# THE INFLUENCE OF HOSPITAL WASTE DUMP AND INCINERATOR ASH ON THE RECEIVING ENVIRONMENT

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## DECLARATION

I hereby declare that this thesis entitled '**THE INFLUENCE OF HOSPITAL WASTE DUMP AND INCINERATOR ASH ON THE RECEIVING ENVIRONMENT'** has been performed by me in the department of chemistry under the supervision of prof. (Mrs.) E.B. Agbaji, prof. J. A Kagbu and prof. C.E Gimba. The information derived from literature has been duly acknowledged in the text and a list of references provided. No part of this thesis has been previously presented for another degree or diploma at any university.

_____ _____

Sunday Moses Date

## CERTIFICATION

This thesis entitled 'THE INFLUENCE OF HOSPITAL WASTE DUMP AND INCINERATOR ASH ON THE RECEIVING ENVIRONMENT' by Sunday Moses meets the regulations governing the award of the Degree of Master of Science (Analytical Chemistry) of Ahmadu Bello University Zaria and is approved for its contribution to scientific knowledge and literary presentation.

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**DEDICATION**

**TO**

My parents: Elder and Mrs. Rufus Sunday Akamo

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## ABSTRACT

The seasonal variation in the concentration of Pb, Fe, Mn, Cd, Cr, Ni, Co and organic contaminant such as Buthylated hydroxytoluene, 1,2-benzenedicarboxylic acid, methylester, fluorouracil, 1,2-benzenedicarboxylic acid, mono (2ethyl hexyl) ester, ethylbenzene and xylene were determined in the dumpsite soil, incinerator ash, and food crops (tomatoes, guava banana, cassava, potatoes and mango) grown within the vicinity of the dumpsite at a University Teaching Hospital. AAS was used for the heavy metal analysis which indicated the order of relative abundance as Fe>Pb>Mn>Cr>Cd>Co>Ni for both seasons while GC/MS was used for the organic contaminant determination. Analysis of variance with t-test showed no significant difference for the metal level within the study area for both season. The levels of these metals and organic contaminants in all the sources and food crops were within tolerable limit. The result also showed that the hospital waste dumpsite and incinerator ash are major sources of these metals and organic contaminants in the food crops.

## TABLE OF CONTENTS


| TITLE PAGE | Pages |
|---|---|
| Declaration - - - | ii |
| Certification - - - | iii |
| Dedication - - - | iv |
| Acknowledgment - - - | v |
| Abstract - - - | vi |
| Table of contents - - - | vii |
| List of tables - - - | xi |
| List of figures - - - | xii |
| List of appendix - - - | xiii |

**CHAPTER ONE**

**INTRODUCTION**

| | | |
|---|---|---|
| 1.1 | Background Study - - - | 1 |
| 1.2 | Hospital Waste - - - | 2 |
| 1.3 | Nature of the Environment - - | 3 |
| 1.4 | Risk of Heavy metal contamination due to the presence of the Hospital- - | 4 |
| 1.5 | Aim and objectives of the Research - - - - - | 5 |

