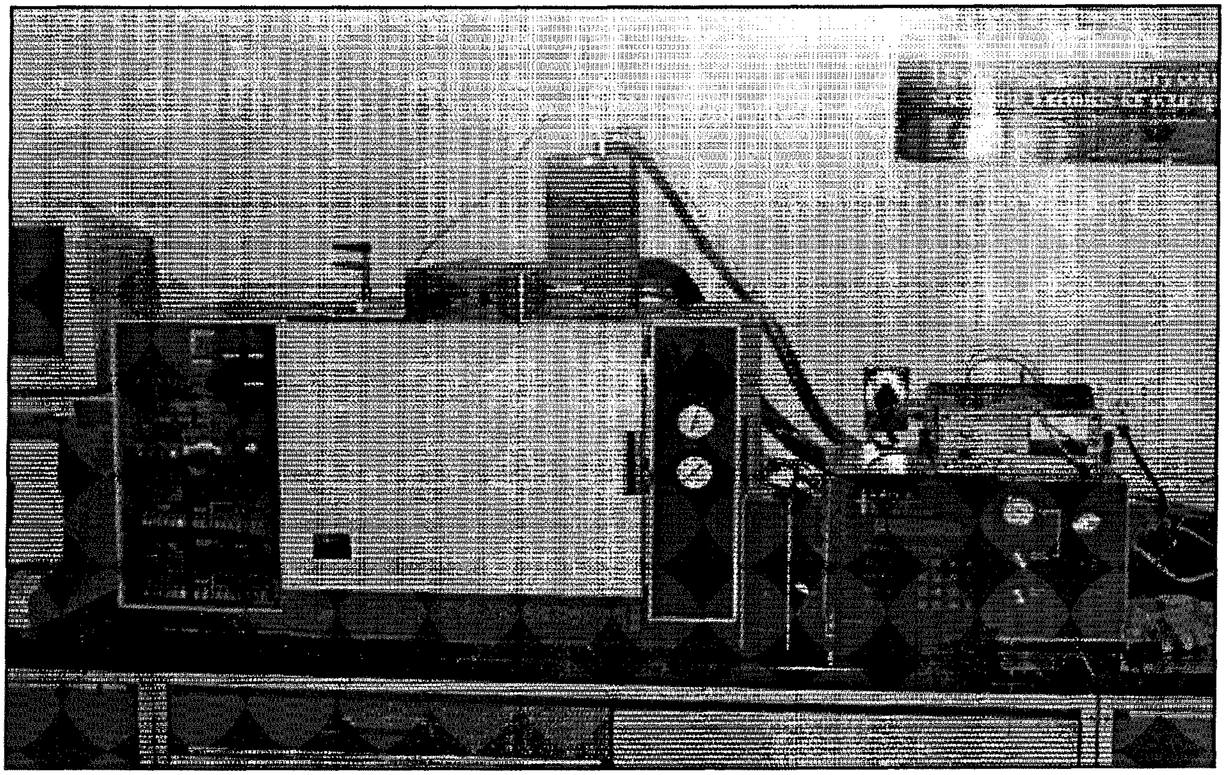


Figure 4 Gas Chromatograph Instrument

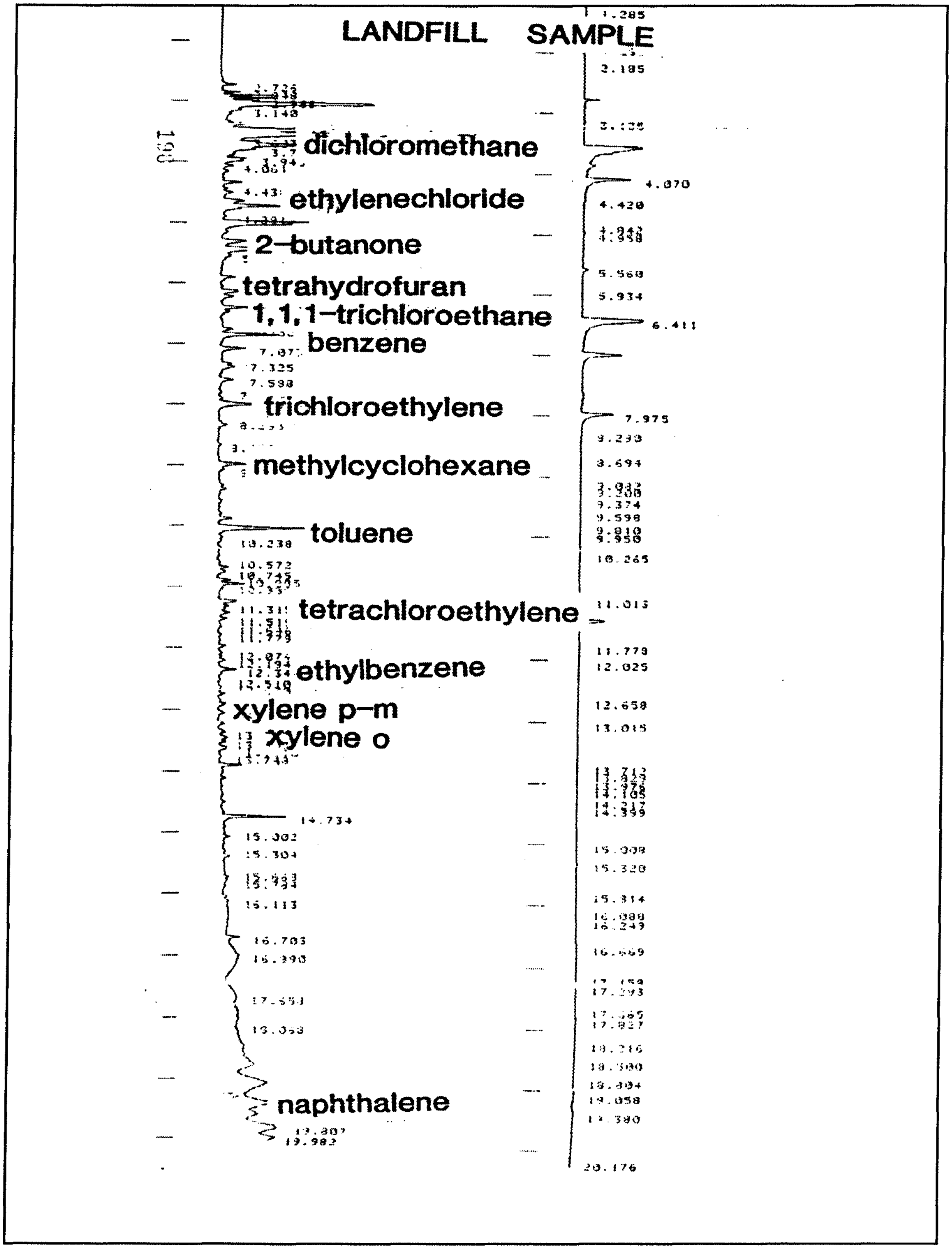


Figure 5. GC FID(left) and ECD(right) Results For The Landfill Sample

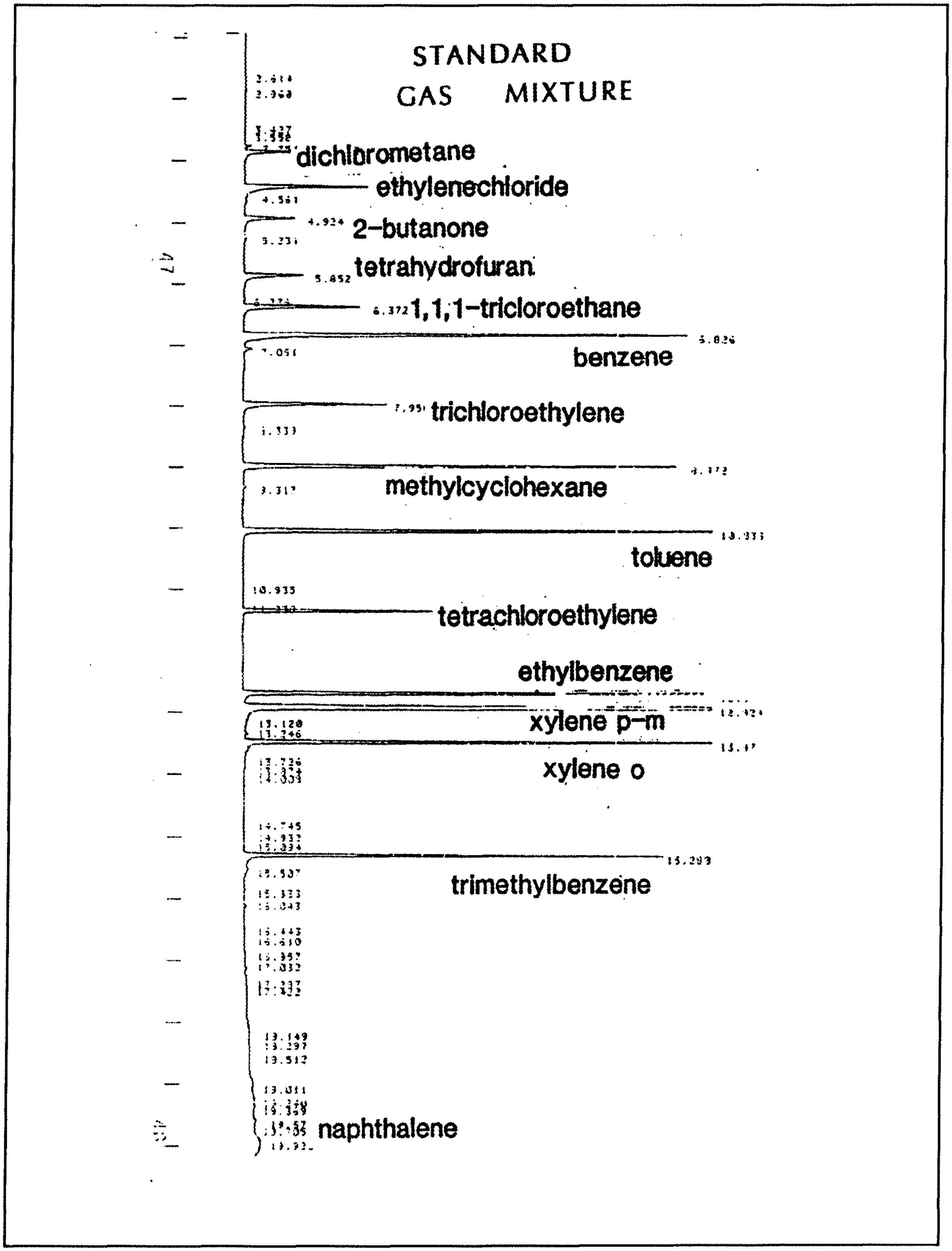


Figure 6. GC FID Results For The Standard Air Sample

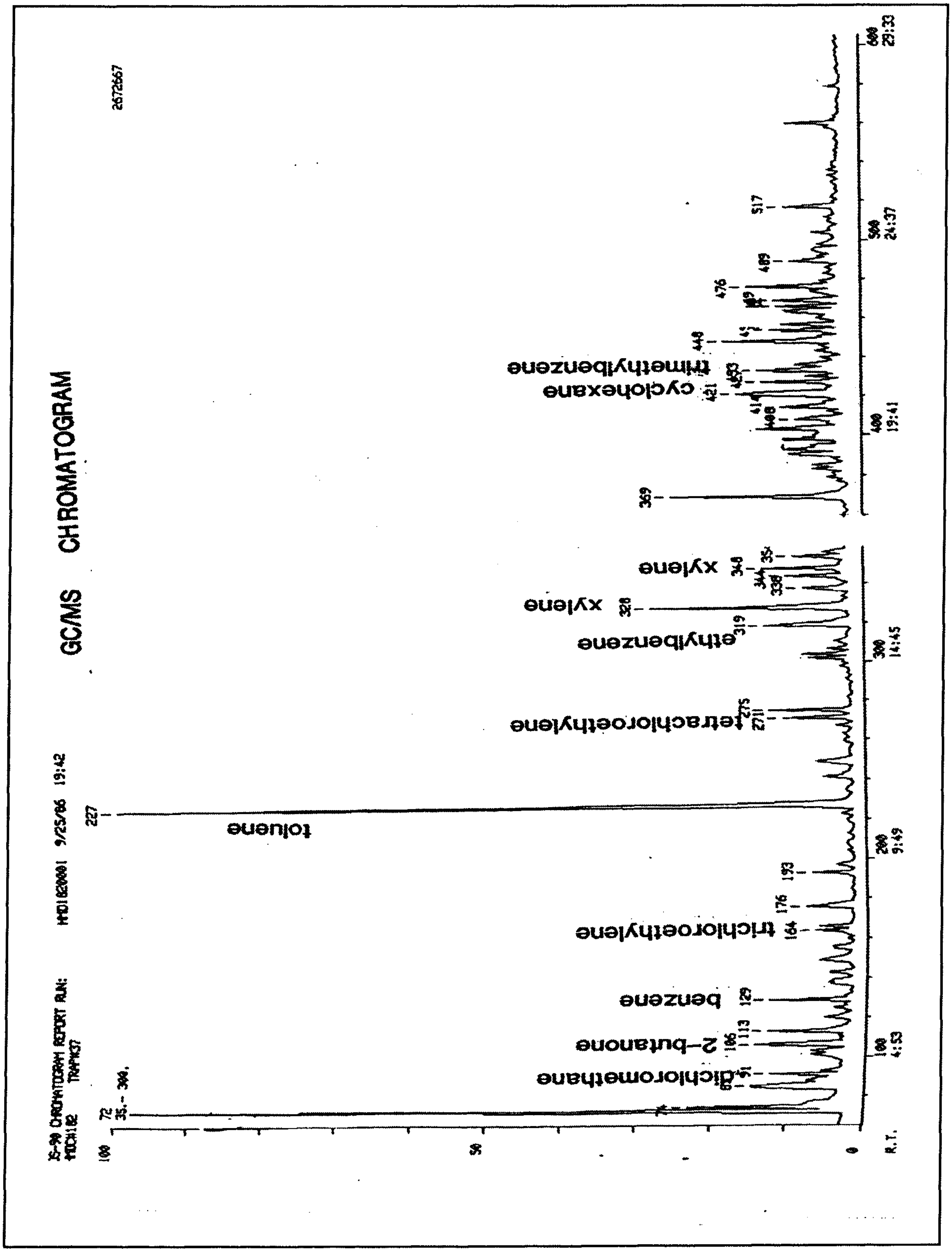


Figure 7. GC/MS Result For The Landfill Sample

4 Quality Control And Assurance

4.1 Tenax Traps

A program of quality control and assurance is applied to all sampling and analysis of VOC in both the NJIT and HMDC laboratories. The Tenax traps are carefully assembled to insure that each has the same amount of material (0.5 g) and that once packed, the pressure drop for each is close to 2" H_2O for 20 $^{ml}/_{min}$ flow. Traps are attached to a manifold for cleaning, in batches of 12 or 18, and are conditioned by passing 10 $^{ml}/_{min}$ of clean nitrogen gas through the traps while heating to 300°C for 48 hours. The flow through each trap is checked to insure against plugging or channeling. After conditioning, one trap from each batch is analyzed as a sample with typical sample volumes and instrument calibration factors used to quantitate the impurities. If this is found to contain any pollutant concentration greater than 0.09 ppb for a typical air sample volume or 0.2 ppb for benzene or toluene, the batch is considered to be contaminated, and is recleaned. The blank is run again after cleaning. A resulting blank trap sample chromatogram is shown as Figure 8.

When a set of traps was sent to the field, several traps were not used for sample collection, but were used as controls. These control traps routinely show less than 0.5 ppbv for the pollutants, but occasionally show significant contamination for 1 or 2 specific chemicals. Traps were disassembled after no more than 40 uses, or if controls

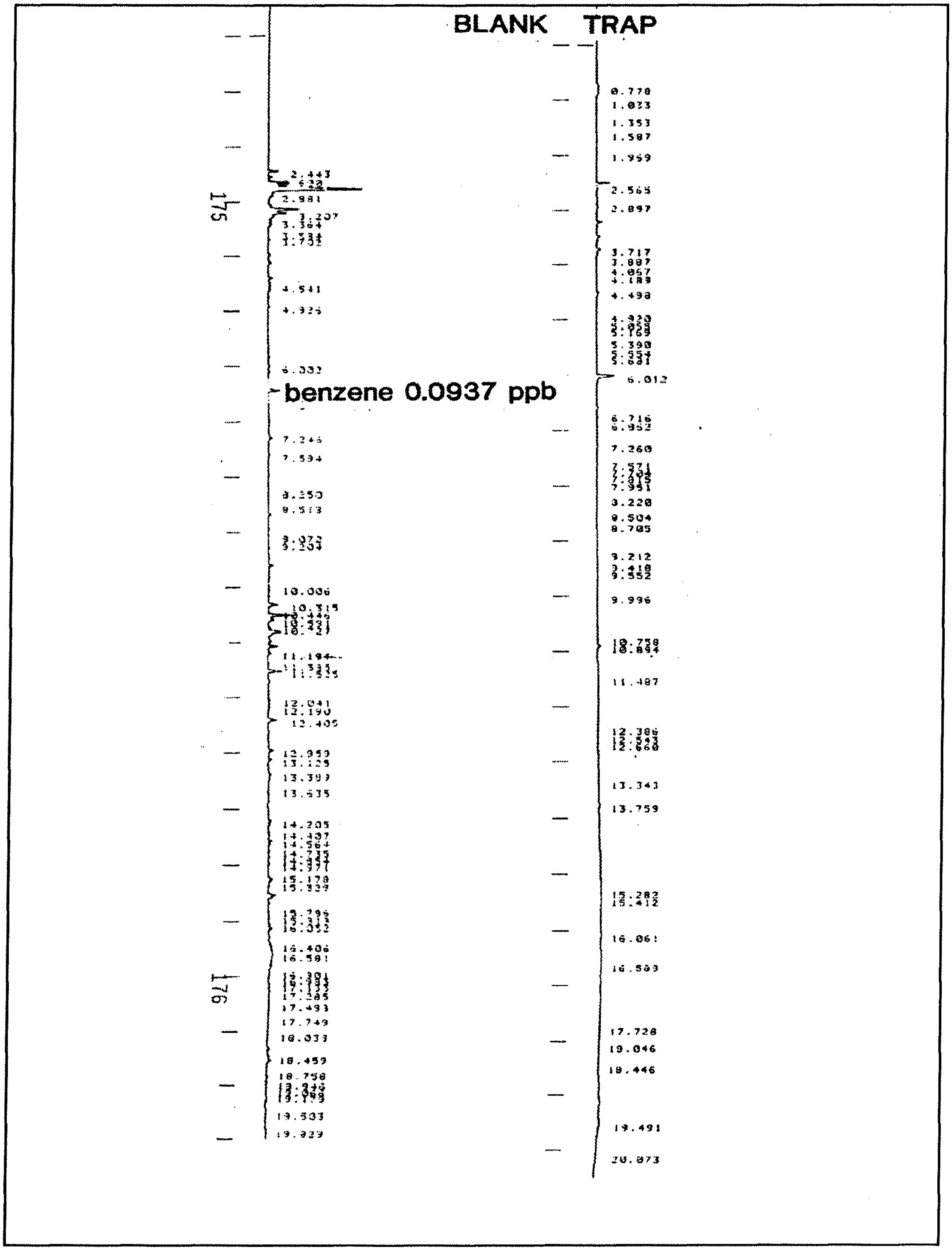


Figure 8. GC FID(left) ECD(right) Results For The Blank Sample

indicated leakage, or a channeling condition was found during the recondition procedures.

4.2 Sampling Pumps

During the sampling period, if the starting and ending flow deviates by more than 15% from the average flow, the sample is discarded or appropriately marked and pump or battery is serviced or replaced as necessary. Rotameters in the field can be compared to a reference flowmeter that was calibrated in the laboratory against a soap film flowmeter or wet test meter. Rotameters are checked for free movement before each use.

4.3 Calibration of GC

The standard gas mixture is run at the very beginning of each batch sample analysis to establish the daily criterion for the retention times, to calibrate the ECD, and check the functioning of the instrument for changes in the column or contamination of the system. A purchased benzene standard was used to quantitatively calibrate the gas chromatograph at the beginning and end of each run of field samples. This standard is guaranteed by the manufacturer to be accurate to within 2%. The previously determined benzene RRF (relative response factor) is used to generate a new set of calibration factors for each compound. Any equipment problems shall be noted with these analytical data. A spiked samples is run after the field sample to help the identification of peaks in the chromatogram when the result of the field sample is obscure or when the sample is from one location to the others.

4.4 Tenax Trap Contamination

It is felt that other possibilities for the traps becoming contaminated a) while sitting idle due to atmospheric exposure, b) polymer decomposition of Tenax particles, c) the dead volume inside the traps, and d) leaking seals, are unlikely.

Interferences might also come from the unremoved contaminating organic compounds which can be desorbed from Tenax trap and produce common fragments that chromatographically coincide with those of sampled organic pollutants. Therefore, a trap campaign is applied for specific analysis of trap history along with observation of unusually high levels for each trap used throughout this campaign. All traps were new at campaign start up, and the result in the campaign measurements showed no likely errors. A procedure of analyzing the cleaned trap which in prior analysis showed the highest concentration. Sealing it for seven days and then re-analyzing, it was also initiated midway through the project. One possible solution would be vacuum conditioning at the desorption temperature to increase the diffusion and volatilization rates of contaminant removal, where a small purge gas flow would allow transfer of the volatile compounds out of the traps. Further studies will have to be done to gain a better understanding of the efficiency of such vacuum conditioning.

Contamination could also be partly responsible for the level of precision exhibited in duplicate samples. Since sample pumps are carefully calibrated and yield errors in flow of only 2.3% to 6.4% with a mean of 3.6%, this contribution to the imprecision is considered small.