## CHAPTER TWO

## LITERATURE REVIEW


2.1 Classification of Hospital Waste - - - 6

2.2 Persistent organic pollutants (POPs) - - - 8

2.3 Effects of organic contaminants on human health- - - - 9

2.4 The Effects of Heavy metals on Human Health - - - 10

2.5 Lead - - - 12

2.6 Iron - - - 13

2.7 Cadmium - - - 14

2.8 Manganese- - - - 15

2.9 Nickel - - - 16

2.10 Chromium - - - 16

2.11 Cobalt - - - 17


## CHAPTER THREE

## MATERIALS AND METHOD


3.1 Preamble - - - 18

3.2 Description of sampling are - - 18

3.3 Sample collection - - - 18

3.4 Sample preparation - - - 20

3.5 Digestion of sample for AAS - - - 20

3.6 Digestion of sample for GC/MS - - - 21

3.7 Preparation of standard stock solution for AAS- - - 22

3.8 Determination of pH - - - 23

3.9 Determination of organic carbon in soil - - - 24

3.10 Particle size distribution - - - 25

3.11 Atomic Absorption Spectrometry (AAS)- - - - 30

3.12 Instrumentation - - - 31

3.13 Gas Chromatography/ Mass Spectroscopy- - - - 32

3.14 Description of technique- - - - 32

3.15 Statistical Analysis- - - - 34

**CHAPTER FOUR**

**RESULT AND DISCUSSION**

4.1 Organic contaminants- - - - 35

4.1.1 Soil - - - 35

4.1.2 Ash - - - 38

4.1.3 Food crops - - - 39

4.2.0 Heavy metals - - - 42

4.2.1 Soil - - - 42

4.2.2 Incinerator - - - 51

4.2.3 Metal concentration in the vegetation analyzed - 53

4.2.4 Physicochemical parameters - - - 60

**CHAPTER FIVE**

**SUMMARY OF FINDINGS AND CONCLUSION**

5.1 Summary of findings - - - 61

5.2 Conclusion - - - 61

5.3 Recommendation - - - 62

**References - - - 63**

**Appendices - - - 67**

## LIST OF TABLES


Table page

3.1 Showing the operating condition used for the spectrometer - - 31

4.1 Showing the concentration and organic contaminants identified in the analysis during the dry season. - - - - - - - - 36

4.2 Showing the concentration and organic contaminants identified in the study in the wet season - - --- -- ----- -- -- - 37

4.3: A table showing the mean concentration (mg/kg) of heavy metals on the dump 43

4.4: A table showing the mean concentration (mg/kg) of heavy metals outside dump soil (5m) - - - - - - - - - 44

4.4: A table showing the mean concentration (mg/kg) of heavy metals outside dump soil (10m) - - - - - - - - 45

## List of figures


Figure page

3.1 Map of study area - - - - - - - - 19

3.2 Burning hospital waste - - - - - - - - 27

3.3 View of the incinerator - - - - - - - 28

3.4 Burnt waste in the incinerator- - - - - - - - 29

4.1 Metal concentration on the dump soil (0-5cm) - - - - 47

4.2 Metal concentration on the dump soil (5-10cm) - - - - 48

4.3 Metal concentration outside dump (5m) (0-5cm) - - - - 49

4.4 Metal concentration outside dump (5m) (5-10cm) - - - - 50

4.5 Metal concentration in the incinerator ash - - - - 52

4.6 Metal concentration of tomatoes - - - - - - 54

4.7 Metal concentration of guava - - - - - - - 55

4.8 Metal concentration of banana - - - - - - - 56

4.9 Metal concentration of mango - - - - - - - 57

4.10 Metal concentration of the dump soil, ash and fruits in the wet season 58

4.11 Metal concentration of the dump soil, ash and fruits in the dry season- 59

## List of appendices


| Appendix | | Page |
|---|---|---|
| 1 | Conc. of heavy metals for wet and dry season in the ash - - - | 67 |
| 2 | Conc. of heavy metals for wet and dry season in guava - - - | 68 |
| 3 | Conc. of heavy metals for wet and dry season in banana - - - | 69 |
| 4 | Conc. of heavy metals for wet and dry season in mango - - - | 70 |
| 5 | Conc. of heavy metals for wet and dry season in tomatoes - - - | 71 |
| 6 | Conc. of heavy metals fall all source and fruits for wet season - - - | 72 |
| 7 | Conc. of heavy metals fall all source and fruits for wet season - - - | 73 |
| 8 | Calibration curve for standard lead metal - - - | 74 |
| 9 | Calibration curve for standard iron metal - - - | 75 |
| 10 | Calibration curve for standard manganese metal - - - | 76 |
| 11 | Calibration curve for standard cadmium metal - - - | 77 |
| 12 | Calibration curve for standard chromium metal - - - | 78 |
| 13 | Calibration curve for standard cobalt metal - - - | 79 |
| 14 | Concentration of Control (C1) heavy metal on dump soil - - - | 80 |
| 15 | Concentration of Control (C2) heavy metal on dump soil - - - | 81 |
| 16 | GC/MS trace of sample dumpsite soil (D1) (dry season) - - - | 82 |
| 17. | GC/MS spectra for sample D1 (dry season) - - - | 83 |
| 18 | GC/MS trace of sample outside dump soil (D2) (dry season) - - - | 84 |
| 19 | GC/MS spectra for sample D2 (dry season) - - - | 85 |
| 20 | GC/MS trace of sample potatoes (dry season) - - - | 86 |
| 21 | GC/MS spectra for sample P2 (dry season) - - - | 87 |
| 22 | GC/MS trace of sample cassava C2 (dry season) - - - | 88 |
| 23 | GC/MS spectra for sample C2 (dry season) - - - | 89 |
| 24 | GC/MS spectra for sample C2 (dry season) - - - | 90 |
| 25 | GC/MS trace of sample tomatoes T2 (dry season) - - - | 91 |
| 26 | GC/MS spectra for sample T2 (dry season) - - - | 92 |
| 27 | GC/MS trace of sample ash A1 (wet season) - - - | 93 |

28 GC/MS spectra for sample A1 (wet season) - - - 94
29 GC/MS spectra for sample A1 (wet season) - - - 95
30 GC/MS spectra for sample A1 (wet season) - - - 96
31 GC/MS trace of sample ash A2 (dry season) - - - 97
32 GC/MS spectra for sample A2 (dry season) - - - 98
33 GC/MS trace of sample dumpsite soil D3 (wet season) - - - 99
34 GC/MS spectra for sample D3 (wet season) - - - 100
35 GC/MS spectra for sample D3 (wet season) - - - 101
36 GC/MS spectra for sample D3 (wet season) - - - 102
37 GC/MS trace of sample outside dump soil D4 (wet season) - - - 103
38 GC/MS spectra for sample D4 (wet season) - - - 104
39 GC/MS spectra for sample D4 (wet season) - - - 105
40 GC/MS trace of sample potatoes P1 (wet season) - - - 106
41 GC/MS spectra for sample P1 (wet season) - - - 107
42 GC/MS spectra for sample P1 (wet season) - - - 108
43 GC/MS trace of sample cassava C1 (wet season) - - - 109
44 GC/MS spectra for sample C1 (wet season) - - - 110
45 GC/MS spectra for sample C1 (wet season) - - - 111
46 GC/MS spectra for sample C1 (wet season) - - - 112
47 GC/MS spectra for sample C1 (wet season) - - - 113
48 GC/MS trace of sample tomatoes T1 (wet season) - - - 114
49 GC/MS spectra of sample T1 (wet season) - - - 115
50 GC/MS spectra of sample T1 (wet season) - - - 116
51 GC/MS spectra of sample T1 (wet season) - - - 117

# CHAPTER ONE

# INTRODUCTION

## 1.1 BACKGROUND STUDY

Since beginning, the hospitals are known for the treatment of sick persons but are unaware of the adverse effects of the garbage and filth generated by them on human body and environment. Now it is a well-established fact that there are many adverse and harmful effects to the environment and human beings which are caused by the hospital waste generated during the patient care. Hospital waste is a potential health hazard to the health care workers, public and the flora and fauna of the area. Hospital acquired infection, transfusion transmitted diseases, rising incidences of hepatitis B, and HIV, increasing land and water pollution lead to increasing possibility of contracting many diseases. Air pollution due to emission of hazardous gases by incinerators such as furan, dioxin, hydrochloric acid etc. have compelled the authorities to think seriously about hospital waste and the diseases transmitted through their improper disposal (Hem,1999) .

The modern hospitals and health care institutions including research centres use a wide variety of drugs including antibiotics, cytotoxics, corrosive chemicals, radioactive substances, which ultimately become part of hospital waste. The advent of disposables in hospitals has brought in its wake, attendant ills e.g inappropriate recycling, unauthorized and illegal reuse and increase in the quantity of waste.