4.5 Precision Control For The Duplicate Samples

A quality control program is also applied to study the stability of traps and instruments. Once in a while duplicate samples were taken at the same sampling site by connecting two cleaned traps to one or two air sampler(s) to study sample data reproducibility. After these samples are analyzed, the concentration difference for each target compound is recorded. From July 1986 to February 1987, 20 sets of duplicate samples were analyzed and used as the control criterion. An average concentration difference (R) and its relative standard deviation for each target compound in these 20 sets duplicate samples were then calculated. The 95% confidence interval is applied to these 20 sets of samples so that a 3.28R value for the Upper Control Limit (UCL) and a 2.52R value for the Upper Warning Limit (UWL) are found for each target compound. The subsequent set of duplicate samples were then analyzed and compared with the UCL and UWL for each target compound. For each target compound a precision control chart is created with these three control lines (average concentration variation (R), UCL, and UWL). The resulting concentration difference for the subsequent duplicate samples is plotted onto the chart for easily visualizing the control effect.

5. Result and Discussion

In our first GC/MS qualitative analysis of the landfill sample, we chose 15 of the most obvious compounds to be our target VOC. Table 2 lists the toxicity and carcinogenic properties of the target volatile organic compounds we found through the landfill air samples. These VOCs are tabulated according to their retention (response) time from the GC experimental result. Table 3 lists the common source of these VOCs. The compounds we assayed fall into three chemical categories: hydrocarbons (8 compounds); chlorinated hydrocarbons (5 compounds); and oxygen-containing hydrocarbons (2 compounds). All of these compounds are somewhat volatile and it is likely that their presence in the air samples is due to simple evaporation from products in the landfills. It is also possible that the presence of some compounds in the air samples may be due to both evaporation and degradation of products in the landfills.

5.1 Toxicities Of The VOCs

The toxicities of the fifteen compounds in our study are quite varied (Table II). However, compounds with similar chemical properties often induce similar toxic responses. For example, 4 out of the 5 chlorinated hydrocarbons are known human and/or animal carcinogens while only one of the 8 hydrocarbons (benzene) is a known carcinogen. In addition, the two unsubstituted aromatic hydrocarbons (benzene and

Table II

	COMPOUNDS	Toxicity Rank	Carcinogenic Activity	Reproductive Effects	TLV[a]
1.	Dichloromethane	7	Human	Mouse Rat	100 ppm[b]
2.	Ethylene chloride	2	Human Animal	Rat	10 ppm
3.	2 - Butanone	12		Rat	200 ppm
4.	Tetrahydrofuran	12			200 ppm
5.	1,1,1-Trichloroethane	14		Rat	350 ppm
6.	Benzene	1	Human Animal	Mouse Rat	1 ppm
7.	Trichloroethylene	5	Animal	Mouse Rat	50 ppm
8.	Methylcyclohexane	15			400 ppm
9.	Toluene	7		Mouse Rat	100 ppm
10.	Tetrachloroethylene	5	Animal	Mouse Rat	50 ppm
11.	Ethylbenzene	7		Rat	100 ppm
12.	p,m - Xylene	7		Mouse Rat	100 ppm
13.	o - Xylene	7		Rat	100 ppm
14.	Trimethylbenzene	4			25 ppm
15.	Naphthalene	2		Rat	10 ppm

a. Threshold Limit Value (TLV) as recommended by American Conference of Industrial Hygienists. All Values represent time weighted average.
b. Permissible Exposure Limits (PEL) assigned by the Occupational Safety and Health Administration (OSHA).

naphthalene) are known to be toxic to the hematopoietic system while the substituted aromatic hydrocarbons (ethylbenzene, toluene, trimethylbenzene, and the xylenes) are respiratory irritants and affect the central nervous system but do not affect the hematopoietic system. Thus, for ease of presentation, the toxicities of these compounds can be grouped according to general chemical structure.

A. Hydrocarbons

Seven of the eight hydrocarbons in our study are aromatic hydrocarbons, the exception being methylcyclohexane. The most toxic of the eight hydrocarbons are the

Table 3

Common Sources Of Selected Volatile Organic Compounds

1. Dichloromethane -- Solvents, Degreasing, Cleaning fluid, Paint remover.
2. Ethylene chloride -- Solvents, Degreasers, Leaded Fuels.
3. 2 - Butanone -- Solvent, Paint, Stripper, Adhesive.
4. Tetrahydrofuran -- Combustion.
5. 1,1,1-Trichloroethane -- Solvent applications, Dry cleaning, Degreaser.
6. Benzene -- Automobiles, Gasoline Stations, Solvent
   -- Dyes, Paint and Coatings.
7. Trichloroethylene -- Solvent metal degreaser.
8. Methylcyclohexane -- Degradation of landfill biologically formed from Toluene.
9. Toluene -- Automobiles, Gasoline.
10. Tetrachloroethylene -- Dry cleaning, Degreasing, Solvent recovery.
11. Ethylbenzene -- Solvent.
12. p,m - Xylene -- Solvent applications, Automobiles.
13. o - Xylene -- Solvent applications, Automobiles.
14. Trimethylbenzene -- Degradation of landfill, Solvent.
15. Naphthalene -- Moth repellent, Insecticide.

two unsubstituted aromatic hydrocarbons, benzene and naphthalene. Both of these compounds are metabolized to polyhydroxylated aromatic ring compounds which in turn are easily oxidizable to benzoquinones, in the case of benzene *(51)*, and naphthoquinones in the case of naphthalene *(52)*. These quinones are highly electrophilic and can react with even weak nucleophiles *(53)* and thus are likely to react with nucleophilic centers in proteins, RNA and DNA. In contrast, the substituted aromatic hydrocarbons are metabolized primarily to benzoic acids and not to polyhydroxylated aromatic ring compounds *(54)*. Benzoic acids are not highly reactive and appear to undergo only conjugation reactions with amino acids or glucuronides before elimination *(54)*. Thus the toxicities of benzene and naphthalene which are manifested by permanent cell damage (e.g., aplastic anemia, cataracts) appear to be caused by their electrophilic metabolites while the toxicities of the substituted aromatic hydrocarbons which are usually manifested by transitory effects (e.g., respiratory irritation, central nervous system stimulation) appear to be mediated by the parent (unmetabolized) compound.

B. Chlorinated Hydrocarbons.

The chlorinated hydrocarbons in our study consist of three chlorinated alkanes (1,2-dichloroethane, dichloromethane and trichloroethane) and two chlorinated alkenes (tetrachloroethylene and trichloroethylene). Among these compounds, only trichloroethane is considered to be without carcinogenic activity. The carcinogenic activities of the other four chlorinated hydrocarbons are thought to be mediated via the formation of reactive intermediates during in vivo metabolism. For example, 1,2-dichloroethane is thought to form two very electrophilic intermediates, s-chloroethyl-glutathione and chloroacetaldehyde *(56)* while tetrachloroethylene and trichloroethylene are believed to form electrophilic tetrachloro- and trichloro-epoxide intermediates, respectively *(57, 58)*. Similarly, dichloromethane is known to form the electrophilic compound formaldehyde during in vivo metabolism *(59)*. In contrast to the carcinogenic chlorinated hydrocarbons, trichloroethane appears to be almost inert to in vivo metabolism. Indeed, in one experiment with rats, more than 98% of the absorbed dose of trichloroethane was expired unchanged *(60)*. In addition, trichloroethane is not dechlorinated in vitro in the presence of hepatic microsomes *(60)*, a further indication of the relative stability of this compound.

C. Oxygen-Containing Hydrocarbons.

The two oxygen-containing hydrocarbons in our target list appear to be without marked toxicological effects. Both of these compounds (tetrahydrofuran and 2-butanone) are water soluble and perhaps it is their water solubility that renders them somewhat innocuous. Because these compounds are water soluble they need not induce metabolic activity necessary to convert them to a water soluble state for elimination. A lack of metabolic activity, with its attendant formation of reactive oxygen species and/or reactive intermediates, may explain the relative benign behavior of these compounds although there appear to have been no studies concerning this possibility.

5.2 Data Tables

From July 1986 through September 1987, more than 500 field samples, 140 standard, and 50 blank and spike samples have been analyzed. Table 4 shows the arithmetic mean concentration for each sampling site and its standard deviation, where the corresponding maximum/minimum concentrations of each sampling site are shown in Table 5. The monthly average for each VOC in the whole landfill is shown as Table 6. The arithmetic mean concentration for each sampling site is shown as Table 7. And the total arithmetic mean and related concentration information based on the 15 months' data is shown in Table 8. Concentrations are expressed in parts per billion volumetrically (ppbv). The gas chromatograph detection limit here is 0.01 ppbv. The monthly arithmetic averages concentration data for the 15 VOC's on each different sampling site from July 1986 to September 1987 are presented in Appendix A from Table A-A through Table A-J, while the weekend samples are shown in the Appendix Table A-K. The monthly arithmetic averages data for all our target VOC at each sampling site are presented in Appendix B from Tables B-A through Table B-O.

From these tables, dichloromethane, trichloroethylene, benzene, toluene, and p,m-xylenes were consistently detected at high concentrations when compared with the

Table 4 (Unit : ppbv)

Average Concentration / Std. Deviation of All Sampling Sites

	COMPOUND	1C1	1C2	AVON	BC1	BC2
1	Dichloromethane	1.71 / 1.80	1.30 / 1.69	2.25 / 3.71	2.05 / 2.97	2.33 / 3.23
2	Ethylenechloride	0.59 / 0.89	0.40 / 0.34	0.98 / 2.02	0.72 / 0.78	0.67 / 0.76
3	2-Butanone	0.74 / 0.74	0.81 / 0.63	1.45 / 3.01	1.04 / 1.12	1.13 / 1.59
4	Tetrahydrofuran	0.14 / 0.11	0.15 / 0.17	0.22 / 0.34	0.31 / 0.88	0.79 / 1.55
5	1,1,1-Trichloroethane	0.74 / 0.71	0.94 / 1.96	0.85 / 1.86	1.00 / 1.57	1.02 / 1.59
6	Benzene	0.58 / 0.45	0.62 / 0.59	0.67 / 0.77	0.75 / 0.85	0.72 / 1.08
7	Trichlorothylene	1.21 / 1.21	1.40 / 1.45	2.18 / 3.68	1.57 / 1.63	1.60 / 1.83
8	Methylcyclohexane	0.31 / 0.42	0.65 / 0.98	0.38 / 0.41	0.64 / 0.71	0.84 / 1.16
9	Toluene	3.75 / 2.40	4.59 / 4.24	3.63 / 3.92	5.93 / 4.52	4.72 / 4.41
10	Tetrachloroethylene	0.72 / 0.65	2.23 / 3.66	1.23 / 1.97	1.57 / 2.02	1.82 / 3.22
11	Ethylbenzene	0.24 / 0.37	0.35 / 0.71	1.13 / 2.24	0.58 / 1.31	0.75 / 1.91
12	p,m - Xylene	3.15 / 2.88	4.28 / 5.77	6.61 / 7.50	4.35 / 4.85	5.46 / 4.55
13	o - Xylene	0.17 / 0.19	0.14 / 0.20	0.26 / 0.56	0.34 / 1.01	0.40 / 0.57
14	Trimethylbenzene	0.21 / 0.50	0.16 / 0.64	0.18 / 0.37	0.43 / 1.52	0.53 / 1.83
15	Naphthalene	0.04 / 0.15	0.01 / 0.03	0.02 / 0.07	0.07 / 0.28	0.04 / 0.19

	COMPOUND	BC3	BF1	BF2	DOWNWIND	RESIDENT
1	Dichloromethane	1.64 / 1.90	1.93 / 1.90	1.62 / 1.88	1.95 / 2.06	1.92 / 2.27
2	Ethylenechloride	0.95 / 1.14	0.80 / 0.80	0.64 / 0.72	0.78 / 0.93	0.81 / 1.08
3	2-Butanone	0.90 / 0.99	1.13 / 1.05	1.06 / 1.52	1.21 / 1.84	1.04 / 0.86
4	Tetrahydrofuran	0.82 / 1.39	0.28 / 0.40	0.31 / 0.35	0.22 / 0.36	0.30 / 0.91
5	1,1,1-Trichloroethane	0.91 / 1.16	0.82 / 0.79	0.61 / 0.77	0.78 / 0.95	0.75 / 0.88
6	Benzene	0.62 / 0.64	1.13 / 1.74	0.59 / 0.64	0.58 / 0.62	0.54 / 0.49
7	Trichlorothylene	2.08 / 2.19	1.23 / 1.49	1.08 / 1.43	1.78 / 3.27	1.63 / 1.69
8	Methylcyclohexane	0.74 / 0.77	1.12 / 2.41	0.42 / 0.67	0.65 / 1.89	0.42 / 0.99
9	Toluene	5.25 / 4.94	3.98 / 3.71	4.62 / 4.62	2.62 / 3.29	2.53 / 2.67
10	Tetrachloroethylene	2.12 / 2.64	1.10 / 1.72	1.22 / 1.49	0.70 / 1.43	0.93 / 1.48
11	Ethylbenzene	1.14 / 2.58	0.57 / 0.75	0.64 / 1.23	0.39 / 0.79	0.26 / 0.38
12	p,m - Xylene	5.55 / 4.78	4.35 / 4.73	4.86 / 5.12	4.01 / 6.14	4.09 / 5.42
13	o - Xylene	0.72 / 1.94	0.26 / 0.43	0.28 / 0.29	0.28 / 0.76	0.16 / 0.40
14	Trimethylbenzene	0.71 / 2.38	0.28 / 0.81	0.20 / 0.36	0.16 / 0.61	0.08 / 0.31
15	Naphthalene	0.06 / 0.17	0.04 / 0.16	0.03 / 0.12	0.02 / 0.06	0.01 / 0.03

Table 5 (Unit : ppbv)
Maximum/Minimum Concentration of All Sampling Sites

COMPOUND	1C1	1C2	AVON	BC1	BC2
1 Dichloromethane	9.18 / 0.34	7.38 / 0.00	24.15 / 0.00	15.84 / 0.00	16.46 / 0.00
2 Ethylenechloride	5.12 / 0.00	1.28 / 0.00	11.86 / 0.00	4.90 / 0.00	4.06 / 0.00
3 2-Butanone	3.72 / 0.16	3.27 / 0.00	21.25 / 0.00	6.41 / 0.00	9.35 / 0.00
4 Tetrahydrofuran	0.40 / 0.00	0.86 / 0.00	1.93 / 0.00	7.06 / 0.00	9.09 / 0.00
5 1,1,1-Trichloroethane	3.76 / 0.17	9.14 / 0.00	13.53 / 0.00	8.05 / 0.00	10.39 / 0.00
6 Benzene	2.08 / 0.05	2.10 / 0.00	4.61 / 0.00	5.56 / 0.00	7.83 / 0.00
7 Trichlorothylene	6.08 / 0.00	4.89 / 0.00	22.91 / 0.00	7.01 / 0.00	7.43 / 0.00
8 Methylcyclohexane	2.59 / 0.05	3.66 / 0.00	1.71 / 0.00	4.26 / 0.00	7.56 / 0.00
9 Toluene	9.32 / 0.13	21.00 / 0.02	15.56 / 0.00	19.59 / 0.00	17.78 / 0.00
10 Tetrachloroethylene	3.04 / 0.00	15.34 / 0.00	11.33 / 0.00	8.83 / 0.00	15.02 / 0.00
11 Ethylbenzene	1.69 / 0.00	4.14 / 0.04	8.85 / 0.00	7.95 / 0.00	14.24 / 0.00
12 p,m - Xylene	13.13 / 0.00	25.87 / 0.00	29.90 / 0.00	19.27 / 0.00	18.95 / 0.00
13 o - Xylene	0.79 / 0.00	1.01 / 0.00	3.50 / 0.00	7.82 / 0.00	2.84 / 0.00
14 Trimethylbenzene	2.82 / 0.00	3.72 / 0.00	1.81 / 0.00	8.50 / 0.00	14.00 / 0.00
15 Naphthalene	0.79 / 0.00	0.17 / 0.00	0.43 / 0.00	2.01 / 0.00	1.28 / 0.00

COMPOUND	BC3	BF1	BF2	DOWNWIND	RESIDENT
1 Dichloromethane	11.03 / 0.00	7.80 / 0.00	6.60 / 0.00	8.91 / 0.00	10.69 / 0.00
2 Ethylenechloride	5.59 / 0.00	3.44 / 0.00	2.56 / 0.00	4.94 / 0.00	6.00 / 0.00
3 2-Butanone	5.27 / 0.00	4.72 / 0.00	5.93 / 0.00	10.68 / 0.00	4.06 / 0.20
4 Tetrahydrofuran	6.78 / 0.00	2.25 / 0.00	1.71 / 0.00	2.56 / 0.00	6.07 / 0.00
5 1,1,1-Trichloroethane	6.21 / 0.00	3.36 / 0.12	3.65 / 0.00	4.96 / 0.00	5.16 / 0.00
6 Benzene	3.91 / 0.00	7.94 / 0.00	2.36 / 0.00	3.86 / 0.00	1.91 / 0.00
7 Trichlorothylene	11.84 / 0.00	4.86 / 0.00	6.45 / 0.00	17.30 / 0.00	9.34 / 0.00
8 Methylcyclohexane	3.66 / 0.00	12.35 / 0.00	3.36 / 0.00	13.10 / 0.00	6.20 / 0.00
9 Toluene	18.59 / 0.00	12.26 / 0.05	17.00 / 0.00	12.78 / 0.00	12.64 / 0.06
10 Tetrachloroethylene	12.07 / 0.00	9.65 / 0.00	5.91 / 0.00	7.91 / 0.00	9.11 / 0.00
11 Ethylbenzene	13.06 / 0.00	2.61 / 0.00	5.61 / 0.00	3.69 / 0.00	2.06 / 0.00
12 p,m - Xylene	15.78 / 0.00	18.04 / 0.00	20.90 / 0.00	25.39 / 0.00	23.36 / 0.00
13 o - Xylene	15.31 / 0.00	1.79 / 0.00	1.02 / 0.00	5.11 / 0.00	2.67 / 0.00
14 Trimethylbenzene	14.00 / 0.00	4.85 / 0.00	1.43 / 0.00	4.49 / 0.00	2.05 / 0.00
15 Naphthalene	0.82 / 0.00	0.99 / 0.00	0.70 / 0.00	0.41 / 0.00	0.14 / 0.00

Table 6 (Unit : ppbv)

Monthly Average Concentration For The Whole Landfill

	COMPOUNDS	*July-86*	*Aug-86*	*Sept-86*	*Oct-86*	*Nov-86*	*Dec-86*	*Jan-87*
1	Dichloromethane	0.53	0.33	1.03	0.83	1.29	3.01	1.71
2	Ethylenechloride	0.40	0.71	0.50	0.80	1.01	0.62	1.48
3	2-Butanone	1.75	0.92	0.82	0.93	1.10	1.94	0.99
4	Tetrahydrofuran	0.96	0.69	0.47	0.47	0.27	0.82	0.37
5	1,1,1-Trichloroethane	0.77	0.86	1.61	1.00	0.72	1.23	1.29
6	Benzene	0.65	0.34	0.52	0.73	0.72	1.09	0.75
7	Trichlorothylene	0.01	0.03	0.00	0.32	1.17	3.55	2.69
8	Methylcyclohexane	0.48	0.90	1.97	0.64	0.84	1.08	0.37
9	Toluene	5.18	2.96	3.41	4.90	3.20	6.41	3.61
10	Tetrachloroethylene	0.48	0.03	0.00	1.01	0.88	1.31	2.12
11	Ethylbenzene	1.19	0.59	0.35	0.42	0.50	0.70	0.30
12	p,m - Xylene	1.64	1.10	0.65	1.97	4.36	6.62	5.79
13	o - Xylene	0.74	0.54	0.42	0.49	0.23	0.90	0.29
14	Trimethylbenzene	0.69	0.38	0.70	0.19	0.09	0.39	0.10
15	Naphthalene	0.33	0.22	0.02	0.14	0.12	0.03	0.00

	Feb-87	*Mar-87*	*Apr-87*	*May-87*	*June-87*	*Jule-87*	*Aug-87*	*Sept-87*
1	4.71	1.56	2.50	2.16	1.20	1.06	2.50	1.44
2	0.90	0.73	0.68	0.40	0.51	0.63	0.76	0.94
3	1.24	0.65	0.97	0.72	0.89	0.56	1.65	1.30
4	0.26	0.14	0.24	0.29	0.50	0.28	0.21	0.41
5	0.97	0.51	0.87	0.56	0.45	0.40	1.12	1.13
6	0.67	0.74	0.68	0.49	0.54	0.82	0.41	0.68
7	2.31	1.52	2.29	1.37	1.06	0.87	1.74	2.38
8	0.66	0.34	0.58	0.57	0.29	0.55	0.56	0.61
9	4.82	2.90	5.04	3.50	3.01	2.83	5.66	5.11
10	1.48	1.36	1.62	1.88	1.63	1.19	2.33	1.72
11	0.84	0.63	0.94	0.85	0.35	0.66	1.33	0.40
12	5.60	4.57	6.84	6.61	4.26	3.78	7.15	4.85
13	0.26	0.14	0.31	0.32	0.13	0.17	0.38	0.23
14	0.13	0.10	0.31	0.11	0.09	0.07	0.61	1.01
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 7 (Unit : ppbv)

Total Average Concentration For Each Sampling Site

	COMPOUNDS	1C1	1C2	AVON	BC1	BC2
1	Dichloromethane	1.71	1.30	2.22	2.05	2.23
2	Ethylenechloride	0.59	0.40	0.97	0.72	0.67
3	2-Butanone	0.74	0.81	1.45	1.04	1.13
4	Tetrahydrofuran	0.14	0.15	0.21	0.31	0.79
5	1,1,1-Trichloroethane	0.74	0.94	0.84	1.00	1.02
6	Benzene	0.58	0.62	0.68	0.75	0.72
7	Trichlorothylene	1.21	1.40	2.20	1.57	1.60
8	Methylcyclohexane	0.31	0.65	0.39	0.64	0.84
9	Toluene	3.75	4.59	3.56	5.93	4.72
10	Tetrachloroethylene	0.72	2.23	1.23	1.57	1.82
11	Ethylbenzene	0.24	0.35	1.13	0.58	0.75
12	p,m - Xylene	3.15	4.28	6.75	4.35	5.46
13	o - Xylene	0.17	0.14	0.25	0.34	0.40
14	Trimethylbenzene	0.21	0.16	0.18	0.43	0.53
15	Naphthalene	0.04	0.01	0.02	0.07	0.04

	COMPOUNDS	BC3	BF1	BF2	DOWNWIND	RESIDENT
1	Dichloromethane	1.45	1.93	1.62	1.95	1.92
2	Ethylenechloride	0.91	0.80	0.64	0.78	0.81
3	2-Butanone	0.85	1.13	1.06	1.21	1.04
4	Tetrahydrofuran	0.81	0.28	0.31	0.22	0.30
5	1,1,1-Trichloroethane	0.85	0.82	0.61	0.78	0.75
6	Benzene	0.62	1.13	0.59	0.58	0.54
7	Trichlorothylene	1.90	1.23	1.08	1.78	1.63
8	Methylcyclohexane	0.69	1.12	0.42	0.65	0.42
9	Toluene	5.15	3.98	4.62	2.62	2.53
10	Tetrachloroethylene	2.14	1.10	1.22	0.70	0.93
11	Ethylbenzene	1.25	0.57	0.64	0.39	0.26
12	p,m - Xylene	5.33	4.35	4.86	4.01	4.09
13	o - Xylene	0.80	0.26	0.28	0.28	0.16
14	Trimethylbenzene	0.53	0.28	0.20	0.16	0.08
15	Naphthalene	0.06	0.04	0.03	0.02	0.01

Table 8 (Unit : ppbv)

Total VOCs Concentration Data Of The Whole Landfill

	COMPOUND	AVG.	MIN.	MAX.	STD. DEV.	COUNT
1	Dichloromethane	1.88	0.0	24.15	2.55	480
2	Ethylenechloride	0.75	0.0	11.86	1.07	480
3	2–Butanone	1.07	0.0	21.25	1.56	480
4	Tetrahydrofuran	0.39	0.0	9.09	0.93	480
5	1,1,1–Trichloroethane	0.85	0.0	13.53	1.34	480
6	Benzene	0.68	0.0	7.94	0.87	480
7	Trichlorothylene	1.62	0.0	22.91	2.27	480
8	Methylcyclohexane	0.63	0.0	13.10	1.21	480
9	Toluene	4.21	0.0	21.00	4.16	480
10	Tetrachloroethylene	1.40	0.0	15.34	2.32	480
11	Ethylbenzene	0.66	0.0	14.24	1.61	480
12	p,m – Xylene	4.77	0.0	29.90	5.44	480
13	o – Xylene	0.34	0.0	15.31	0.94	480
14	Trimethylbenzene	0.30	0.0	14.00	1.17	480
15	Naphthalene	0.04	0.0	2.01	0.16	480

other compounds. 2-butanol, 1,1,1-trichloroethane, and ethylbenzene nearly always found, where naphthalene was only found once in a while at each sampling site. All of the samples we analyzed have average concentrations below the 10 ppb New Jersey ambient air quality standard.