A modern hospital is a complex, multidisciplinary system which consumes thousands of items for delivery of medical care. All these products used in the hospital leave some unusable leftovers i.e. hospital waste. There are four primary ways to manage hospital waste: landfilling, source reduction, recycling and incineration. Historically, landfilling was the most

preferred means of disposal of medical waste. Public opposition and positive correlation with groundwater contamination have resulted in this option steadily going out of favour. In many countries, medical waste can no longer be disposed in landfills, unless it is so thoroughly detoxified as to pose no risk to human health. This is very expensive. Burning the waste material in open air can never be complete, with small quantities of many organic and chlorinated organic compounds as well as pathogens surviving. This will lead to dispersal of dangerous diseases. Incineration is currently used to destroy hospital waste, especially biomedical waste and hazardous chemical waste by reducing the volume and destroying some harmful constituents**.** Disposal of hospital waste in an environmentally acceptable manner is thus a critical necessity.

Among the broad range of organic pollutants contaminating soil-water, environment, polycyclic aromatic hydrocarbons and pesticides are of great environmental concern. Polycyclic aromatic hydrocarbons (PAHs) are composed of two or more fused aromatic rings and produced by combustion of organic matter. PAHs are hydrophobic organic contaminants and persist in the environment because of their recalcitrance to degradation and widespread occurrence in contaminated industrial wastelands. Thereby these compounds pose a health risk due to their toxic, mutagenic and carcinogenic properties (Corgie *et al.,* 2004; Maila and Cloete, 2002). Out of the 16 major toxic polycyclic aromatic hydrocarbons, anthracene is a tricyclic aromatic hydrocarbon that needs to be studied as signature PAH compound since its chemical structures are found in carcinogenic PAHs like benz(*a*)anthracene, dibenz(a,h) Anthracene and benzo(a)pyrene (Fiedler, 2001).

## 1.2 HOSPITAL WASTE

Hospitals, health-care units, maternity and nursing homes, and research facilities produce large quantities of hazardous waste. These include human anatomical waste (tissues, organs), blood and body fluid, microbiological waste, animal waste, highly infectious waste, discarded

medicines, disposables, etc. Based on occupancy ratio of the hospitals, 700 g/day waste is generated per bed in hospitals at Ahmedabad (Ray et al., 1998).

Medical waste has been classified into two categories: (i) general waste, which is not potentially dangerous and does not require special handling and disposal, and (ii) hazardous waste, which requires special handling, treatment and disposal, usually according to specific regulations and guidelines. The latter may pose potential health, safety or environmental hazards. There are three categories of hazardous waste – chemical waste, infectious waste and radioactive waste. Infectious waste, known as red-bag waste, includes materials considered to be potential health hazards because of possible contamination with pathogenic micro-organisms. Typical medical waste components are shown below:

| Waste | weight (%) |
|---|---|
| Paper and cloth items | 50-70 |
| plastic | 20-60 |
| glassware | 10-20 |
| fluid | 1-10 |

### 1.3 Nature of the Environment

Metal pollution can be defined as less natural elements which occurs in excess i.e. elements which under normal circumstances are essential, may become pollutant when present in excess by exhibiting toxic effects to their host organisms and vice- versa (Coombs., 1979).

Elements normally considered toxic i.e. pollutants, may serve an essential function at sufficiently low concentrations; Cr, Se, Ni, V, As, and Si may be quoted as example of the latter case (Peter, 1999). The distribution of metals is not uniform over the land and the

oceans and as a consequence living organisms have adapted themselves to these conditions and to the availability of certain elements. Man's intervention however has resulted in a redistribution of metals with the result that localized areas of high concentration are found. These not surprisingly usually occur close to areas of high industrial activity.

Most times industrial pollution is caused by man activities, which include careless disposal of toxic chemicals from industries, mining waste and radioactive materials into the environment (Goulden, 1978).