5.2.1 Volatilization and diffusion factors

The concentrations of the VOC varied considerably from site to site and month to month, as would be expected. For example, benzene ranged from 0.19 ppbv at site BC2 on July-86 to 2.07 ppbv at Downwind site in the same month, toluene ranged from 0.30 ppbv at site 1C2 on October 1986 to 7.35 ppbv on November 1986. Such variations are not uncommon for VOCs, since we are dealing with levels in the low to sub ppbv concentration range. The results can be explained as the result of volatilization and diffusion of the VOCs (70-74). The essential factors affecting the volatilization of organic chemical waste for this situation are due to: 1.) Vapor pressure: compounds with higher vapor pressure usually volatilize more rapidly than compounds with lower vapor pressure. 2.) Temperature: (70) higher temperature of the waste will increases vapor pressure, and increase volatilization rate. 3.) Reactivity: (71) reactions with other chemical waste can speed, slow, or end volatilization. 4.) Leaching: (71) soluble waste constituents volatilize slowly and may migrate beyond the landfill boundary with laterally moving ground water. The diffusion through the landfill could also be affected by the soil porosity (72), atmospheric pressure fluctuations (72), wind speed, landfill gas migration, thickness of soil landfill cover (75), infiltration of surface water and resultant soil moisture content, (75) the rainfall, and weather ...etc.

5.2.2 Environmental Factors

From Appendix Table A-A through A-J, toluene, p,m-Xylene, and dichloromethane are usually the three highest concentration compounds found in every sample, where 2-butanol, methylcyclohexane, and trichloroethane are in the second rank, benzene, ethylene chloride, and ethylbenzene are in the third rank. All of these can be considered to be related to the garbage trucks and other working vehicles. It is clear when one checks with the common source (Table 3) and compares with the average diesel gasoline composition and the average exhaust emissions (48,49). But, when one compares the weekend samples (Appendix Table A-K) with the weekday samples average (Table 4). Most of the VOCs concentration in the weekend are lower than those found in the weekday. Other factors still play a big role in the determination of the VOC concentration. But the disturbance from the working vehicles is one of the source of these VOCs.

Our sampling term covers two summers and one winter. From Table 6 and the related tables on Appendix Table A-A to Table A-J, most of the VOCs in our analysis had higher concentration in both summer and winter seasons when compared to the concentrations found in the spring and fall. The higher concentration in the summer can be considered as a temperature effect, while the higher concentration in the winter can be expressed as the result of ground surface convection. Two thirds of our target VOCs reached the maximum concentrations in December (7 of 15) or January (3 of 15). This can be explained as follows: during the hot and warm seasons, the temperature of the ground and the ground surface is lower than the temperature of the atmosphere above the ground surface. Most of the VOCs evaporate from the ground to the atmosphere and are quickly diluted by the wind current. On the contrary, in winter, the temperature of the ground and the ground surface is higher than the temperature of the atmosphere above the ground surface. Most of the VOCs stay in the ground or at ground surface. However, the concentration drops off again when the ground is snow covered because the snow obstructs the convection. These trends can be seen in the Table 6 and in the detailed monthly average concentration of each sampling site Tables from Appendix Table A-A to A-J. Nearly every site and every VOC has the highest concentration in either November, December or January, then drops off in February due to the snow and rainfall. This is not always the same from site to site, because it still is affected by the wastes that have been dumped in the site where the air sample were taken. Some wastes have very high concentrations of some of the target VOCs. This will result in high concentrations emission of those VOCs being detected in the sample.

5.2.3 Landfill Gas Migration.

Site Avon has been closed since 1985. The air sample shows that a certain amount of VOCs still remain in this open space. The concentration detected on site Avon are very similar to its neighbors, site BCs. Most of concentration is smaller than those found on the BCs. It is similar at the Resident and Downwind site. The VOCs concentration we found in Resident site is fairly similar to it neighbors, site BFs, BCs. The concentration in Downwind site is close to that at Avon and BCs. Although we can not eliminate the other possibilities of VOC sources at these three sites, such as automobile exhaust for the Resident and Downwind sites, the landfill gas leaching within the closed landfill. But the wind speed and landfill gas migration factors play a significant role here. The wind helps the diffusion of these landfill VOCs from the active landfill sites to the downwind and residential areas.

5.2.4 Comparison With The Other Urban Areas

Table 9 presents concentrations for the six most prevalent volatile compounds found in the 5 urban areas of major American cities. Comparison with the data from our study in Table 4, 5, 6, 7 and 8, shows a dramatic difference. Benzene, ethylbenzene, o-Xylene, and trimethylbenzene, shows concentrations which are lower than all of the

Table 9

COMPARISON VOC CONCENTRATION DATA (ppbv)

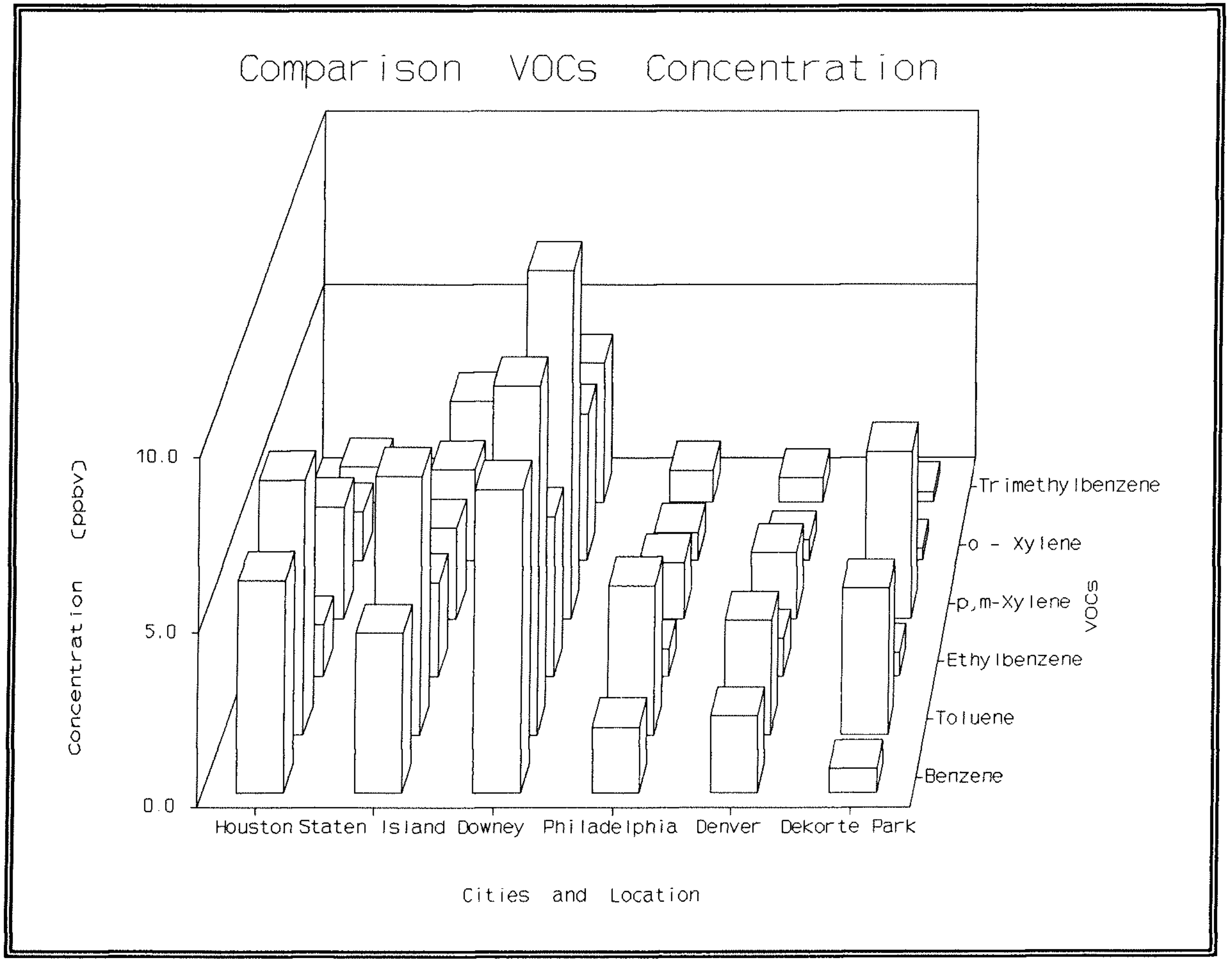
	Philadelphia PA	Staten Island NY	Downey CA	Houston TX	Denver CO
Benzene	1.9/1.7[a]	4.6/3.3	8.7/5.9	6.1/5.8	2.2/2.1
	8.8/0.6[b]	34.0/0.1	28.8/1.0	40.3/1.0	13.5/0.4
Toluene	4.3/4.1	7.4/9.3	16.9/12.3	7.3/9.5	3.3/3.9
	30.6/0.4	44.7/0.5	64.0/1.6	78.2/0.3	25.8/0.4
Ethylbenzene	0.8/0.8	2.7/4.2	4.6/3.7	1.5/1.6	1.1/3.5
	7.3/0.1	16.7/0.0	16.3/0.0	8.2/0.0	31.5/0.0
p,m - Xylene	1.6/1.5	2.6/3.3	10.2/7.8	3.2/3.1	1.9/2.3
	14.1/0.2	15.6/0.0	37.5/0.9	17.9/0.0	14.8/0.0
o - Xylene	0.8/0.8	2.6/3.5	4.2/3.2	1.4/1.4	0.6/1.1
	5.9/0.0	17.4/0.0	16.0/0.0	7.2/0.0	6.6/1.1
Trimethylbenzene	0.9/0.8	2.9/4.8	4.0/3.3	1.0/1.0	0.7/1.0
	5.4/0.0	29.7/0.0	15.6/0.0	7.2/0.0	5.7/0.0

a. The data shown in this line is the arithmetic mean concentration and its standard deviation value.
b. The data shown in this line is the Maximum/Minimum concentration.

five cities. This remains the same even when we compare with each sampling site. The landfill toluene concentration is larger than Denver, similar to Philadelphia, and much smaller than the other three cities. The landfill m,p-xylene concentration is lower than Downey and higher than the other four cities.

To help visualize the general comparison pattern in Table 8 and Table 9, Figure 9 presents a graphic comparison of the concentrations of the six VOCs between the six sites. The figure clearly shows the relatively high level in the outdoor air in the Downey, California, and the low level in the landfill samples. Table 9 and Figure 9 indicate that our landfill has the common air VOC level lower than most of the cities in the mainland area. One exception was the m,p-Xylene, which is higher than the other four cities.

Figure 9



5.2.5 Comparison With The Other Hazardous Waste Site

In order to do the further exposure assessment about the VOCs data we collected, the literature VOC data of another hazardous waste site inside New Jersey, the Elizabeth area (69), are used to do the comparison with the data we obtained. The exposure assessment was conducted for the five most hazardous compounds and shown as Table 10. The outdoor and indoor concentrations of the five VOCs at Elizabeth are obtained from the Airborne Toxic Elements and Organic Species (ATEOS) study (30) and the Total Exposure Assessment Methodology (TEAM) study (62). The concentration of outdoor Lyndhurst and the landfill site are chosen from the average concentration of the resident site on Table 4. Benzene is the only compound found in Lyndhurst to be smaller than that found in Elizabeth. The concentration of the other four compounds in Lyndhurst are about 3 times to 8 times higher than those found in Elizabeth.

A population of possible park users was identified as individuals that live around the residential sampling site in our study, or around a sampling site in Elizabeth of the ATEOS study (30). The primary basis for selection of these two urban areas was the availability of 1.) volatile organic data for the target compounds, and 2.) published information on the quality assurance programs. A secondary basis was the likelihood of individual from each community participating in activities at the park. Two other sites were available in ATEOS, but Elizabeth was viewed to be the most representative

Table 10

Mean Air Concentration In ppbv For Top 5 Ranked Compounds In Toxicological Analysis For Various Environmental Settings

	Outdoor			Landfill	Site
	Lyndhurst	Elizabeth[a]	Indoor	Low	High
Benzene	0.54	1.06	9.40[b]	0.58	1.13
Dichloromethane	1.92	0.23	**	1.30	2.33
Trichloroethylene	1.63	0.27	1.36[b]	1.08	2.18
TetraChloroethylene	0.93	0.31	1.62[b]	0.70	2.23
1,2 - Dichloroethane (Ethylenechloride)	0.81	0.0	**	0.40	0.95

a. From Toxic Air Pollution, P. J. Lioy and J. M. Daisey, ed., 1986, Lewis Publications, Chelsea, MI.
b. From The Total Exposure Assessment Methodology (TEAM) Study, L. Wallace, 1987 U. S. EPA, Washington, DC
** Assume penetration of 70 % of outdoor air for either site, since there was no indoor data, and none speculated.

of a typical commercial-residential district.

To obtain a more complete picture of the potential exposures to the five target VOC, literature values on indoor concentrations were obtained from The Total Exposure Assessment Methodology Study (TEAM) (62). For benzene, trichloroethylene, and tetrachloroethylene, no indoor values were available for these VOCs, and we did not estimate concentrations from any indoor sources. We did assume that 70% of the outdoor concentrations for each pollutant penetrated indoors. The lack of indoor concentrations would not affect the estimates of exposure and risk from activities associated with the range of mean values for the proposed DeKorte Park. To examine the exposures for the active landfill sites we used the high and low mean concentrations associated with the range of mean values for the eight landfill sites as shown in the Table 10.

Table 11

Estimated Mean Air Exposure (ppbv) Using Non-occupational Contribution From Indoor, Outdoor, And Recreation At DeKorte Park

	Elizabeth		Lyndhurst	
	Low	High	Low	High
Benzene	7.71	7.71	7.63	7.65
Dichloromethane	0.23	0.46	1.43	1.66
Trichloroethylene	1.18	1.24	1.39	1.44
Tetrachloroethylene	1.39	1.46	1.47	1.55
1,2 - Dichloroethane	0.03	0.05	0.58	0.60

Projected Distribution of time for an individual who could use the park

80 %	Indoors
15 %	Other Outdoors + Travel
5 %	Park

For a person from Lyndhurst: participating in activities at the high Benzene landfill site

Indoors Outdoors Park
0.80 (9.40) + 0.15 (0.54) + 0.05 (1.13) = 7.65

The arithmetic mean air exposures (ppbv) for people living in Elizabeth and Lyndhurst (residential) were estimated from the time spent in three non-occupational micro-environments and the concentrations associated with each, Table 11. An individual was estimated to spend 80% of the time indoors, 15% of the time in transit or other community settings and 5% of the time at the park. This time profile is reasonable for the non-park activities, but is an over-estimate of the amount of time to be spent at the park. Each individual, however, would be considered to be part of an active sub-group. The results of the activity weighted exposure calculations are found in Table 11.

5.2.6 Dose Exposure And Risk Assessment

Before we talk risk assessment we need to explain the dose response first. For every chemical there is a dose range where no toxic response is observed, a dose range at which the toxic effects may be observed, and a range at which the chemical is lethal. According to the regulation published from U.S.E.P.A. (62-66), the unit used to express the dose exposure is by mg/kg/day (64). That means the milligrams of VOC inhaled per kilogram of body weight per day. Therefore, in order to determine the inhaled dose in our study we use the concentration data on Table 11 (for the Elizabeth and Lyndhurst area) and Table 10 (for Landfill). These data are converted from ppb volumetrically to weight unit (mg/kg/day). Then the daily ventilation volume is multiplied by the deposition factor and the absorption factor, and divided by the weight (64). The ventilation, deposition, absorption, and weight factors are obtained from the USEPA public health evaluation manual (67) and the guideline for carcinogen risk assessment (62). These values take into account daily air inhalation, average body weight, and the estimated working factor of the lung. The final result is presented as Table 12. These data were used in conjunction with parameters that control the quantity of inhaled VOC deposited in the lung for each of the five target compounds.

Table 12

Estimated Daily Dose (mg/kg/Day) x 10^{-4}

	Elizabeth		Lyndhurst		Landfill	
	Low	High	Low	High	Low	High
Benzene	35.1	35.3	34.8	34.9	2.6	5.1
Dichloromethane	1.1	2.3	7.1	8.2	6.4	11.6
Trichloroethylene	9.1	9.5	10.6	11.0	8.3	16.7
Tetrachloroethylene	13.5	14.1	14.2	15.0	6.8	21.6
1,2 - Dichloroethane	0.1	0.2	2.2	2.3	1.5	3.6

Dose Calculation :
D (mg/kg/Day) = (Concentration) x (Ventilation) x 1/Weight x (Deposition) x (Absorption)

Assumption (From USEPA reference)
Ventilation = 20 m^3/day
Deposition = 0.5
Absorption = 1.0
Weight = 70 Kg

Conversions Factors:	1 ppb =	3.19 ug/m^3	Benzene
		3.47 ug/m^3	Dichloromethane
		5.37 ug/m^3	Trichloroethylene
		6.78 ug/m^3	Tetrachloroethylene
		2.65 ug/m^3	1,2-Dichloroethane

The dose estimates calculated in Table 12 were required for the final risk as assessment. This calculation employed the inhaled dose, as shown in Table 12, times the Carcinogen Assessment Group (CGA) Risk Factors estimates of carcinogenic potency (1/(mg/kg/day)) to determine the upper bound risk derived from a conservative model and the exposures and doses calculated in Table 11 (exposure) and Table 12 (Dose) for individuals from each town and the individual stay in park for more than 24 hours *(63,64)*. The result is shown on Table 13. The risks are estimated as probabilities. The carcinogenic potency factor, which is an upper 95 percent confidence limit on the probability of response per unit intake of a chemical over a life time, converts estimated dose directly into incremental risk *(62)*. If the exposure assessment is conservative, the resultant risk predicted is an upper bound estimate. Consequently, the predicted risk may overestimate the actual risk at a site.

Based upon the time profile selected for these individuals, the risk attributable to a park (Table 12) and on the active landfill site was 1.) less than 20 in a million for benzene, trichlorethylene, and dichloromethane 2.) between 13 and 33 in a million for 1,2-dichloroethane 3.) between 34 and 110 in a million for tetrachloroethylene. In most cases the park would contribute less than 10% of the estimated total risk for each compound. According to the regulation published by the USEPA, the safe range for the carcinogenic risk is within 10^{-4} to 10^{-7} *(63,66)*. To our result, we have one compound (Tetrachloroethylene) which reaches the upper limit, and four compounds of above average probabilities. The overall probability is located at the above average

Table 13

Risk Calculated For Each Compound Based on CAG Value (10^{-6})

	Elizabeth		Lyndhurst		Landfill	
	Low	High	Low	High	Low	High
Benzene	101.8	102.4	100.9	101.2	7.5	14.8
Dichloromethane	1.5	3.2	9.9	11.5	9.0	16.2
Trichloroethylene	10.0	10.5	11.7	12.1	9.1	18.4
TetraChloroethylene	68.9	71.9	72.4	76.5	34.7	110.2
1,2 - Dichloroethane	0.9	1.8	20.0	20.9	13.7	32.8

Risk Calculation :
Risk Concentration (ppm) = (Daily Dose) x (CAG potency factor)

Carcinogen Assessment Group Risk Factor:

Compound	Potency Factor $(mg/kg/day)^{-1}$
Benzene	2.9×10^{-2}
Dichloromethane	1.4×10^{-2}
Trichloroethylene	1.1×10^{-2}
Tetrachloroethylene	5.1×10^{-2}
1,2-Dichloroethane	9.1×10^{-2}

range, but still falls into the acceptable risk probability range. It must be emphasized that the levels measured in our study were done at an active landfill. Once closed, and prepared for use as a park (addition of top soil and grass), the levels of VOC would probably be reduced. Also, the local garbage truck traffic would no longer contribute VOC emissions to the area which should lead to further reduction in VOC concentrations at the future park site.

5.3 Statistical Data Examination -- ANOVA

The first part of statistical examination to the sample data we collected and analyzed is using one of the popular statistical methods -- Analysis Of Variance (ANOVA) *(68)*. This method was developed in the 1920s by statistician Ronald Fisher as a way to evaluate the agricultural experiments. The purpose to use this method is to examine the data similarity difference between the data set we collect randomly. We now give a briefly introduction of the way ANOVA works.

We first introduce the term "sum of squares," abbreviated as SS. Sum of square is similar to variance (or standard deviation) but does not have the divisor which one can find in the variances. For example, $Sum((x_i - \bar{x})^2/(n - 1))$ is a variance, whereas $Sum((x_i - \bar{x})^2)$ is a sum of squares. Now suppose that we independently select all the r samples from r different populations and call the respective sample size $n_1, n_2, n_3, \ldots\ldots, n_r$. We summarize the sum for each population and denote as $T_1 + T_2 + T_3 + \ldots\ldots + T_r$. The sum of all the T_is is designated as T. We next calculate the means of the r samples and denote as $\bar{x}_1, \bar{x}_2, \bar{x}_3, \ldots\ldots, \bar{x}_r$ and the sample variance $s_1^2, s_2^2, s_3^2, \ldots\ldots, s_r^2$. If we regard all the data as a large single sample, it will contain $n_1 + n_2 + n_3 + \ldots\ldots + n_r$ values and we refer this sum as N. We call the mean of this large sample, obtained by adding all of the N values (e.g the T value) and then dividing by the number N, the "grand" mean and denote it as $\bar{x}_\bullet$. Therefore the relationship between each different sum of squares are expressed as:

$$\underset{SS_{total}}{\overset{N}{Sum}((x_i - \bar{x}_\bullet)^2)} = \underset{SS_{between}}{\overset{r}{Sum}(\, n_r\, (\bar{x}_i - \bar{x}_\bullet)^2)} + \underset{SS_{within}}{\overset{r}{Sum}(\, (n_i - 1)\, s_r^2\,)} \qquad (1)$$

The SS_{total} in above equation reflects the extent to which all the individual N values vary around the grand mean, $\bar{x}_{\bullet}$. The $SS_{between}$ measures the extent to which the r sample means $\bar{x}_1, \bar{x}_2, \bar{x}_3, \ldots\ldots, \bar{x}_r$ vary around the grand mean, $\bar{x}_{\bullet}$. Finally the SS_{within} summarizes the extent to which the value (x_i) within each sample vary around that sample mean ($\bar{x}_i$). There are (r - 1) degree of freedom associated with $SS_{between}$ and (N - r) degree of freedom associated with SS_{within} to form a totally (N - 1) degree of freedom for the SS_{total}. The form of the sum of square shown in above equation is not the most efficient computation method. A preferable form is shown below:

$$SS_{between} = \mathrm{S}\overset{r}{\mathrm{u}}\mathrm{m}(\, T_i^2 / n_i \,) - (\, T^2 / N \,) \qquad (2)$$

$$SS_{within} = \mathrm{S}\overset{N}{\mathrm{u}}\mathrm{m}(\, x_i^2 \,) - \mathrm{S}\overset{r}{\mathrm{u}}\mathrm{m}(\, T_i^2 / n_i \,) \qquad (3)$$

$$SS_{total} = \mathrm{S}\overset{r}{\mathrm{u}}\mathrm{m}(\, x_i^2 \,) - (\, T^2 / N \,) \qquad (4)$$

When we divide a sum of squares by its associated number of degrees of freedom, we then obtain a variance-like quantity which is referred to as a "Mean Square" and denoted as MS. A final F-test figure is obtained by dividing the mean square value between the populations (e.g. $MS_{between}$) by the mean square value within the samples (e.g. MS_{within}). This resulting figure is then compare to the tabulated F-test value with same kinds of degrees of freedom of desired confidence interval.

There are two independent variables in our study, the sampling site and the target volatile compound, and one dependent variable, the concentration. When compare the two independent variables, the different sampling sites have more meaning than the different compounds. Therefore, we treat each target compound as an independent experiment, and focusing on the relationship between each sampling site and time. This tables are shown as the upper figure on Appendix B Table B-A through Table B-O.

The data is arranged by each sampling site and each month. The middle box of each table shows a basic mathematical calculation on the data shown on above. The bottom box of each table shows the summary of the calculation, SS as the sums of squares, df as the degree of freedom, MS as the mean square, F as the result figure of F - test or F distribution. On the bottom, there are two function lines which show the area of F - test of which the 95% and 99% area are encountered. Actually, these two function lines should be F(9,135,0.05) and F(9,135,0.01) instead of the two we used in the appendix tables. But we can not find this two function result from the statistical reference we can find. Hence we use the one most close to our requirement. The real value will be about 1% to 2% smaller than the one we find and the difference is small enough to be neglected.

The result shows that 11 of the 15 compounds fall below 95% confidence interval, 3 compounds are between 95% and 99%. Only one, tetrahydrofuran, falls outside the 99% interval. This evidence shows that for most of the compounds, the sampling and analysis methods we use result in no significant difference for the concentration we found in each sampling site. Some of them (3 of the 15 compounds) show some slight but is still acceptable difference (95% and 99% confidence interval are closed) in each site. And only one compound has big difference in each sampling site. This is a good way to examine the data we collect to see if they are statistically acceptable. This analysis result can be beneficial in finding out the sampling or analysis error for those sites or compounds which have significant difference in the future experiment.

5.4 Quality Control

The Gas Chromatograph is calibrated for quantitation at the beginning and end of each batch sample analysis by using a purchased 100 ppb Benzene standard. Table C-1 on the Appendix C show the accuracy relative to benzene standard from July-86 to September 87. The average relative error falls into the acceptable 4.8%. The result reveal that the gas chromatograph we use in our study perform a very stable and reliable result.

The desorbtion efficiency of Tekmar Thermal Desorber was checked with trap spiked with several compounds of interest. During these experiments the proper parameters were chosen for transfer time of 3 minutes and inject time of 1 minute instead of the 1 minute transfer time and 0.5 minute inject time recommended by the manufacturer. Due to these and a few more changes in the desorbtion methods, the attained desorbtion efficiency was about 85 - 96 percent.

Table C-2 on the appendix C show the precision estimates on the duplicate sample analysis on the HMDC and the comparison between HMDC and NJIT laboratories. The overall precision for HMDC (14%) are well within the ± 30% margin and considered acceptable. More variability was seen in the duplicate analyses conducted between NJIT and HMDC, with Trimethylbenzene, o-xylene, m,p-xylene and ethylbenzene showing the most significant errors. Such deviations between instruments are not uncommon for VOC, since we are dealing with levels in the low to sub ppb concentrations range.

Another precision control chart were prepared using the analysis of duplicate samples collect in 1986 and first few months of 1987 (total 20 duplicates). The result of subsequent analysis were used to compare to the charts for control. The overall precision ranged from 4 to 16 percent and can be accounted for the collection, storage, and instrument variability. Figures C-1 to C-15 on the Appendix C give a depiction of the precision control chart for each compound except naphthalene. Most of the compounds fall well below the upper warning line (UWL), only dichloromethane and toluene have one sample for each above the upper warning line but below the upper control line. These charts show again that the Gas Chromatograph is in a stable condition and the data resulting from the GC analysis is in an acceptable range. The concentration unit used in these tables, charts, and figures is ppbv.

6 Conclusion

From the tables and figures of our study result, the concentration levels of the selected VOCs inside the whole landfill varied from site to site and month to month. Weather, molecular weight, reactivity, and temperature can affect the emission rate dramatically. The concentrations usually come to the peak in both the summer and winter. Snow and rainfall, generally, will lower the emission concentration while sunlight will promote the rate. Indeed, such variations are not uncommon and exhibited in any ambient air sampling that takes place because we are dealing with levels in the low to sub ppbv range. However, during our comparison of the six prevalent VOCs with the other five urban cities, the overall levels were smaller than those found in the other five urban environment. For these specific VOCs and it seems likely that the higher levels in the urban area are due to the fuel consumption and exhaust emission from both automobiles and industrial/commercial activities.

On our other comparison with the Elizabeth area, New Jersey, we evaluated the list of potential emanations and prepared a risk assessment based on the five known carcinogens among the fifteen compounds sampled by using the method published by USEPA. These five compounds were: benzene, ethylene chloride, tetrachloroethylene, trichloroethylene, and dichloromethane. The risk assessments are based on the Carcinogen Assessment Group (CAG) risk factor estimates of carcinogenic potency developed by the USEPA. The risk assessment was based on a model that involved exposure to an active individual who would spend as much as five percent of their lifetime in the park. This was an intentional over estimation of exposure. The approach used to examine the risk at the proposed Dekorte site assumed no alterations in the area after cessation of operations. The result of risk assessment for the five carcinogens showed that for the fraction of time spent at the site the maximum increase in lifetime risk for cancer was in the range of one in a million for each compound. And exposure to the levels of volatile organic compounds detected at DeKorte Park would not increase the risk of cancer in individuals residing in the surrounding urban environment. In fact the atmospheric concentrations used in the assessment were for the active landfill. It did not include the introduction of mitigation measures and site alterations (e.g., addition of topsoil) that would probably reduce any residual emissions from the soil site. Thus, the exposure which is equal to the concentration of the pollutant times the time of contact with the pollutant is deliberately over estimated for both terms.

The ANOVA statistical examination of the data we collected shows that the mean concentrations measured at each site on the landfill and the residential area (Lyndhurst) were not statistically significantly different. From the Benzene standard calibration result, there is an acceptable relative accuracy (4.6%). The precision control charts show only two compounds (Dichloromethane and Toluene) have one sample over the upper warning limit but all the duplicate sample are under the upper control. It shows that all the GC analysis are under a stable condition and all the data are in the acceptable range.

Finally, a word about the toxicology of mixtures is in order. It is self evident that the off-gas produced by landfills will contain mixtures of many compounds. Very little is known about the combined toxicological effects of exposures to mixtures of compounds. It is possible that at the low concentrations of compounds found in our study, the components of the landfill off-gas may not interact toxicologically. At the present state of knowledge, however, the toxic effects of mixtures remain an area of scientific speculation.

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Appendix A

Monthly Arithmetical Mean Concentration For Each Sampling Site

Appendix Table A-A (Unit: ppbv)

Monthly Avg. Conc. On Site AVON From July-86 To Sept-87

	COMPOUND	*Sept-86*	*Oct-86*	*Nov-86*	*Dec-86*	*Jan-87*	*Feb-87*	*Mar-87*
1	Dichloromethane	0.60	0.49	1.45	8.39	1.78	3.33	1.35
2	Ethylenechloride	0.26	0.67	1.83	0.48	3.41	0.37	2.33
3	2-Butanone	0.67	1.11	1.00	6.62	1.04	0.69	0.46
4	Tetrahydrofuran	0.00	0.16	0.14	0.26	0.52	0.10	0.15
5	1,1,1-Trichloroethane	0.79	0.79	0.79	0.48	4.44	0.66	0.39
6	Benzene	0.74	1.09	0.78	0.70	0.44	0.98	0.66
7	Trichlorothylene	0.00	0.00	1.76	3.86	6.76	2.72	2.05
8	Methylcyclohexane	0.32	0.37	0.22	0.76	0.25	0.67	0.21
9	Toluene	4.89	6.23	1.91	5.76	3.58	3.25	4.99
10	Tetrachloroethylene	0.00	0.00	0.28	1.16	2.30	0.67	3.30
11	Ethylbenzene	0.04	0.32	0.13	0.38	0.09	1.41	1.63
12	p,m - Xylene	0.13	1.74	4.53	6.01	3.92	7.55	9.91
13	o - Xylene	0.15	0.20	0.17	0.49	0.03	0.00	0.00
14	Trimethylbenzene	0.13	0.06	0.03	0.12	0.02	0.19	0.09
15	Naphthalene	0.07	0.10	0.14	0.00	0.00	0.00	0.00

	COMPOUND	*Apr-87*	*May-87*	*June-87*	*July-87*	*Aug-87*	*Sept-87*
1	Dichloromethane	3.15	2.64	1.19	0.77	1.85	0.91
2	Ethylenechloride	0.59	0.33	0.64	0.52	0.54	0.33
3	2-Butanone	0.68	0.58	0.66	0.30	3.92	1.96
4	Tetrahydrofuran	0.10	0.22	0.49	0.10	0.19	0.13
5	1,1,1-Trichloroethane	0.48	0.22	0.46	0.35	0.91	0.45
6	Benzene	0.50	0.43	0.49	0.56	0.75	0.47
7	Trichlorothylene	1.02	1.18	1.66	0.74	2.41	3.83
8	Methylcyclohexane	0.53	0.26	0.30	0.04	0.66	0.36
9	Toluene	5.00	2.08	2.09	0.63	6.60	2.93
10	Tetrachloroethylene	1.17	1.24	1.57	0.79	1.47	1.86
11	Ethylbenzene	0.31	1.08	0.24	0.46	6.59	2.73
12	p,m - Xylene	10.15	9.93	2.86	3.07	16.25	9.18
13	o - Xylene	0.02	1.05	0.08	0.08	0.93	0.45
14	Trimethylbenzene	0.24	0.03	0.23	0.02	0.54	1.10
15	Naphthalene	0.00	0.00	0.00	0.00	0.00	0.00

Appendix Table A-B (Unit: ppbv)

Monthly Avg. Conc. On Site BC-1 From July-86 To Sept-87

	COMPOUND	*July-86*	*Aug-86*	*Sept-86*	*Oct-86*	*Nov-86*	*Dec-86*	*Jan-87*
1	Dichloromethane	0.36	0.00	0.53	0.43	1.49	0.65	2.35
2	Ethylenechloride	0.66	0.41	0.39	0.64	0.84	0.40	1.40
3	2-Butanone	0.49	1.26	1.00	0.43	0.73	0.46	0.97
4	Tetrahydrofuran	0.23	0.16	0.19	0.06	0.10	0.34	0.31
5	1,1,1-Trichloroethane	0.44	0.17	4.49	0.53	0.48	4.44	0.80
6	Benzene	0.36	0.16	0.69	0.25	0.88	0.27	1.32
7	Trichlorothylene	0.00	0.00	0.00	0.84	1.09	3.51	1.81
8	Methylcyclohexane	0.26	0.22	0.56	0.54	0.37	1.03	0.77
9	Toluene	2.40	1.81	3.28	6.16	6.69	13.07	8.34
10	Tetrachloroethylene	0.00	0.00	0.03	0.09	1.16	1.32	2.26
11	Ethylbenzene	0.27	0.38	0.07	0.05	0.28	0.19	0.60
12	p,m - Xylene	0.55	0.14	0.28	0.61	8.61	6.29	10.07
13	o - Xylene	0.50	0.24	0.24	0.20	0.11	0.15	0.17
14	Trimethylbenzene	0.41	0.14	0.02	0.11	0.12	0.09	0.28
15	Naphthalene	0.11	0.29	0.00	0.40	0.00	0.00	0.00

	Feb-87	*Mar-87*	*Apr-87*	*May-87*	*June-87*	*July-87*	*Aug-87*	*Sept-87*
1	7.70	1.18	3.35	0.66	0.80	0.90	2.25	1.40
2	1.05	0.28	0.80	0.46	0.53	0.78	0.95	0.67
3	1.55	0.72	0.93	0.58	0.81	1.00	2.96	1.61
4	0.17	0.07	0.30	0.06	0.25	0.18	0.38	0.25
5	1.72	0.40	0.53	0.70	0.77	0.29	1.83	1.20
6	1.41	1.23	0.35	0.80	1.01	0.56	0.18	0.97
7	1.97	1.82	2.54	1.77	1.89	0.77	2.43	1.85
8	0.90	0.45	0.94	0.43	0.48	0.22	1.41	0.87
9	7.56	3.40	4.78	5.50	4.68	3.21	10.69	9.74
10	1.60	1.00	1.52	1.90	3.10	0.47	4.35	3.19
11	0.36	0.63	0.45	4.31	0.40	0.10	0.42	0.43
12	4.18	3.67	3.45	5.87	1.39	1.29	10.33	7.61
13	0.20	0.16	1.18	0.38	0.10	0.08	0.26	0.20
14	0.04	0.30	1.18	0.06	0.00	0.12	0.01	1.71
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix Table A-C (Unit: ppbv)

Monthly Avg. Conc. On Site BC-2 From July-86 To Sept-87

	COMPOUND	*July-86*	*Aug-86*	*Sept-86*	*Oct-86*	*Nov-86*	*Dec-86*	*Jan-87*
1	Dichloromethane	0.19	0.00	0.39	2.01	0.54	0.63	0.86
2	Ethylenechloride	0.31	2.28	0.18	0.61	0.34	0.99	0.52
3	2-Butanone	0.39	0.14	1.06	1.62	0.72	0.66	1.36
4	Tetrahydrofuran	0.04	4.92	0.52	0.14	0.09	1.54	1.29
5	1,1,1-Trichloroethane	0.39	0.98	1.17	2.35	0.95	0.51	0.53
6	Benzene	0.19	0.36	0.50	0.78	0.59	2.24	0.27
7	Trichlorothylene	0.00	0.00	0.00	0.00	1.32	2.41	2.03
8	Methylcyclohexane	0.16	0.59	0.28	0.97	1.44	1.78	0.23
9	Toluene	3.05	0.59	1.98	10.35	2.98	6.00	2.67
10	Tetrachloroethylene	0.00	0.00	0.00	0.00	0.27	0.68	7.77
11	Ethylbenzene	0.76	0.05	0.04	0.91	0.48	3.31	0.38
12	p,m - Xylene	1.56	2.81	0.16	4.35	2.82	5.75	4.53
13	o - Xylene	0.73	1.10	0.15	1.03	0.37	0.96	0.44
14	Trimethylbenzene	0.74	1.19	0.10	0.26	0.14	1.30	0.09
15	Naphthalene	0.48	0.64	0.02	0.09	0.00	0.00	0.00

	Feb-87	*Mar-87*	*Apr-87*	*May-87*	*June-87*	*July-87*	*Aug-87*	*Sept-87*
1	7.33	2.99	3.00	1.62	0.85	0.33	3.16	3.30
2	0.60	0.55	0.46	0.51	0.46	0.39	0.76	1.65
3	2.36	0.93	0.77	0.40	2.20	0.59	1.72	0.65
4	0.49	0.14	0.20	0.29	2.00	0.53	0.28	1.29
5	0.62	0.43	0.60	0.57	0.98	0.67	3.86	1.83
6	0.90	0.72	0.79	0.17	0.85	0.26	0.56	0.57
7	0.94	1.59	2.61	2.22	0.69	1.91	1.62	4.06
8	0.86	0.66	0.81	1.58	0.52	0.28	0.73	1.30
9	4.92	3.26	5.08	7.55	2.10	4.24	8.64	4.76
10	1.73	1.82	1.22	5.49	0.61	3.09	1.24	2.14
11	1.07	0.18	0.25	0.54	1.10	0.47	0.44	0.29
12	7.05	5.33	7.67	5.97	6.84	6.40	5.62	6.24
13	0.58	0.08	0.09	0.11	0.19	0.18	0.22	0.22
14	0.18	0.08	0.38	0.54	0.03	0.06	4.72	0.39
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix Table A-D (Unit: ppbv)

Monthly Avg. Conc. On Site BC-3 From July-86 To Sept-87

	COMPOUND	*July-86*	*Aug-86*	*Sept-86*	*Oct-86*	*Nov-86*	*Dec-86*	*Jan-87*	*Feb-87*	*Mar-87*	*Apr-87*	*May-87*	*June-87*	*July-87*	*Aug-87*	*Sept-87*
1	Dichloromethane	0.49	0.48	0.74	0.00	0.00	0.26	2.29	3.05	1.99	3.24	1.08	1.45	0.55	1.65	1.42
2	Ethylenechloride	0.33	0.65	0.59	1.52	1.68	0.39	2.08	1.02	0.73	1.16	0.25	0.67	0.62	0.41	0.82
3	2-Butanone	2.79	1.56	1.64	0.49	0.56	0.71	0.63	0.90	0.52	1.31	0.48	1.04	0.41	0.39	0.85
4	Tetrahydrofuran	2.51	0.12	0.16	2.28	1.17	2.07	0.16	0.44	0.11	0.48	0.64	0.87	0.60	0.12	0.32
5	1,1,1-Trichloroethane	0.85	0.65	2.18	0.38	0.14	0.82	1.66	1.96	0.39	1.20	0.63	0.61	0.30	0.17	0.88
6	Benzene	0.36	0.47	0.23	1.34	0.57	0.78	0.62	0.28	0.83	0.70	0.16	0.93	0.16	0.12	0.78
7	Trichlorothylene	0.00	0.00	0.00	0.68	0.44	2.71	2.97	2.04	1.27	4.78	1.03	2.23	0.64	1.67	4.06
8	Methylcyclohexane	0.38	0.25	0.64	0.26	2.40	0.87	0.57	0.70	0.43	0.94	0.64	0.47	0.43	1.35	0.69
9	Toluene	11.52	4.09	8.68	3.13	1.87	1.76	4.74	1.97	3.56	9.94	2.98	5.70	4.68	8.88	7.58
10	Tetrachloroethylene	0.00	0.00	0.00	5.91	2.68	1.30	1.49	1.40	1.29	3.14	1.98	1.63	0.81	7.20	3.33
11	Ethylbenzene	2.52	0.70	0.64	0.16	0.70	0.37	0.23	0.39	1.09	4.02	0.91	0.88	2.33	1.80	0.41
12	p,m - Xylene	6.50	0.32	1.91	0.75	0.52	8.50	7.95	2.47	4.81	10.39	6.28	8.04	6.74	4.61	5.06
13	o - Xylene	1.22	0.61	0.56	1.16	0.44	4.03	0.98	0.22	0.32	0.45	0.23	0.14	0.76	2.11	0.34
14	Trimethylbenzene	0.35	0.42	0.25	0.43	0.05	0.48	0.12	0.29	0.06	0.44	0.12	0.31	0.28	0.08	3.89
15	Naphthalene	0.10	0.10	0.00	0.23	0.42	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix Table A-E (Unit: ppbv)