### 1.4 Risk of Heavy Metal Contamination due to the presence of the hospital

One of the most serious problems facing the world today is the contamination of the environment, including surface and ground waters, with heavy metals such as arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb) and mercury (Hg) (Jones, 1991). Most trace elements especially the heavy metals remain in the soil nearly indefinitely. These metals remain bound to organic matter unless they are remobilized mechanically as wind-blown dusts (Turer *et al*., 2001). Human exposure to metals and their compounds in the environment is through food, drinks, water. Other forms of uptake are via skin contact. (Ewers, 1991). However, over a period of time, adverse toxic effects may occur as a result of long-term low level exposure (Ewers, 1991). Heavy metals are generally considered to be those whose density exceeds 5 grams per cubic centimetre. A large number of elements fall into this category, but the most relevant in the environmental context are those mentioned above (Baetz *et al*., 1973).These toxic metals are biologically non-degradable, non-destructible and tend to accumulate in various vital animal organs and plant tissues. Even exposure to trace concentrations of several of these toxic metals ions can lead to long term toxic effects. Heavy-metal poisoning could result, for instance, from drinking contaminated water, high 5

ambient air concentrations near emission sources or intake via the food chain since these can bio-accumulate in plant and animal tissues (ATSDR, 1995).

### 1.5 Aim and Objectives

The aim of this study is to examine the effect of hospital waste at the dumpsite and the incinerator ash on the surrounding soil and vegetation.

**The objectives are as follows:**

- To identify and determine the concentration of organic contaminants present in the dumpsite soil, incinerator ash and on the food crops grown within the vicinity of the dumpsite.
- To determine the seasonal variation in the concentration of the heavy metals and organic contaminant present in the soil and food crops.
- To determine some physicochemical parameters such as pH Ratio, % organic- carbon Particle size distribution in the study site soil

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Classification of Hospital waste

The hospital waste is classified into seven (Akter *et al*.,1998) comprising of both the liquid and the dissolved substance generated within the hospital environment (Heen, 1991, FEPA 1991).

(I) General waste: This is composed largely of non-hazardous particles such as kitchen waste, paper and plastics.

(II) Infectious wastes: This includes waste which includes pathogens in sufficient concentration of quantity that could cause diseases. It is hazardous e.g. culture and stocks of infectious agents from laboratories, waste from surgery, waste originating from infectious patients.

(III) Pathological waste: Consist of tissue, organ, body parts, human foetuses, blood and body fluid. It is hazardous waste.

(IV) Sharps: Waste which could cause the person handling it, a punch or puncture of skin e.g. needles, broken glass, saws, nails, blades, scalpels.

(V) Pharmaceutical waste: This includes pharmaceutical products, drugs and chemicals that have been spilled are outdated, expired or contaminated.

(VI) Chemical waste: This comprises discarded solid, liquid and gaseous chemicals e.g. House-keeping and disinfecting products such as waste anaesthetic gases, formaldehyde solutions .

(VII) Radioactive waste: It includes solid, liquid and gaseous waste that is contaminated with radionuclides generated from in-vitro analysis of body tissues and fluid, in-vivo body organ imaging and tumor localization and therapeutic procedures.

WHO, (1999) reported that, about 85% of hospital waste is non-hazardous, 10% infective and 5% not infective but hazardous in the United States of America, while about 15% of hospital waste is regarded infective. In India, it was reported that the value could increase from 15% to 35% depending on the amount of hospital waste generated , while in Pakistan about 20% of hospital waste could be found potentially infective or hazardous[Agawral,1998]. Sources of pharmaceutical products in the environment are more than just consumers expelling unabsorbed medication through excretion into septic systems and waste water treatment plants. Sewage and waste water from hospitals and many clinics are huge distributors of this problem [Rhodes et. al., 2000]. Hazardous medical waste consist primarily chemicals and discarded citotoxic drugs, which find their way into the environment due to improper usage and indiscriminate disposal. Their presence in the environment poses serious environmental health risk due to their carcinogenic nature [Akter, *et. al*., 1988, Shanner.1997].

The major health risks posed by medical waste to the inhabitants of the terrestrial and aquatic ecosystem as audited by the WHO report of 1999 includes the following: contamination of dirty water possibly the leachate entering the aquifers. Surface water accumulation of toxic non-biodegradable hospital waste products, which could lead to the blockage of the sewage system, release of toxic substance into the air due to burning, accumulation of heavy metals and unprotected landfill as well as inefficient sorting of waste materials.