Monthly Avg. Conc. On Site BF-1 From July-86 To Sept-87

	COMPOUND	*July-86*	*Aug-86*	*Sept-86*	*Oct-86*	*Nov-86*	*Dec-86*	*Jan-87*
1	Dichloromethane	0.80	1.40	1.53	0.58	1.75	3.65	1.58
2	Ethylenechloride	0.36	1.40	0.57	0.37	0.35	0.57	3.44
3	2-Butanone	2.03	0.70	0.13	1.47	0.48	1.88	1.69
4	Tetrahydrofuran	0.00	0.41	1.15	0.07	0.13	0.21	0.68
5	1,1,1-Trichloroethane	0.20	1.27	0.68	0.50	0.90	1.22	3.17
6	Benzene	1.13	0.27	0.53	0.70	0.93	0.90	0.62
7	Trichlorothylene	0.00	0.00	0.00	0.00	0.60	3.16	4.86
8	Methylcyclohexane	0.31	0.76	6.21	0.26	0.43	1.37	0.28
9	Toluene	4.65	9.41	1.41	4.24	0.91	10.60	0.36
10	Tetrachloroethylene	0.00	0.00	0.00	0.00	0.87	1.71	0.56
11	Ethylbenzene	0.97	2.22	0.82	0.46	0.07	0.31	0.59
12	p,m - Xylene	0.29	4.98	0.72	1.03	2.25	11.24	4.49
13	o - Xylene	0.91	1.68	0.37	0.09	0.07	0.43	0.09
14	Trimethylbenzene	0.45	0.68	2.46	0.33	0.02	0.20	0.23
15	Naphthalene	0.00	0.57	0.06	0.05	0.00	0.00	0.00

	Feb-87	*Mar-87*	*Apr-87*	*May-87*	*June-87*	*July-87*	*Aug-87*	*Sept-87*
1	4.85	1.21	1.48	7.80	1.84	2.93	1.09	0.72
2	0.27	0.57	0.54	0.72	0.32	1.52	0.75	1.32
3	0.91	0.31	0.37	2.60	2.46	0.97	0.99	1.55
4	0.10	0.21	0.22	0.80	0.49	0.19	0.13	0.21
5	0.12	0.35	1.04	1.42	0.52	0.50	0.69	0.42
6	0.11	0.09	1.10	1.89	0.26	5.45	0.89	0.56
7	0.67	0.46	1.92	0.45	1.81	0.52	1.42	0.98
8	0.21	0.29	0.25	0.41	0.59	4.51	0.27	0.10
9	3.10	0.10	3.61	4.24	6.32	1.76	2.82	1.66
10	0.49	0.53	0.67	0.92	2.29	1.29	3.66	0.49
11	0.43	0.08	0.65	0.09	0.22	1.55	0.17	0.15
12	1.66	0.87	6.19	4.44	8.58	1.40	5.19	2.36
13	0.25	0.05	0.07	0.13	0.34	0.05	0.10	0.07
14	0.02	0.00	0.07	0.00	0.32	0.00	0.03	0.01
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix Table A-F (Unit: ppbv)

Monthly Avg. Conc. On Site BF-2 From July-86 To Sept-87

	COMPOUND	*July-86*	*Aug-86*	*Sept-86*	*Oct-86*	*Nov-86*	*Dec-86*	*Jan-87*	*Feb-87*	*Mar-87*	*Apr-87*	*May-87*	*June-87*	*July-87*	*Aug-87*	*Sept-87*
1	Dichloromethane	0.77	3.34	0.52	0.24	5.90	4.08	1.36	0.00	0.00	1.13	5.60	1.58	2.68	1.02	0.49
2	Ethylenechloride	0.39	2.30	0.15	1.09	0.69	1.22	0.79	0.25	1.15	0.84	0.48	0.37	0.33	0.81	0.41
3	2-Butanone	4.76	2.76	0.27	0.13	5.51	0.20	0.23	0.17	0.61	0.56	1.06	1.94	0.50	1.10	1.03
4	Tetrahydrofuran	0.32	1.89	0.14	0.23	0.31	0.95	0.23	0.00	0.26	0.23	0.00	0.13	0.26	0.25	1.10
5	1,1,1-Trichloroethane	3.65	2.46	0.10	0.06	0.93	1.97	0.88	0.00	0.43	0.71	0.30	0.11	0.44	0.44	0.25
6	Benzene	0.53	2.77	0.12	0.08	0.98	1.99	0.54	0.21	0.85	1.27	1.19	0.21	0.47	0.12	0.44
7	Trichlorothylene	0.00	2.83	0.00	0.00	2.30	5.22	0.33	0.25	1.30	1.65	0.59	0.25	0.52	1.29	1.25
8	Methylcyclohexane	0.47	2.90	0.05	0.13	2.82	0.85	0.22	0.05	0.26	0.26	0.10	0.42	0.28	0.34	0.18
9	Toluene	8.68	5.65	0.18	1.40	10.01	13.65	0.52	15.33	4.21	4.45	0.00	0.34	4.07	5.79	3.30
10	Tetrachloroethylene	0.00	2.87	0.00	0.00	2.94	2.09	1.47	0.24	0.83	1.05	0.37	1.28	1.12	3.31	0.97
11	Ethylbenzene	0.09	2.36	0.09	0.25	3.08	0.52	0.07	0.33	2.29	0.11	0.00	0.06	0.48	1.21	0.13
12	p,m - Xylene	0.27	5.95	0.12	0.42	19.05	7.30	1.83	2.15	3.49	5.28	0.00	3.20	6.03	8.30	4.63
13	o - Xylene	0.33	2.07	0.06	0.21	0.50	0.36	0.60	0.33	0.35	0.11	0.00	0.61	0.08	0.53	0.02
14	Trimethylbenzene	0.72	2.18	0.02	0.08	0.49	0.46	0.00	0.03	0.51	0.01	0.00	0.02	0.05	0.07	0.73
15	Naphthalene	0.70	1.90	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix Table A-G (Unit: ppbv)

Monthly Avg. Conc. On Site 1C-1 From July-86 To Sept-87

	COMPOUND	*July-86*	*Aug-86*	*Sept-86*	*Oct-86*	*Nov-86*	*Dec-86*	*Jan-87*
1	Dichloromethane	0.51	0.69	0.38	0.80	0.34	1.83	3.30
2	Ethylenechloride	0.41	0.35	0.25	0.92	2.11	0.34	5.12
3	2-Butanone	1.30	0.91	0.64	0.32	0.16	0.38	1.46
4	Tetrahydrofuran	0.15	0.00	0.00	0.17	0.17	0.09	0.00
5	1,1,1-Trichloroethane	1.15	1.90	0.64	3.76	1.84	0.69	0.90
6	Benzene	0.45	0.40	0.62	0.14	0.25	1.55	0.81
7	Trichlorothylene	0.00	0.00	0.00	0.00	0.00	3.72	1.19
8	Methylcyclohexane	0.23	2.59	0.20	0.46	0.21	0.41	0.45
9	Toluene	3.33	9.32	5.78	0.75	2.92	7.16	1.30
10	Tetrachloroethylene	0.00	0.00	0.00	0.00	0.00	0.92	0.99
11	Ethylbenzene	0.60	1.69	0.05	0.04	0.04	0.11	0.18
12	p,m - Xylene	1.75	0.48	0.20	0.03	0.19	5.98	3.75
13	o - Xylene	0.42	0.79	0.20	0.02	0.03	0.07	0.67
14	Trimethylbenzene	0.66	0.71	0.03	0.10	0.05	0.18	0.08
15	Naphthalene	0.39	0.12	0.00	0.00	0.46	0.00	0.00

	Feb-87	*Mar-87*	*Apr-87*	*May-87*	*June-87*	*July-87*	*Aug-87*	*Sept-87*
1	2.78	1.29	0.58	4.65	1.08	1.23	2.61	1.69
2	0.21	0.52	0.15	0.00	0.37	0.47	0.74	0.53
3	0.79	0.69	1.12	0.69	0.34	0.21	1.38	0.51
4	0.17	0.21	0.09	0.13	0.07	0.12	0.17	0.25
5	0.64	0.92	0.43	0.18	0.34	0.22	0.52	0.39
6	0.20	0.51	0.87	0.85	0.34	0.48	0.54	0.67
7	2.53	1.62	0.71	1.43	0.67	0.84	1.08	1.12
8	0.34	0.21	0.19	0.23	0.10	0.20	0.18	0.19
9	4.77	2.26	3.38	4.16	1.36	3.79	3.23	4.22
10	0.98	1.74	1.06	0.49	0.73	0.32	0.74	0.67
11	0.23	0.16	0.32	0.06	0.08	0.57	0.14	0.07
12	6.83	1.74	2.71	2.26	1.11	5.06	3.65	3.53
13	0.08	0.12	0.21	0.24	0.15	0.06	0.18	0.05
14	0.06	0.05	0.15	0.06	0.01	0.04	0.06	0.73
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix Table A-H (Unit: ppbv)

Monthly Avg. Conc. On Site 1C-2 From July-86 To Sept-87

	COMPOUND	July-86	Aug-86	Sept-86	Oct-86	Nov-86	Dec-86	Jan-87
1	Dichloromethane	1.36	0.22	0.38	0.49	0.42	1.98	0.55
2	Ethylenechloride	0.54	0.54	1.28	0.33	0.30	0.21	0.13
3	2-Butanone	1.28	0.78	0.86	2.03	0.82	1.31	0.40
4	Tetrahydrofuran	0.41	0.00	0.00	0.11	0.08	0.07	0.04
5	1,1,1-Trichloroethane	0.00	0.65	0.69	1.14	0.26	0.85	0.24
6	Benzene	0.93	0.45	0.65	1.70	0.05	1.64	0.18
7	Trichlorothylene	0.20	0.14	0.00	0.00	0.40	3.39	0.67
8	Methylcyclohexane	3.35	2.87	0.18	0.25	0.00	0.36	0.08
9	Toluene	4.46	0.14	3.49	0.30	7.35	4.97	1.31
10	Tetrachloroethylene	7.14	0.16	0.00	0.15	0.00	0.77	0.25
11	Ethylbenzene	0.99	0.25	0.04	0.61	0.75	0.14	0.13
12	p,m - Xylene	0.96	0.12	0.19	0.58	1.47	5.47	1.95
13	o - Xylene	0.36	0.00	0.15	1.01	0.45	0.09	0.03
14	Trimethylbenzene	0.00	0.00	0.14	0.00	0.15	0.19	0.04
15	Naphthalene	0.00	0.00	0.00	0.00	0.17	0.00	0.00

	Feb-87	Mar-87	Apr-87	May-87	June-87	July-87	Aug-87	Sept-87
1	7.31	1.07	0.51	0.00	0.78	1.59	0.92	1.20
2	0.28	0.34	0.31	0.86	0.22	0.73	0.43	0.36
3	1.18	0.70	0.49	0.97	0.39	0.28	1.47	0.41
4	0.25	0.15	0.14	0.15	0.46	0.17	0.12	0.15
5	0.18	0.49	2.83	1.31	0.42	0.20	3.24	0.22
6	0.16	0.33	0.74	0.13	0.49	0.46	0.81	0.50
7	0.62	2.16	3.54	1.23	0.65	0.66	1.82	1.37
8	0.36	0.26	0.87	0.12	0.26	0.23	0.53	0.22
9	4.72	3.45	8.30	2.66	10.01	1.38	6.24	4.73
10	0.59	0.99	6.72	3.49	7.24	2.50	0.93	1.46
11	0.06	0.45	1.44	0.06	0.21	0.15	0.09	0.14
12	1.10	3.04	10.93	23.18	5.94	4.92	3.56	2.90
13	0.11	0.07	0.30	0.07	0.16	0.05	0.05	0.09
14	0.02	0.02	0.06	0.06	0.05	0.02	0.03	0.94
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix Table A-I (Unit: ppbv)

Monthly Avg. Conc. On Site Downwind From July-86 To Sept-87

	COMPOUND	*July-86*	*Aug-86*	*Sept-86*	*Oct-86*	*Nov-86*	*Dec-86*	*Jan-87*	*Feb-87*	*Mar-87*	*Apr-87*	*May-87*	*June-87*	*July-87*	*Aug-87*	*Sept-87*
1	Dichloromethane	0.63	0.00	1.18	1.77	0.57	2.21	1.86	3.37	0.98	3.23	0.82	1.55	0.67	6.35	1.35
2	Ethylenechloride	0.33	0.00	1.44	0.66	0.89	0.59	0.74	2.12	0.62	0.70	0.56	0.55	0.47	1.01	0.67
3	2-Butanone	3.87	1.71	2.01	0.85	0.36	3.00	1.05	1.00	0.67	1.87	0.78	0.32	0.52	0.35	2.43
4	Tetrahydrofuran	0.26	0.31	2.56	0.07	0.27	0.40	0.11	0.18	0.18	0.23	0.06	0.16	0.08	0.16	0.11
5	1,1,1-Trichloroethane	0.77	2.42	4.46	1.30	0.65	1.65	0.55	0.14	0.66	0.84	0.32	0.17	0.25	0.57	1.51
6	Benzene	2.07	0.10	1.58	0.35	0.58	0.59	0.95	0.36	0.96	0.21	0.59	0.28	0.36	0.13	0.90
7	Trichlorothylene	0.00	0.00	0.00	0.03	1.23	6.27	1.97	4.92	1.19	1.09	2.23	0.44	0.47	1.27	1.95
8	Methylcyclohexane	0.37	0.11	13.10	1.91	0.10	0.86	0.31	0.52	0.13	0.30	0.28	0.06	0.08	0.35	0.97
9	Toluene	7.68	0.91	5.94	1.82	1.03	4.42	2.45	5.16	1.42	2.17	3.34	0.51	1.55	2.67	4.57
10	Tetrachloroethylene	0.00	0.00	0.00	0.01	0.37	0.67	0.45	3.31	1.07	0.53	0.64	0.43	0.17	0.40	0.69
11	Ethylbenzene	0.26	0.05	1.82	0.75	0.13	0.23	0.27	1.88	0.18	0.33	0.09	0.04	0.02	0.31	0.27
12	p,m - Xylene	0.68	0.21	2.75	0.51	3.93	4.58	7.16	8.09	6.77	3.96	4.56	1.38	0.56	4.12	4.18
13	o - Xylene	0.36	0.09	3.04	0.17	0.16	1.11	0.20	0.46	0.14	0.09	0.02	0.06	0.05	0.13	0.10
14	Trimethylbenzene	0.28	0.00	4.49	0.07	0.01	0.37	0.04	0.14	0.01	0.03	0.01	0.03	0.01	0.20	0.12
15	Naphthalene	0.00	0.00	0.00	0.06	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix Table A-J (Unit: ppbv)

Monthly Avg. Conc. On Site Resident From July-86 To Sept-87

	COMPOUND	*Aug-86*	*Sept-86*	*Oct-86*	*Nov-86*	*Dec-86*	*Jan-87*	*Feb-87*
1	Dichloromethane	0.00	N/A	N/A	1.24	5.16	0.91	2.70
2	Ethylenechloride	0.27	N/A	N/A	0.55	0.85	0.33	1.81
3	2-Butanone	1.31	N/A	N/A	2.16	1.77	0.87	1.21
4	Tetrahydrofuran	0.00	N/A	N/A	0.16	1.33	0.11	0.37
5	1,1,1-Trichloroethane	0.43	N/A	N/A	0.67	1.32	0.22	2.24
6	Benzene	0.63	N/A	N/A	1.25	0.63	1.10	0.55
7	Trichlorothylene	0.00	N/A	N/A	1.84	2.10	3.00	3.48
8	Methylcyclohexane	0.11	N/A	N/A	0.23	1.58	0.14	0.84
9	Toluene	2.39	N/A	N/A	2.99	4.70	2.68	3.61
10	Tetrachloroethylene	0.00	N/A	N/A	0.43	2.54	0.41	1.36
11	Ethylbenzene	0.25	N/A	N/A	0.22	0.23	0.16	0.78
12	p,m - Xylene	0.10	N/A	N/A	3.55	5.59	0.87	6.05
13	o - Xylene	0.17	N/A	N/A	0.04	0.20	0.06	0.24
14	Trimethylbenzene	0.11	N/A	N/A	0.02	0.10	0.02	0.07
15	Naphthalene	0.13	N/A	N/A	0.00	0.00	0.00	0.00

	COMPOUND	*Mar-87*	*Apr-87*	*May-87*	*June-87*	*July-87*	*Aug-87*	*Sept-87*
1	Dichloromethane	1.37	2.68	1.03	0.71	1.10	3.25	0.70
2	Ethylenechloride	0.62	0.69	0.39	0.59	0.76	0.61	1.82
3	2-Butanone	0.61	1.05	0.90	0.49	0.55	0.44	1.63
4	Tetrahydrofuran	0.11	0.21	0.29	0.07	0.26	0.12	0.14
5	1,1,1-Trichloroethane	0.77	0.67	0.86	0.12	0.68	0.71	0.61
6	Benzene	0.40	0.61	0.13	0.38	0.68	0.13	0.44
7	Trichlorothylene	1.32	1.75	0.79	0.55	0.96	2.22	2.19
8	Methylcyclohexane	0.11	0.38	0.84	0.06	0.18	0.15	0.24
9	Toluene	0.95	3.26	0.57	1.70	1.51	2.71	2.34
10	Tetrachloroethylene	0.28	0.64	0.57	0.61	1.14	0.67	1.39
11	Ethylbenzene	0.12	0.53	0.00	0.14	0.02	0.15	0.31
12	p,m - Xylene	1.71	8.06	4.80	6.16	0.80	0.79	2.02
13	o - Xylene	0.06	0.14	0.03	0.06	0.02	0.03	0.72
14	Trimethylbenzene	0.01	0.05	0.00	0.01	0.01	0.01	0.54
15	Naphthalene	0.00	0.00	0.00	0.00	0.00	0.00	0.02

Appendix Table A - K (Unit: ppbv)

Average VOC Concentration For Weekend Sample

	COMPOUND	***Avon***	***BC1***	***BC2***	***BC3***	***Downwind***	***Resident***
1	Dichloromethane	1.79	1.29	0.98	2.81	1.25	3.70
2	Ethylenechloride	1.11	1.40	0.71	1.10	0.77	0.51
3	2-Butanone	1.29	1.29	1.14	1.67	0.70	1.30
4	Tetrahydrofuran	0.18	0.24	0.40	0.23	0.27	0.14
5	1,1,1-Trichloroethane	0.91	0.55	0.82	2.40	0.95	0.81
6	Benzene	0.92	0.77	0.55	0.55	0.55	0.85
7	Trichlorothylene	1.79	1.40	1.39	1.60	1.72	2.15
8	Methylcyclohexane	0.34	0.71	0.85	0.82	0.95	0.28
9	Toluene	3.18	8.44	5.74	5.43	1.71	3.76
10	Tetrachloroethylene	0.51	0.73	4.08	0.86	0.43	0.64
11	Ethylbenzene	0.28	0.16	0.61	0.49	0.43	0.18
12	p,m - Xylene	4.77	5.37	5.45	4.79	2.27	3.70
13	o - Xylene	0.20	0.23	0.96	0.46	0.60	0.10
14	Trimethylbenzene	0.05	0.13	0.21	0.25	0.05	0.02
15	Naphthalene	0.07	0.14	0.06	0.00	0.04	0.00

Appendix B

Statistical Summaries For Each Target Volatile Compound

Appendix Table B-A

Compound No. 1 Di-Chloro-Methane (Unit: ppbv)

	1C1	1C2	AVON	BC1	BC2	BC3	BF1	BF2	DOWNWD	RESIDT
July-86	0.51	1.36	N/A	0.36	0.19	0.49	0.80	0.77	0.63	N/A
Aug-86	0.69	0.22	N/A	0.00	0.00	0.48	1.40	3.34	0.00	0.00
Sept-86	0.38	0.38	0.60	0.53	0.39	0.74	1.53	0.52	1.18	N/A
Oct-86	0.80	0.49	0.49	0.43	2.01	0.00	0.58	0.24	1.77	N/A
Nov-86	0.34	0.42	1.45	1.49	0.54	0.00	1.75	5.90	0.57	1.24
Dec-86	1.83	1.98	8.39	0.65	0.63	0.26	3.65	4.08	2.21	5.16
Jan-87	3.30	0.55	1.78	2.35	0.86	2.29	1.58	1.36	1.86	0.91
Feb-87	2.78	7.31	3.33	7.70	7.33	3.05	4.85	0.00	3.37	2.70
Mar-87	1.29	1.07	1.35	1.18	2.99	1.99	1.21	0.00	0.98	1.37
Apr-87	0.58	0.51	3.15	3.35	3.00	3.24	1.48	1.13	3.23	2.68
May-87	4.65	0.00	2.64	0.66	1.62	1.08	7.80	5.60	0.82	1.03
Jun-87	1.08	0.78	1.19	0.80	0.85	1.45	1.84	1.58	1.55	0.71
July-87	1.23	1.59	0.77	0.90	0.33	0.55	2.93	2.68	0.67	1.10
Aug-87	2.61	0.92	1.85	2.25	3.16	1.65	1.09	1.02	6.35	3.25
Sept-87	1.69	1.20	0.91	1.40	3.30	1.42	0.72	0.49	1.35	0.70

Ti	23.77	18.78	27.89	24.05	27.20	18.70	33.22	28.69	26.54	20.85
SUM(Xi^2)	59.59	66.93	112.34	89.57	101.63	38.43	125.88	108.84	82.08	59.17
(Ti^2)	565.13	352.59	777.86	578.58	739.81	349.63	1103.40	823.15	704.53	434.72
COUNT: n	15.00	15.00	13.00	15.00	15.00	15.00	15.00	15.00	15.00	12.00
MEAN(X)	1.58	1.25	2.15	1.60	1.81	1.25	2.21	1.91	1.77	1.74
(Ti^2)/n	37.68	23.51	59.84	38.57	49.32	23.31	73.56	54.88	46.97	36.23

Source Of Variability	SS	df	MS	F
Between Mean	13.88	9.00	1.54	0.52
Within	400.62	135.00	2.97	
Total	414.49			

F(9,120,0.05) = 1.96

F(9,120,0.01) = 2.56

Appendix Table B-B

Compound No. 2 Ethylene-Chloride (Unit: ppbv)

	1C1	1C2	AVON	BC1	BC2	BC3	BF1	BF2	DOWNWD	RESIDT
July-86	0.41	0.54	N/A	0.66	0.31	0.33	0.36	0.39	0.33	N/A
Aug-86	0.35	0.54	N/A	0.41	2.28	0.65	1.40	2.30	0.00	0.27
Sept-86	0.25	1.28	0.26	0.39	0.18	0.59	0.57	0.15	1.44	N/A
Oct-86	0.92	0.33	0.67	0.64	0.61	1.52	0.37	1.09	0.66	N/A
Nov-86	2.11	0.30	1.83	0.84	0.34	1.68	0.35	0.69	0.89	0.55
Dec-86	0.34	0.21	0.48	0.40	0.99	0.39	0.57	1.22	0.59	0.85
Jan-87	5.12	0.13	3.41	1.40	0.52	2.08	3.44	0.79	0.74	0.33
Feb-87	0.21	0.28	0.37	1.05	0.60	1.02	0.27	0.25	2.12	1.81
Mar-87	0.52	0.34	2.33	0.28	0.55	0.73	0.57	1.15	0.62	0.62
Apr-87	0.15	0.31	0.59	0.80	0.46	1.16	0.54	0.84	0.70	0.69
May-87	0.00	0.86	0.33	0.46	0.51	0.25	0.72	0.48	0.56	0.39
Jun-87	0.37	0.22	0.64	0.53	0.46	0.67	0.32	0.37	0.55	0.59
July-87	0.47	0.73	0.52	0.78	0.39	0.62	1.52	0.33	0.47	0.76
Aug-87	0.74	0.43	0.54	0.95	0.76	0.41	0.75	0.81	1.01	0.61
Sept-87	0.53	0.36	0.33	0.67	1.65	0.82	1.32	0.41	0.67	1.82

Ti	12.48	6.85	12.31	10.25	10.62	12.93	13.07	11.27	11.34	9.30
SUM(Xi^2)	33.53	4.42	22.85	8.25	11.88	15.15	20.76	12.62	11.96	10.12
(Ti^2)	155.80	46.91	151.45	105.08	112.79	167.08	170.81	126.92	128.66	86.45
COUNT: n	15.00	15.00	13.00	15.00	15.00	15.00	15.00	15.00	15.00	12.00
MEAN(X)	0.83	0.46	0.95	0.68	0.71	0.86	0.87	0.75	0.76	0.77
(Ti^2)/n	10.39	3.13	11.65	7.01	7.52	11.14	11.39	8.46	8.58	7.20

Source Of Variability	SS	df	MS	F
Between Mean	2.38	9.00	0.26	0.55
Within	65.08	135.00	0.48	
Total	67.46			

F(9,120,0.05) = 1.96

F(9,120,0.01) = 2.56

Appendix Table B-C

Compound No. 3 2-Butanone (Unit: ppbv)

	1C1	1C2	AVON	BC1	BC2	BC3	BF1	BF2	DOWNWD	RESIDT
July-86	1.30	1.28	N/A	0.49	0.39	2.79	2.03	4.76	3.87	N/A
Aug-86	0.91	0.78	N/A	1.26	0.14	1.56	0.70	2.76	1.71	1.31
Sept-86	0.64	0.86	0.67	1.00	1.06	1.64	0.13	0.27	2.01	N/A
Oct-86	0.32	2.03	1.11	0.43	1.62	0.49	1.47	0.13	0.85	N/A
Nov-86	0.16	0.82	1.00	0.73	0.72	0.56	0.48	5.51	0.36	2.16
Dec-86	0.38	1.31	6.62	0.46	0.66	0.71	1.88	0.20	3.00	1.77
Jan-87	1.46	0.40	1.04	0.97	1.36	0.63	1.69	0.23	1.05	0.87
Feb-87	0.79	1.18	0.69	1.55	2.36	0.90	0.91	0.17	1.00	1.21
Mar-87	0.69	0.70	0.46	0.72	0.93	0.52	0.31	0.61	0.67	0.61
Apr-87	1.12	0.49	0.68	0.93	0.77	1.31	0.37	0.56	1.87	1.05
May-87	0.69	0.97	0.58	0.58	0.40	0.48	2.60	1.06	0.78	0.90
Jun-87	0.34	0.39	0.66	0.81	2.20	1.04	2.46	1.94	0.32	0.49
July-87	0.21	0.28	0.30	1.00	0.59	0.41	0.97	0.50	0.52	0.55
Aug-87	1.38	1.47	3.92	2.96	1.72	0.39	0.99	1.10	0.35	0.44
Sept-87	0.51	0.41	1.96	1.61	0.65	0.85	1.55	1.03	2.43	1.63

Ti	10.90	13.37	19.69	15.49	15.57	14.28	18.52	20.81	20.78	13.00
SUM(Xi^2)	10.48	15.27	68.81	21.82	22.47	19.50	31.55	68.88	44.84	17.42
(Ti^2)	118.74	178.81	387.71	240.00	242.29	203.82	343.13	432.97	432.00	168.92
COUNT: n	15.00	15.00	13.00	15.00	15.00	15.00	15.00	15.00	15.00	12.00
MEAN(X)	0.73	0.89	1.51	1.03	1.04	0.95	1.23	1.39	1.39	1.08
(Ti^2)/n	7.92	11.92	29.82	16.00	16.15	13.59	22.88	28.86	28.80	14.08

Source Of Variability	SS	df	MS	F
Between Mean	8.12	9.00	0.90	0.93
Within	131.02	135.00	0.97	
Total	139.14			

F(9,120,0.05) = 1.96

F(9,120,0.01) = 2.56

Appendix Table B-D

Compound No. 4 Tetra-Hydro-Furan (Unit: ppbv)

	1C1	1C2	AVON	BC1	BC2	BC3	BF1	BF2	DOWNWD	RESIDT
July-86	0.15	0.41	N/A	0.23	0.04	2.51	0.00	0.32	0.26	N/A
Aug-86	0.00	0.00	N/A	0.16	4.92	0.12	0.41	1.89	0.31	0.00
Sept-86	0.00	0.00	0.00	0.19	0.52	0.16	1.15	0.14	2.56	N/A
Oct-86	0.17	0.11	0.16	0.06	0.14	2.28	0.07	0.23	0.07	N/A
Nov-86	0.17	0.08	0.14	0.10	0.09	1.17	0.13	0.31	0.27	0.16
Dec-86	0.09	0.07	0.26	0.34	1.54	2.07	0.21	0.95	0.40	1.33
Jan-87	0.00	0.04	0.52	0.31	1.29	0.16	0.68	0.23	0.11	0.11
Feb-87	0.17	0.25	0.10	0.17	0.49	0.44	0.10	0.00	0.18	0.37
Mar-87	0.21	0.15	0.15	0.07	0.14	0.11	0.21	0.26	0.18	0.11
Apr-87	0.09	0.14	0.10	0.30	0.20	0.48	0.22	0.23	0.23	0.21
May-87	0.13	0.15	0.22	0.06	0.29	0.64	0.80	0.00	0.06	0.29
Jun-87	0.07	0.46	0.49	0.25	2.00	0.87	0.49	0.13	0.16	0.07
July-87	0.12	0.17	0.10	0.18	0.53	0.60	0.19	0.26	0.08	0.26
Aug-87	0.17	0.12	0.19	0.38	0.28	0.12	0.13	0.25	0.16	0.12
Sept-87	0.25	0.15	0.13	0.25	1.29	0.32	0.21	1.10	0.11	0.14

Ti	1.80	2.28	2.56	3.06	13.78	12.03	5.00	6.28	5.13	3.17
SUM(Xi^2)	0.30	0.60	0.78	0.77	34.96	19.29	3.11	6.25	7.15	2.20
(Ti^2)	3.23	5.21	6.56	9.36	189.88	144.83	25.00	39.43	26.36	10.07
COUNT: n	15.00	15.00	13.00	15.00	15.00	15.00	15.00	15.00	15.00	12.00
MEAN(X)	0.12	0.15	0.20	0.20	0.92	0.80	0.33	0.42	0.34	0.26
(Ti^2)/n	0.22	0.35	0.50	0.62	12.66	9.66	1.67	2.63	1.76	0.84

Source Of Variability	SS	df	MS	F
Between Mean	9.96	9.00	1.11	3.36
Within	44.50	135.00	0.33	
Total	54.46			

F(9,120,0.05) = 1.96
F(9,120,0.01) = 2.56

Appendix Table B-E

Compound No. 5 1,1,1-Trichloro-Ethane (Unit: ppbv)

	1C1	1C2	AVON	BC1	BC2	BC3	BF1	BF2	DOWNWD	RESIDT
July-86	1.15	0.00	N/A	0.44	0.39	0.85	0.20	3.65	0.77	N/A
Aug-86	1.90	0.65	N/A	0.17	0.98	0.65	1.27	2.46	2.42	0.43
Sept-86	0.64	0.69	0.79	4.49	1.17	2.18	0.68	0.10	4.46	N/A
Oct-86	3.76	1.14	0.79	0.53	2.35	0.38	0.50	0.06	1.30	N/A
Nov-86	1.84	0.26	0.79	0.48	0.95	0.14	0.90	0.93	0.65	0.67
Dec-86	0.69	0.85	0.48	4.44	0.51	0.82	1.22	1.97	1.65	1.32
Jan-87	0.90	0.24	4.44	0.80	0.53	1.66	3.17	0.88	0.55	0.22
Feb-87	0.64	0.18	0.66	1.72	0.62	1.96	0.12	0.00	0.14	2.24
Mar-87	0.92	0.49	0.39	0.40	0.43	0.39	0.35	0.43	0.66	0.77
Apr-87	0.43	2.83	0.48	0.53	0.60	1.20	1.04	0.71	0.84	0.67
May-87	0.18	1.31	0.22	0.70	0.57	0.63	1.42	0.30	0.32	0.86
Jun-87	0.34	0.42	0.46	0.77	0.98	0.61	0.52	0.11	0.17	0.12
July-87	0.22	0.20	0.35	0.29	0.67	0.30	0.50	0.44	0.25	0.68
Aug-87	0.52	3.24	0.91	1.83	3.86	0.17	0.69	0.44	0.57	0.71
Sept-87	0.39	0.22	0.45	1.20	1.83	0.88	0.42	0.25	1.51	0.61

Ti	14.51	12.74	11.20	18.77	16.44	12.85	13.01	12.72	16.29	9.29
SUM(Xi^2)	26.20	23.83	24.07	50.60	30.32	16.64	19.14	26.11	35.49	10.56
(Ti^2)	210.56	162.25	125.51	352.34	270.17	165.12	169.23	161.89	265.39	86.23
COUNT: n	15.00	15.00	13.00	15.00	15.00	15.00	15.00	15.00	15.00	12.00
MEAN(X)	0.97	0.85	0.86	1.25	1.10	0.86	0.87	0.85	1.09	0.77
(Ti^2)/n	14.04	10.82	9.65	23.49	18.01	11.01	11.28	10.79	17.69	7.19

Source Of Variability	SS	df	MS	F
Between Mean	2.98	9.00	0.33	0.35
Within	129.01	135.00	0.96	
Total	131.99			

F(9,120,0.05) =	1.96
F(9,120,0.01) =	2.56

Appendix Table B-F

Compound No. 6 Benzene (Unit: ppbv)

	1C1	1C2	AVON	BC1	BC2	BC3	BF1	BF2	DOWNWD	RESIDT
July-86	0.45	0.93	N/A	0.36	0.19	0.36	1.13	0.53	2.07	N/A
Aug-86	0.40	0.45	N/A	0.16	0.36	0.47	0.27	2.77	0.10	0.63
Sept-86	0.62	0.65	0.74	0.69	0.50	0.23	0.53	0.12	1.58	N/A
Oct-86	0.14	1.70	1.09	0.25	0.78	1.34	0.70	0.08	0.35	N/A
Nov-86	0.25	0.05	0.78	0.88	0.59	0.57	0.93	0.98	0.58	1.25
Dec-86	1.55	1.64	0.70	0.27	2.24	0.78	0.90	1.99	0.59	0.63
Jan-87	0.81	0.18	0.44	1.32	0.27	0.62	0.62	0.54	0.95	1.10
Feb-87	0.20	0.16	0.98	1.41	0.90	0.28	0.11	0.21	0.36	0.55
Mar-87	0.51	0.33	0.66	1.23	0.72	0.83	0.09	0.85	0.96	0.40
Apr-87	0.87	0.74	0.50	0.35	0.79	0.70	1.10	1.27	0.21	0.61
May-87	0.85	0.13	0.43	0.80	0.17	0.16	1.89	1.19	0.59	0.13
Jun-87	0.34	0.49	0.49	1.01	0.85	0.93	0.26	0.21	0.28	0.38
July-87	0.48	0.46	0.56	0.56	0.26	0.16	5.45	0.47	0.36	0.68
Aug-87	0.54	0.81	0.75	0.18	0.56	0.12	0.89	0.12	0.13	0.13
Sept-87	0.67	0.50	0.47	0.97	0.57	0.78	0.56	0.44	0.90	0.44

Ti	8.68	9.21	8.59	10.44	9.75	8.31	15.42	11.76	10.00	6.92
SUM(Xi^2)	6.75	9.15	6.20	9.85	9.86	6.30	39.88	17.41	10.97	5.22
(Ti^2)	75.37	84.76	73.81	109.04	94.97	69.13	237.72	138.28	99.92	47.89
COUNT: n	15.00	15.00	13.00	15.00	15.00	15.00	15.00	15.00	15.00	12.00
MEAN(X)	0.58	0.61	0.66	0.70	0.65	0.55	1.03	0.78	0.67	0.58
(Ti^2)/n	5.02	5.65	5.68	7.27	6.33	4.61	15.85	9.22	6.66	3.99

Source Of Variability	SS	df	MS	F
Between Mean	2.59	9.00	0.29	0.76
Within	51.32	135.00	0.38	
Total	53.90			

F(9,120,0.05) = 1.96

F(9,120,0.01) = 2.56

Appendix Table B-G

Compound No. 7 Tri-Chloro-Ethylene (Unit: ppbv)

	1C1	1C2	AVON	BC1	BC2	BC3	BF1	BF2	DOWNWD	RESIDT
July-86	0.00	0.20	N/A	0.00	0.00	0.00	0.00	0.00	0.00	N/A
Aug-86	0.00	0.14	N/A	0.00	0.00	0.00	0.00	2.83	0.00	0.00
Sept-86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A
Oct-86	0.00	0.00	0.00	0.84	0.00	0.68	0.00	0.00	0.03	N/A
Nov-86	0.00	0.40	1.76	1.09	1.32	0.44	0.60	2.30	1.23	1.84
Dec-86	3.72	3.39	3.86	3.51	2.41	2.71	3.16	5.22	6.27	2.10
Jan-87	1.19	0.67	6.76	1.81	2.03	2.97	4.86	0.33	1.97	3.00
Feb-87	2.53	0.62	2.72	1.97	0.94	2.04	0.67	0.25	4.92	3.48
Mar-87	1.62	2.16	2.05	1.82	1.59	1.27	0.46	1.30	1.19	1.32
Apr-87	0.71	3.54	1.02	2.54	2.61	4.78	1.92	1.65	1.09	1.75
May-87	1.43	1.23	1.18	1.77	2.22	1.03	0.45	0.59	2.23	0.79
Jun-87	0.67	0.65	1.66	1.89	0.69	2.23	1.81	0.25	0.44	0.55
July-87	0.84	0.66	0.74	0.77	1.91	0.64	0.52	0.52	0.47	0.96
Aug-87	1.08	1.82	2.41	2.43	1.62	1.67	1.42	1.29	1.27	2.22
Sept-87	1.12	1.37	3.83	1.85	4.06	4.06	0.98	1.25	1.95	2.19

Ti	14.90	16.85	27.99	22.30	21.39	24.53	16.85	17.78	23.08	20.19
SUM(Xi^2)	30.38	37.32	101.55	47.79	49.99	71.22	45.07	49.00	82.35	45.27
(Ti^2)	222.02	283.79	783.72	497.24	457.37	601.55	284.06	316.12	532.51	407.56
COUNT: n	15.00	15.00	13.00	15.00	15.00	15.00	15.00	15.00	15.00	12.00
MEAN(X)	0.99	1.12	2.15	1.49	1.43	1.64	1.12	1.19	1.54	1.68
(Ti^2)/n	14.80	18.92	60.29	33.15	30.49	40.10	18.94	21.07	35.50	33.96

Source Of Variability	SS	df	MS	F
Between Mean	14.99	9.00	1.67	0.89
Within	252.73	135.00	1.87	
Total	267.71			

F(9,120,0.05) = 1.96

F(9,120,0.01) = 2.56

Appendix Table B-H

Compound No. 8 Methylcyclohexane (Unit: ppbv)

	1C1	1C2	AVON	BC1	BC2	BC3	BF1	BF2	DOWNWD	RESIDT
July-86	0.23	3.35	N/A	0.26	0.16	0.38	0.31	0.47	0.37	N/A
Aug-86	2.59	2.87	N/A	0.22	0.59	0.25	0.76	2.90	0.11	0.11
Sept-86	0.20	0.18	0.32	0.56	0.28	0.64	6.21	0.05	13.10	N/A
Oct-86	0.46	0.25	0.37	0.54	0.97	0.26	0.26	0.13	1.91	N/A
Nov-86	0.21	0.00	0.22	0.37	1.44	2.40	0.43	2.82	0.10	0.23
Dec-86	0.41	0.36	0.76	1.03	1.78	0.87	1.37	0.85	0.86	1.58
Jan-87	0.45	0.08	0.25	0.77	0.23	0.57	0.28	0.22	0.31	0.14
Feb-87	0.34	0.36	0.67	0.90	0.86	0.70	0.21	0.05	0.52	0.84
Mar-87	0.21	0.26	0.21	0.45	0.66	0.43	0.29	0.26	0.13	0.11
Apr-87	0.19	0.87	0.53	0.94	0.81	0.94	0.25	0.26	0.30	0.38
May-87	0.23	0.12	0.26	0.43	1.58	0.64	0.41	0.10	0.28	0.84
Jun-87	0.10	0.26	0.30	0.48	0.52	0.47	0.59	0.42	0.06	0.06
July-87	0.20	0.23	0.04	0.22	0.28	0.43	4.51	0.28	0.08	0.18
Aug-87	0.18	0.53	0.66	1.41	0.73	1.35	0.27	0.34	0.35	0.15
Sept-87	0.19	0.22	0.36	0.87	1.30	0.69	0.10	0.18	0.97	0.24

Ti	6.20	9.92	4.95	9.46	12.18	11.03	16.25	9.31	19.43	4.86
SUM(Xi^2)	7.79	21.08	2.43	7.63	13.57	12.22	62.61	17.92	177.67	4.26
(Ti^2)	38.45	98.48	24.49	89.49	148.35	121.67	263.95	86.77	377.66	23.57
COUNT: n	15.00	15.00	13.00	15.00	15.00	15.00	15.00	15.00	15.00	12.00
MEAN(X)	0.41	0.66	0.38	0.63	0.81	0.74	1.08	0.62	1.30	0.40
(Ti^2)/n	2.56	6.57	1.88	5.97	9.89	8.11	17.60	5.78	25.18	1.96

Source Of Variability	SS	df	MS	F
Between Mean	11.49	9.00	1.28	0.71
Within	241.67	135.00	1.79	
Total	253.16			

F(9,120,0.05) = 1.96
F(9,120,0.01) = 2.56

Appendix Table B-I

Compound No. 9 Toluene (Unit: ppbv)

	1C1	1C2	AVON	BC1	BC2	BC3	BF1	BF2	DOWNWD	RESIDT
July-86	3.33	4.46	N/A	2.40	3.05	11.52	4.65	8.68	7.68	N/A
Aug-86	9.32	0.14	N/A	1.81	0.59	4.09	9.41	5.65	0.91	2.39
Sept-86	5.78	3.49	4.89	3.28	1.98	8.68	1.41	0.18	5.94	N/A
Oct-86	0.75	0.30	6.23	6.16	10.35	3.13	4.24	1.40	1.82	N/A
Nov-86	2.92	7.35	1.91	6.69	2.98	1.87	0.91	10.01	1.03	2.99
Dec-86	7.16	4.97	5.76	13.07	6.00	1.76	10.60	13.65	4.42	4.70
Jan-87	1.30	1.31	3.58	8.34	2.67	4.74	0.36	0.52	2.45	2.68
Feb-87	4.77	4.72	3.25	7.56	4.92	1.97	3.10	15.33	5.16	3.61
Mar-87	2.26	3.45	4.99	3.40	3.26	3.56	0.10	4.21	1.42	0.95
Apr-87	3.38	8.30	5.00	4.78	5.08	9.94	3.61	4.45	2.17	3.26
May-87	4.16	2.66	2.08	5.50	7.55	2.98	4.24	0.00	3.34	0.57
Jun-87	1.36	10.01	2.09	4.68	2.10	5.70	6.32	0.34	0.51	1.70
July-87	3.79	1.38	0.63	3.21	4.24	4.68	1.76	4.07	1.55	1.51
Aug-87	3.23	6.24	6.60	10.69	8.64	8.88	2.82	5.79	2.67	2.71
Sept-87	4.22	4.73	2.93	9.74	4.76	7.58	1.66	3.30	4.57	2.34

Ti	57.73	63.52	49.95	91.30	68.17	81.10	55.18	77.58	45.63	29.41
SUM(Xi^2)	294.45	386.21	234.15	705.84	410.08	578.80	337.89	729.44	200.16	86.79
(Ti^2)	3332.75	4034.19	2495.03	8335.88	4647.78	6576.75	3045.38	6018.51	2082.16	865.01
COUNT: n	15.00	15.00	13.00	15.00	15.00	15.00	15.00	15.00	15.00	12.00
MEAN(X)	3.85	4.23	3.84	6.09	4.54	5.41	3.68	5.17	3.04	2.45
(Ti^2)/n	222.18	268.95	191.93	555.73	309.85	438.45	203.03	401.23	138.81	72.08

Source Of Variability	SS	df	MS	F
Between Mean	154.84	9.00	17.20	2.00
Within	1161.58	135.00	8.60	
Total	1316.42			

F(9,120,0.05) = 1.96

F(9,120,0.01) = 2.56

Appendix Table B-J

Compound No. 10 Tetra-Chloro-Ethylene (Unit: ppbv)

	1C1	1C2	AVON	BC1	BC2	BC3	BF1	BF2	DOWNWD	RESIDT
July-86	0.00	7.14	N/A	0.00	0.00	0.00	0.00	0.00	0.00	N/A
Aug-86	0.00	0.16	N/A	0.00	0.00	0.00	0.00	2.87	0.00	0.00
Sept-86	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	N/A
Oct-86	0.00	0.15	0.00	0.09	0.00	5.91	0.00	0.00	0.01	N/A
Nov-86	0.00	0.00	0.28	1.16	0.27	2.68	0.87	2.94	0.37	0.43
Dec-86	0.92	0.77	1.16	1.32	0.68	1.30	1.71	2.09	0.67	2.54
Jan-87	0.99	0.25	2.30	2.26	7.77	1.49	0.56	1.47	0.45	0.41
Feb-87	0.98	0.59	0.67	1.60	1.73	1.40	0.49	0.24	3.31	1.36
Mar-87	1.74	0.99	3.30	1.00	1.82	1.29	0.53	0.83	1.07	0.28
Apr-87	1.06	6.72	1.17	1.52	1.22	3.14	0.67	1.05	0.53	0.64
May-87	0.49	3.49	1.24	1.90	5.49	1.98	0.92	0.37	0.64	0.57
Jun-87	0.73	7.24	1.57	3.10	0.61	1.63	2.29	1.28	0.43	0.61
July-87	0.32	2.50	0.79	0.47	3.09	0.81	1.29	1.12	0.17	1.14
Aug-87	0.74	0.93	1.47	4.35	1.24	7.20	3.66	3.31	0.40	0.67
Sept-87	0.67	1.46	1.86	3.19	2.14	3.33	0.49	0.97	0.69	1.39

Ti	8.62	32.39	15.81	21.99	26.05	32.17	13.46	18.53	8.74	10.04
SUM(Xi^2)	8.78	171.90	29.66	56.62	114.85	129.71	26.29	40.15	14.43	13.54
(Ti^2)	74.37	1049.21	249.89	483.66	678.49	1034.65	181.30	343.49	76.30	100.86
COUNT: n	15.00	15.00	13.00	15.00	15.00	15.00	15.00	15.00	15.00	12.00
MEAN(X)	0.57	2.16	1.22	1.47	1.74	2.14	0.90	1.24	0.58	0.84
(Ti^2)/n	4.96	69.95	19.22	32.24	45.23	68.98	12.09	22.90	5.09	8.40

Source Of Variability	SS	df	MS	F
Between Mean	45.81	9.00	5.09	2.17
Within	316.87	135.00	2.35	
Total	362.68			

F(9,120,0.05) = 1.96

F(9,120,0.01) = 2.56

Appendix Table B-K

Compound No. 11 Ethyl - Benzene (Unit: ppbv)

	1C1	1C2	AVON	BC1	BC2	BC3	BF1	BF2	DOWNWD	RESIDT
July-86	0.60	0.99	N/A	0.27	0.76	2.52	0.97	0.09	0.26	N/A
Aug-86	1.69	0.25	N/A	0.38	0.05	0.70	2.22	2.36	0.05	0.25
Sept-86	0.05	0.04	0.04	0.07	0.04	0.64	0.82	0.09	1.82	N/A
Oct-86	0.04	0.61	0.32	0.05	0.91	0.16	0.46	0.25	0.75	N/A
Nov-86	0.04	0.75	0.13	0.28	0.48	0.70	0.07	3.08	0.13	0.22
Dec-86	0.11	0.14	0.38	0.19	3.31	0.37	0.31	0.52	0.23	0.23
Jan-87	0.18	0.13	0.09	0.60	0.38	0.23	0.59	0.07	0.27	0.16
Feb-87	0.23	0.06	1.41	0.36	1.07	0.39	0.43	0.33	1.88	0.78
Mar-87	0.16	0.45	1.63	0.63	0.18	1.09	0.08	2.29	0.18	0.12
Apr-87	0.32	1.44	0.31	0.45	0.25	4.02	0.65	0.11	0.33	0.53
May-87	0.06	0.06	1.08	4.31	0.54	0.91	0.09	0.00	0.09	0.00
Jun-87	0.08	0.21	0.24	0.40	1.10	0.88	0.22	0.06	0.04	0.14
July-87	0.57	0.15	0.46	0.10	0.47	2.33	1.55	0.48	0.02	0.02
Aug-87	0.14	0.09	6.59	0.42	0.44	1.80	0.17	1.21	0.31	0.15
Sept-87	0.07	0.14	2.73	0.43	0.29	0.41	0.15	0.13	0.27	0.31

Ti	4.34	5.50	15.42	8.94	10.27	17.15	8.79	11.04	6.64	2.91
SUM(Xi^2)	3.82	4.40	57.37	20.49	15.99	35.92	10.32	22.47	7.93	1.23
(Ti^2)	18.82	30.22	237.93	79.86	105.41	294.03	77.18	121.92	44.03	8.45
COUNT: n	15.00	15.00	13.00	15.00	15.00	15.00	15.00	15.00	15.00	12.00
MEAN(X)	0.29	0.37	1.19	0.60	0.68	1.14	0.59	0.74	0.44	0.24
(Ti^2)/n	1.25	2.01	18.30	5.32	7.03	19.60	5.15	8.13	2.94	0.70

Source Of Variability	SS	df	MS	F
Between Mean	13.35	9.00	1.48	1.83
Within	109.50	135.00	0.81	
Total	122.86			

F(9,120,0.05) = 1.96
F(9,120,0.01) = 2.56

Appendix Table B-L

Compound No. 12 p,m - Xylene (Unit: ppbv)

	1C1	1C2	AVON	BC1	BC2	BC3	BF1	BF2	DOWNWD	RESIDT
July-86	1.75	0.96	N/A	0.55	1.56	6.50	0.29	0.27	0.68	N/A
Aug-86	0.48	0.12	N/A	0.14	2.81	0.32	4.98	5.95	0.21	0.10
Sept-86	0.20	0.19	0.13	0.28	0.16	1.91	0.72	0.12	2.75	N/A
Oct-86	0.03	0.58	1.74	0.61	4.35	0.75	1.03	0.42	0.51	N/A
Nov-86	0.19	1.47	4.53	8.61	2.82	0.52	2.25	19.05	3.93	3.55
Dec-86	5.98	5.47	6.01	6.29	5.75	8.50	11.24	7.30	4.58	5.59
Jan-87	3.75	1.95	3.92	10.07	4.53	7.95	4.49	1.83	7.16	0.87
Feb-87	6.83	1.10	7.55	4.18	7.05	2.47	1.66	2.15	8.09	6.05
Mar-87	1.74	3.04	9.91	3.67	5.33	4.81	0.87	3.49	6.77	1.71
Apr-87	2.71	10.93	10.15	3.45	7.67	10.39	6.19	5.28	3.96	8.06
May-87	2.26	23.18	9.93	5.87	5.97	6.28	4.44	0.00	4.56	4.80
Jun-87	1.11	5.94	2.86	1.39	6.84	8.04	8.58	3.20	1.38	6.16
July-87	5.06	4.92	3.07	1.29	6.40	6.74	1.40	6.03	0.56	0.80
Aug-87	3.65	3.56	16.25	10.33	5.62	4.61	5.19	8.30	4.12	0.79
Sept-87	3.53	2.90	9.18	7.61	6.24	5.06	2.36	4.63	4.18	2.02

Ti	39.27	66.32	85.22	64.34	73.11	74.85	55.70	68.00	53.44	40.49
SUM(Xi^2)	167.98	784.98	797.54	461.36	421.71	515.86	347.79	636.46	280.44	215.35
(Ti^2)	1542.41	4397.77	7262.62	4139.70	5344.35	5602.19	3102.83	4624.22	2856.28	1639.57
COUNT: n	15.00	15.00	13.00	15.00	15.00	15.00	15.00	15.00	15.00	12.00
MEAN(X)	2.62	4.42	6.56	4.29	4.87	4.99	3.71	4.53	3.56	3.37
(Ti^2)/n	102.83	293.18	558.66	275.98	356.29	373.48	206.86	308.28	190.42	136.63

Source Of Variability	SS	df	MS	F
Between Mean	145.21	9.00	16.13	1.19
Within	1826.87	135.00	13.53	
Total	1972.08			

F(9,120,0.05) = 1.96
F(9,120,0.01) = 2.56

Appendix Table B-M

Compound No. 13 o - Xylene (Unit: ppbv)

	1C1	1C2	AVON	BC1	BC2	BC3	BF1	BF2	DOWNWD	RESIDT
July-86	0.42	0.36	N/A	0.50	0.73	1.22	0.91	0.33	0.36	N/A
Aug-86	0.79	0.00	N/A	0.24	1.10	0.61	1.68	2.07	0.09	0.17
Sept-86	0.20	0.15	0.15	0.24	0.15	0.56	0.37	0.06	3.04	N/A
Oct-86	0.02	1.01	0.20	0.20	1.03	1.16	0.09	0.21	0.17	N/A
Nov-86	0.03	0.45	0.17	0.11	0.37	0.44	0.07	0.50	0.16	0.04
Dec-86	0.07	0.09	0.49	0.15	0.96	4.03	0.43	0.36	1.11	0.20
Jan-87	0.67	0.03	0.03	0.17	0.44	0.98	0.09	0.60	0.20	0.06
Feb-87	0.08	0.11	0.00	0.20	0.58	0.22	0.25	0.33	0.46	0.24
Mar-87	0.12	0.07	0.00	0.16	0.08	0.32	0.05	0.35	0.14	0.06
Apr-87	0.21	0.30	0.02	1.18	0.09	0.45	0.07	0.11	0.09	0.14
May-87	0.24	0.07	1.05	0.38	0.11	0.23	0.13	0.00	0.02	0.03
Jun-87	0.15	0.16	0.08	0.10	0.19	0.14	0.34	0.61	0.06	0.06
July-87	0.06	0.05	0.08	0.08	0.18	0.76	0.05	0.08	0.05	0.02
Aug-87	0.18	0.05	0.93	0.26	0.22	2.11	0.10	0.53	0.13	0.03
Sept-87	0.05	0.09	0.45	0.20	0.22	0.34	0.07	0.02	0.10	0.72

Ti	3.27	2.97	3.64	4.16	6.44	13.56	4.67	6.15	6.18	1.75
SUM(Xi^2)	1.47	1.53	2.51	2.19	4.61	26.47	4.20	6.06	10.98	0.68
(Ti^2)	10.71	8.84	13.26	17.27	41.46	183.92	21.84	37.78	38.19	3.06
COUNT: n	15.00	15.00	13.00	15.00	15.00	15.00	15.00	15.00	15.00	12.00
MEAN(X)	0.22	0.20	0.28	0.28	0.43	0.90	0.31	0.41	0.41	0.15
(Ti^2)/n	0.71	0.59	1.02	1.15	2.76	12.26	1.46	2.52	2.55	0.26

Source Of Variability	SS	df	MS	F
Between Mean	6.05	9.00	0.67	2.56
Within	35.42	135.00	0.26	
Total	41.47			

F(9,120,0.05) = 1.96

F(9,120,0.01) = 2.56

Appendix Table B-N

Compound No. 14 Tri-Methyl-Benzene (Unit: ppbv)

	1C1	1C2	AVON	BC1	BC2	BC3	BF1	BF2	DOWNWD	RESIDT
July-86	0.66	0.00	N/A	0.41	0.74	0.35	0.45	0.72	0.28	N/A
Aug-86	0.71	0.00	N/A	0.14	1.19	0.42	0.68	2.18	0.00	0.11
Sept-86	0.03	0.14	0.13	0.02	0.10	0.25	2.46	0.02	4.49	N/A
Oct-86	0.10	0.00	0.06	0.11	0.26	0.43	0.33	0.08	0.07	N/A
Nov-86	0.05	0.15	0.03	0.12	0.14	0.05	0.02	0.49	0.01	0.02
Dec-86	0.18	0.19	0.12	0.09	1.30	0.48	0.20	0.46	0.37	0.10
Jan-87	0.08	0.04	0.02	0.28	0.09	0.12	0.23	0.00	0.04	0.02
Feb-87	0.06	0.02	0.19	0.04	0.18	0.29	0.02	0.03	0.14	0.07
Mar-87	0.05	0.02	0.09	0.30	0.08	0.06	0.00	0.51	0.01	0.01
Apr-87	0.15	0.06	0.24	1.18	0.38	0.44	0.07	0.01	0.03	0.05
May-87	0.06	0.06	0.03	0.06	0.54	0.12	0.00	0.00	0.01	0.00
Jun-87	0.01	0.05	0.23	0.00	0.03	0.31	0.32	0.02	0.03	0.01
July-87	0.04	0.02	0.02	0.12	0.06	0.28	0.00	0.05	0.01	0.01
Aug-87	0.06	0.03	0.54	0.01	4.72	0.08	0.03	0.07	0.20	0.01
Sept-87	0.73	0.94	1.10	1.71	0.39	3.89	0.01	0.73	0.12	0.54

Ti	2.96	1.74	2.80	4.61	10.18	7.57	4.82	5.35	5.82	0.94
SUM(Xi^2)	1.56	0.98	1.70	4.73	26.67	16.37	7.01	6.50	20.50	0.32
(Ti^2)	8.79	3.02	7.85	21.22	103.63	57.29	23.20	28.64	33.83	0.89
COUNT: n	15.00	15.00	13.00	15.00	15.00	15.00	15.00	15.00	15.00	12.00
MEAN(X)	0.20	0.12	0.22	0.31	0.68	0.50	0.32	0.36	0.39	0.08
(Ti^2)/n	0.59	0.20	0.60	1.41	6.91	3.82	1.55	1.91	2.26	0.07

Source Of Variability	SS	df	MS	F
Between Mean	4.22	9.00	0.47	0.94
Within	67.02	135.00	0.50	
Total	71.24			

F(9,120,0.05) = 1.96

F(9,120,0.01) = 2.56

Appendix Table B-O

Compound No. 15 Naphthalene (Unit: ppbv)

	1C1	1C2	AVON	BC1	BC2	BC3	BF1	BF2	DOWNWD	RESIDT
July-86	0.39	0.00	N/A	0.11	0.48	0.10	0.00	0.70	0.00	N/A
Aug-86	0.12	0.00	N/A	0.29	0.64	0.10	0.57	1.90	0.00	0.13
Sept-86	0.00	0.00	0.07	0.00	0.02	0.00	0.06	0.00	0.00	N/A
Oct-86	0.00	0.00	0.10	0.40	0.09	0.23	0.05	0.10	0.06	N/A
Nov-86	0.46	0.17	0.14	0.00	0.00	0.42	0.00	0.00	0.19	0.00
Dec-86	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00
Jan-87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb-87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar-87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apr-87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May-87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun-87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
July-87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug-87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sept-87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02

Ti	0.98	0.17	0.32	0.81	1.24	1.09	0.68	2.71	0.25	0.15
SUM(Xi^2)	0.38	0.03	0.03	0.26	0.65	0.30	0.33	4.11	0.04	0.02
(Ti^2)	0.95	0.03	0.10	0.65	1.54	1.18	0.46	7.32	0.06	0.02
COUNT: n	15.00	15.00	13.00	15.00	15.00	15.00	15.00	15.00	15.00	12.00
MEAN(X)	0.07	0.01	0.02	0.05	0.08	0.07	0.05	0.18	0.02	0.01
(Ti^2)/n	0.06	0.00	0.01	0.04	0.10	0.08	0.03	0.49	0.00	0.00

Source Of Variability	SS	df	MS	F
Between Mean	0.34	9.00	0.04	0.95
Within	5.34	135.00	0.04	
Total	5.68			

F(9,120,0.05) = 1.96
F(9,120,0.01) = 2.56

Appendix C

Quality Control Data
And
Precision Control Charts

Appendix Table C - 1
Accuracy Relative To Benzene Standard

Standard = 10 PPB Average Relative Error = 4.8% Count = 145

Jul - 86		Aug - 86		Sept - 86		Oct - 86		Nov - 86	
Measured Value	Relative Error	Measured Value	Relative Error	Measured Value	Relative Error	Measured Value	Relative Error	Measured Value	Relative Error
10.8	7.4%	10.0	0.0%	11.5	13.0%	9.8	2.0%	11.1	9.9%
10.4	3.8%	9.8	2.0%	11.3	11.5%	10.1	1.0%	10.4	3.8%
10.1	1.0%	10.9	8.3%	10.2	2.0%	11.2	10.7%	10.1	1.0%
10.2	2.0%	11.3	11.5%	11.2	10.7%	11.1	9.9%	9.9	1.0%
9.8	2.0%	11.0	9.1%	12.0	16.7%	10.0	0.0%	10.3	2.9%
10.2	2.0%	10.4	3.8%	9.9	1.0%	11.6	13.8%	10.1	1.0%
10.1	1.0%			11.8	15.3%	10.0	0.0%	10.0	0.0%
						11.3	11.5%		

Dec - 86		Jan - 87		Feb - 87		Mar - 87		Apr - 87	
Measured Value	Relative Error	Measured Value	Relative Error	Measured Value	Relative Error	Measured Value	Relative Error	Measured Value	Relative Error
10.0	0.0%	11.0	9.2%	10.2	2.0%	10.1	0.8%	10.2	2.0%
9.8	2.0%	10.1	0.5%	9.4%	6.4%	10.1	0.8%	10.3	2.9%
9.9	1.0%	9.1	10.4%	10.6	5.7%	10.4	3.8%	9.8	2.0%
11.1	9.9%	11.1	9.9%	11.0	9.1%	11.2	10.7%	9.7	3.1%
11.0	9.1%	9.6	4.2%	10.1	0.5%	10.6	5.7%	9.9	1.0%
10.4	3.8%	11.9	16.0%	11.1	9.9%	11.0	9.1%	10.1	1.0%
10.2	2.0%			10.2	2.0%	9.6	4.2%	10.1	1.0%
10.0	0.0%			9.7	3.1%	11.2	10.7%	10.2	2.0%
				11.2	10.7%	10.4	3.8%	10.5	4.8%
				10.9	8.3%	9.9	1.0%	11.0	9.2%
				9.6	4.2%			10.1	1.0%
								10.7	6.5%

May - 87		Jun - 87		Jul - 87		Aug - 87		Sept - 87	
Measured Value	Relative Error	Measured Value	Relative Error	Measured Value	Relative Error	Measured Value	Relative Error	Measured Value	Relative Error
10.1	1.0%	9.8	2.0%	9.8	2.0%	11.0	9.4%	10.7	6.5%
10.1	1.0%	9.9	1.0%	11.0	9.1%	10.3	2.9%	10.5	4.8%
11.0	9.1%	10.2	2.0%	11.1	9.9%	10.5	4.8%	9.5	5.3%
10.3	2.9%	9.8	2.0%	9.5	5.3%	10.8	7.4%	9.7	3.1%
9.8	2.0%	10.3	2.9%	9.8	2.0%	10.1	1.0%	9.8	2.0%
9.8	2.0%	10.1	1.0%	9.7	3.1%	10.4	3.8%	10.3	2.9%
		9.9	1.0%	9.6	4.2%			10.1	1.0%
		10.2	2.0%	11.2	10.7%			9.9	1.0%
				9.6	4.2%			9.8	2.0%
				9.7	3.1%			9.4	6.4%
				10.3	2.9%			10.2	2.0%
				9.9	1.0%			10.4	3.8%
				10.7	6.7%				
				11.1	9.9%				
				10.5	4.8%				

Appendix Table C - 2
PRECISION ESTIMATES

HMDC Duplications
Count = 28 Overall Precision = 14 %

COMPOUND	Average (ppbv)	Standard Deviation	Relative Error (RSD)
Dichloromethane	2.91	0.19	6 %
Ethylenechloride	0.53	0.07	13 %
2 - Butanone	1.10	0.15	14 %
Tetrahydrofuran	0.14	0.03	21 %
1,1,1-Trichloroethane	0.70	0.09	13 %
Benzene	1.11	0.06	5 %
Trichloroethylene	1.90	0.13	7 %
Methylcyclohexane	0.87	0.04	5 %
Toluene	4.50	0.21	5 %
Tetrachloroethylene	1.19	0.15	13 %
Ethylbenzene	0.39	0.07	19 %
p,m - Xylene	4.41	0.25	6 %
o - Xylene	0.17	0.04	22 %
Trimethylbenzene	0.16	0.06	35 %

HMDC / NJIT Duplications
Inter-laboratory Comparison

Count = 20 Overall Precision = 36 %

COMPOUND	Average (ppbv)	Standard Deviation	Relative Error (RSD)
Dichloromethane	2.34	0.52	33 %
Ethylenechloride	0.33	0.14	44 %
2 - Butanone	1.48	0.19	17 %
Tetrahydrofuran	0.39	0.08	32 %
1,1,1-Trichloroethane	0.81	0.17	22 %
Benzene	0.77	0.22	18 %
Trichloroethylene	0.97	0.21	19 %
Methylcyclohexane	0.78	0.50	29 %
Toluene	4.71	0.20	44 %
Tetrachloroethylene	0.97	0.56	40 %
Ethylbenzene	0.63	0.51	62 %
p,m - Xylene	2.94	2.58	58 %
o - Xylene	0.16	0.08	49 %
Trimethylbenzene	0.14	0.13	73 %

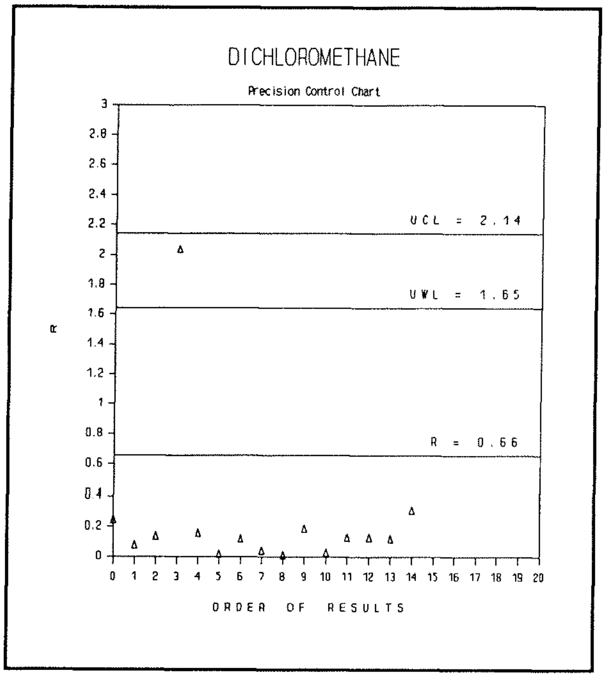


Figure C-1

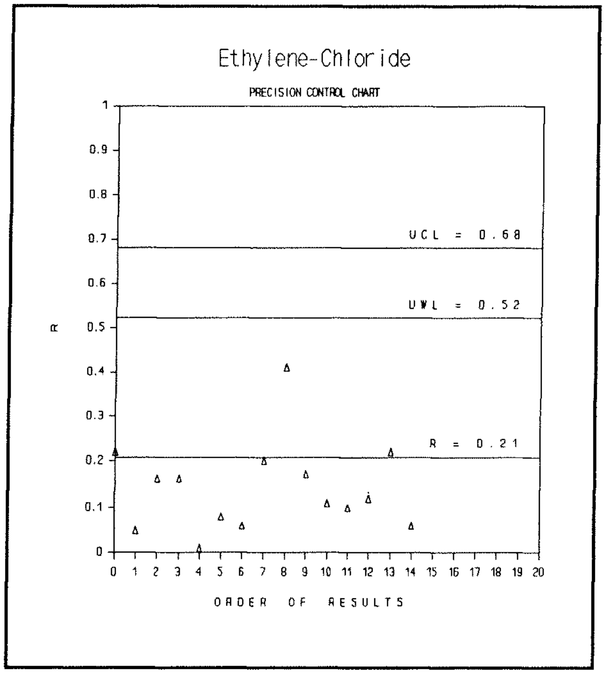


Figure C-2

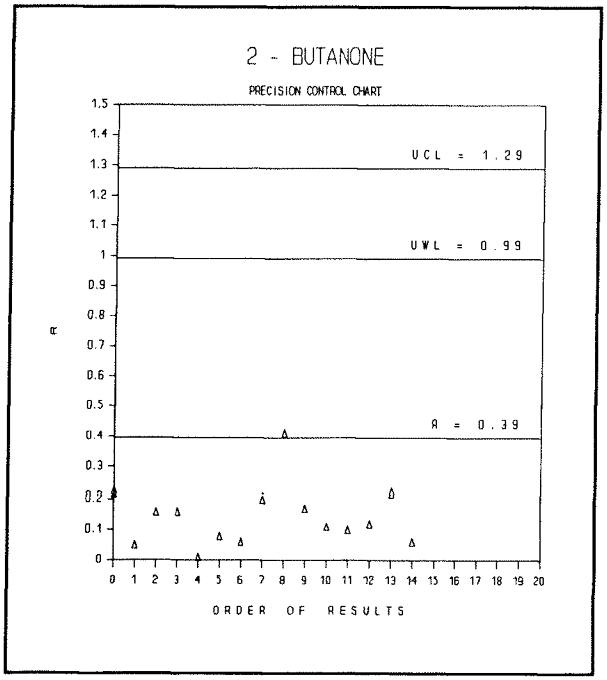
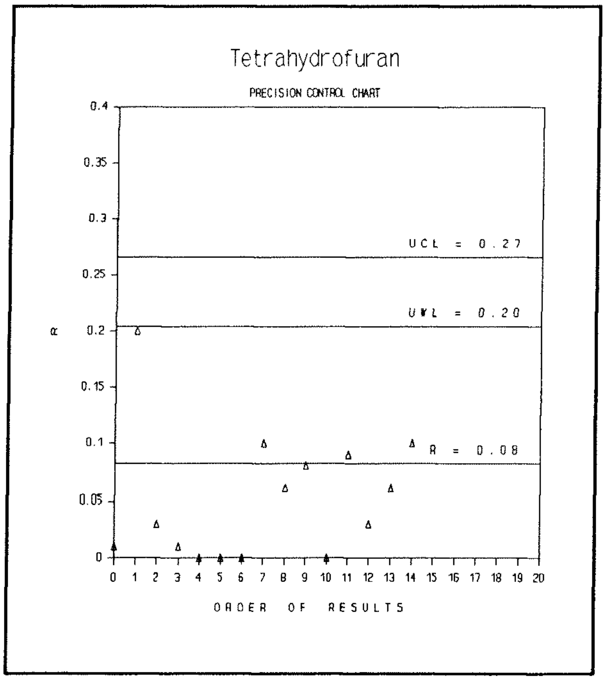


Figure C-3



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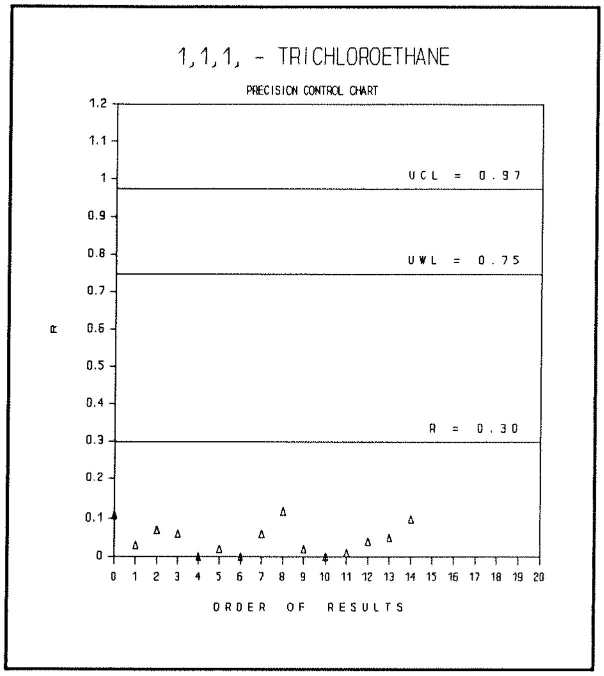

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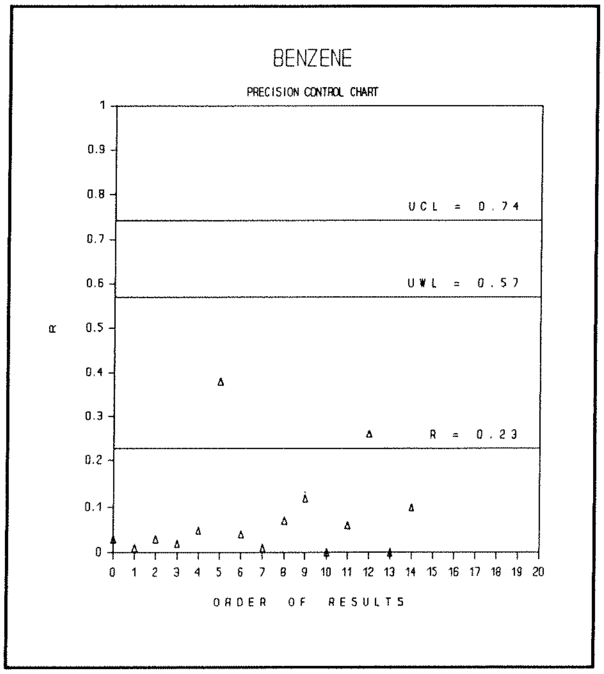

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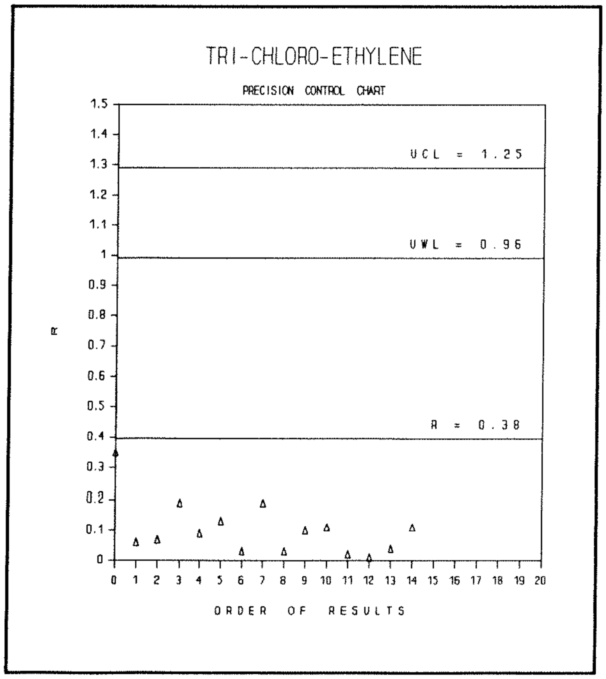

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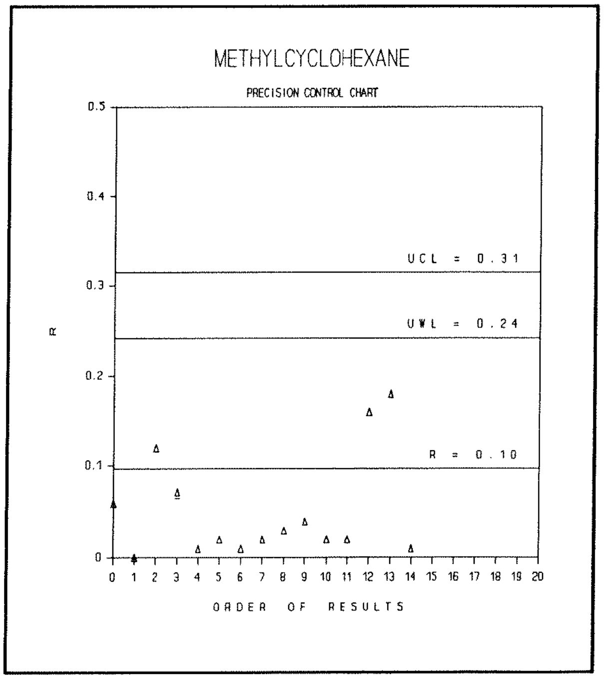

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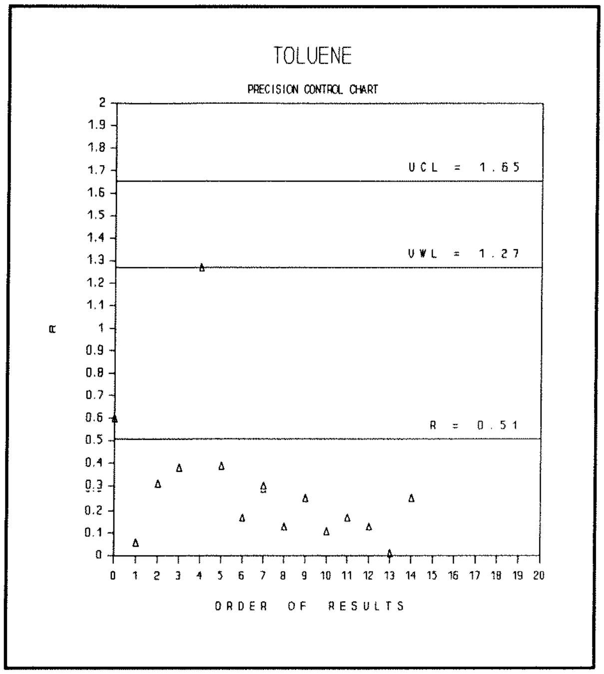

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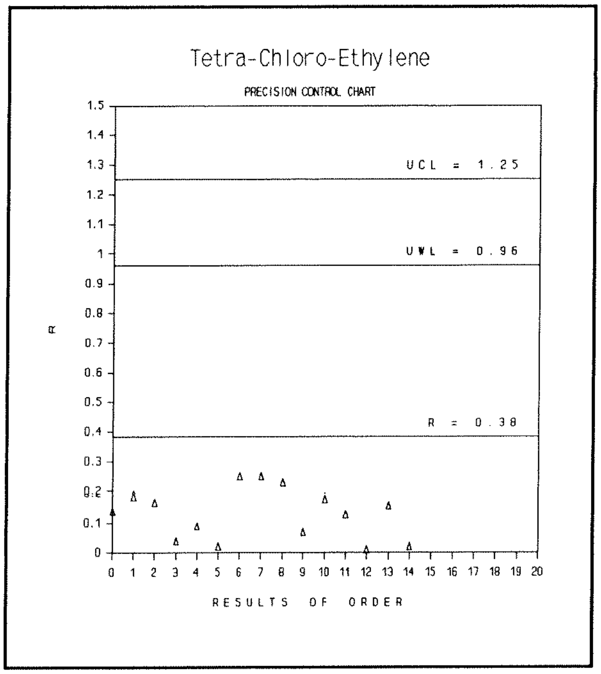
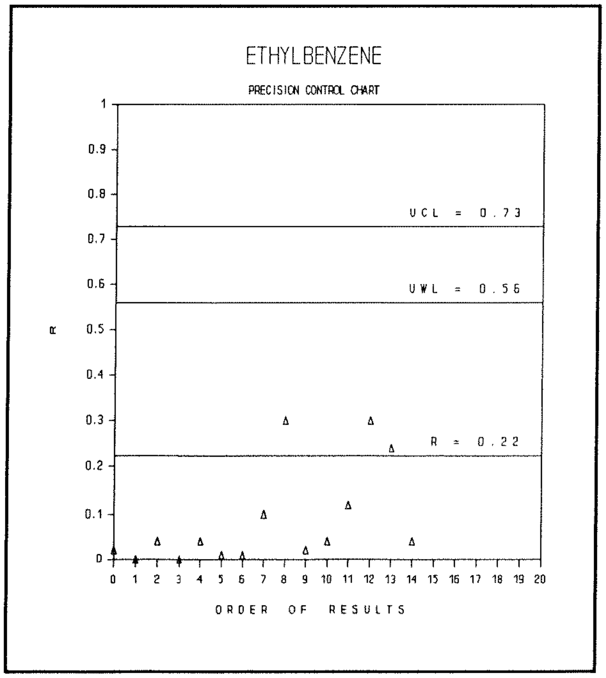


Figure C-10



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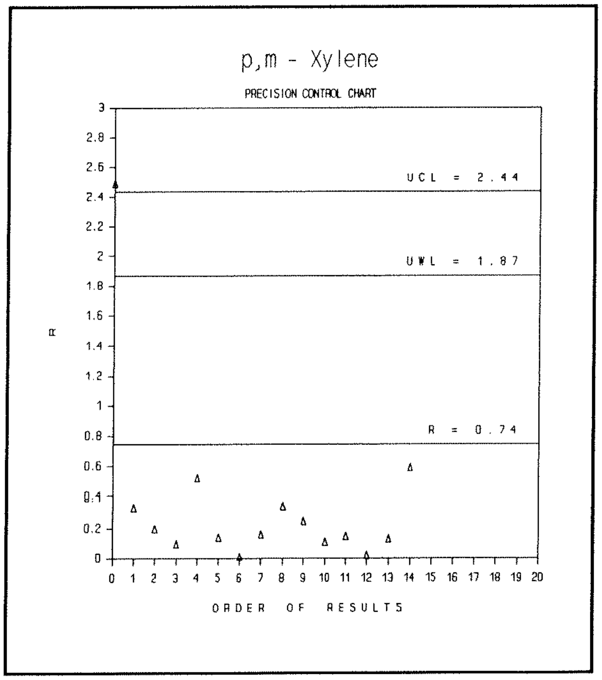

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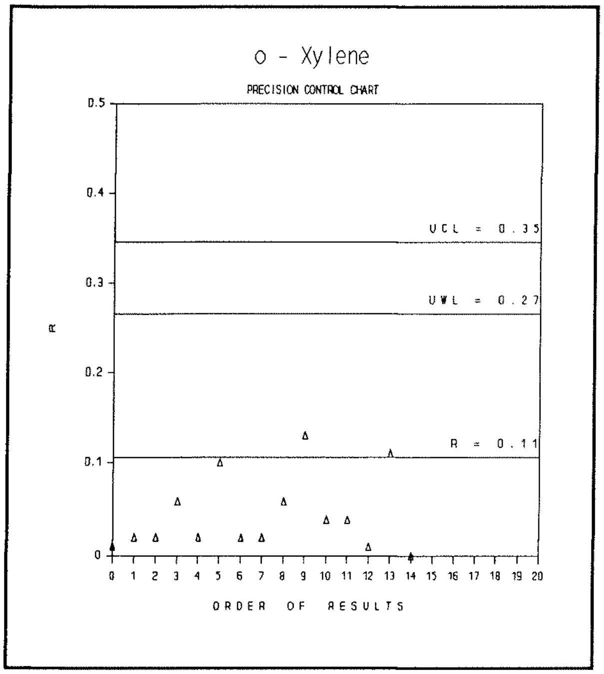

Figure C - 13

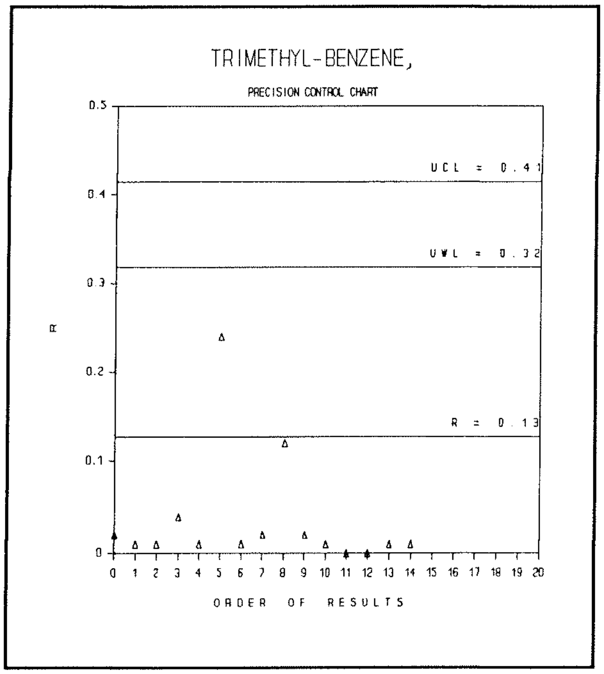

Figure C - 14

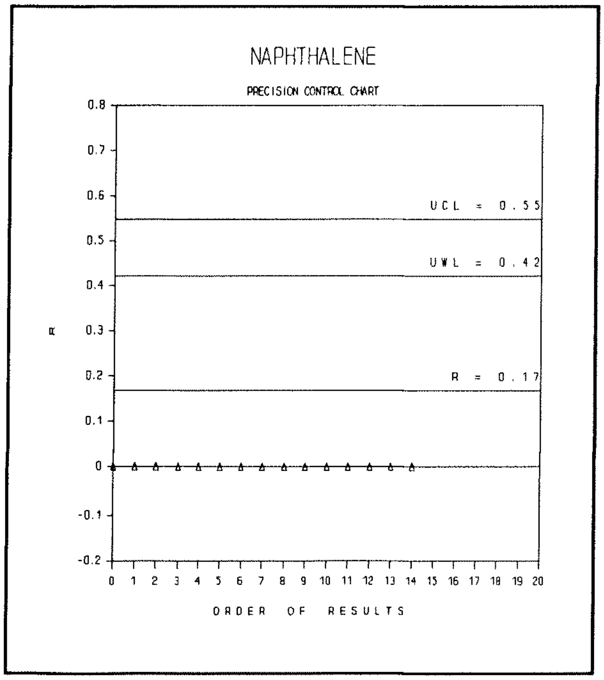

Figure C - 15