Waste water generated principally from health care institutions may represent a serious health hazard and little or none is known about the health hazard of hospital wastes in Zaria metropolis.

Children, adults and animals all have the potential to come into contact with these wastes, which may pose severe health risks to them [Akter,2000] .

## 2.2 Persistent organic pollutants (POPs)

Persistent organic pollutants have become a vital issue to mankind due to their hazardous nature. These chemicals, often called "Dirty Dozen" do not degrade readily and can travel thousands of miles away from their source. Persistent organic pollutants, more commonly known as POPs are chemical compounds or mixtures that include industrial chemicals, pesticides and some industrial wastes. They are named "Persistent" because these do not degrade in the environment by physical, chemical or biological processes. POPs are semi-volatile and do not readily dissolve in water thus they concentrate in plants, animals and also in humans. Even in extremely small amounts POPs can injure human health and health of other organisms. Wildlife and humans can come in contact with POPs through breathing contaminated air, by eating contaminated foods or drinking or washing in contaminated water (Parivesh, 2001).

Polycyclic aromatic hydrocarbons (PAHs) are hydrophobic organic contaminants and persist in the environment because of their recalcitrance to degradation and widespread occurrence in contaminated industrial wastelands. Thereby these compounds pose a health risk due to their toxic, mutagenic and carcinogenic properties (Corgie *et al*., 2004: Mailer and Cloete, 2002).

Although many different chemicals may be defined as POPs, only 12 have been chosen as priority pollutants by the United Nations Environment Program (UNEP, 2003) for their impact on human health and environment for initial inclusion in the Stockholm Convention. An additional five substances have been nominated for addition to the Convention and are

currently being evaluated (perfluorooctansulfonate, penta-bromodiphenylether, chlordecone, hexabromobiphenyl, and Lindane).

Polychlorinated dibenz-para-dioxins (dioxins) and polychlorinated dibenzofurans (furans) are two structurally similar families of compounds that include 75 and 135 congeners, respectively collectively as dioxins. Dioxins are not commercially produced, but are by-products of combustion and industrial processes, including the manufacture of chlorinated chemicals, the incineration of hospital, hazardous and municipal waste, and the bleaching of paper products.

Dioxins are stable, persistent compounds that are believed to have a half-life of seven to twenty years in the human body. At least seventeen are considered highly toxic.

According to the European Dioxin Inventory report the major industrial emission sources in Europe (accounting for about 62% of total dioxin air emissions) are probably:

• Incinerators for municipal waste

• Iron or sinter plants

• Incinerators for clinical waste

• Facilities of the non-ferrous metal industry

### 2.3 Effects of organic contaminants on human health

The greatest part of human exposure to the 12 Persistence Organic Pollutants (POP) is attributed to the ingestion of food.

Contamination of food may occur through environmental pollution in the air, water and soil, or through the previous use or un-authorized use of pesticides on food crops. The health effects of POPs are generally subtle and can be triggered at extraordinary low concentrations.

The latency period for POPs may be very long, between exposure and outcome in the exposed individual, in some cases effects occurring in future generations.

Exposure to POPs can be associated with the following health effects in humans:

• Immune system biochemical alterations

• A shortened period of lactation in nursing mothers

• Neurobehavioral impairment including learning disorders, reduced performance on standard tests, and attention deficits

• Diabetes

**.**Cancer

High-dose acute exposure: typically results from accidental fires or explosions involving electrical capacitors or other PCB-containing equipment, or high dose food contamination.

Mid-level chronic exposure is predominantly due to the occupational exposure.

Chronic, low-dose exposure is characteristic for the general population world-wide as a consequence of the existing global background levels of POPs with variations due to diet, geography, and level of industrial pollution. Low level and population-wide effects are more difficult to study. People are exposed to multiple POPs during their lifetime and most people today carry detectable levels of a number of POPs in their body (Parivesh, 2001)

## 2.4 The effects of heavy metals to human health

Heavy metals are natural components of the Earth's crust. They cannot be degraded or destroyed. To a small extent they enter human body via food, drinking water and air. As trace elements, some heavy metals (e.g. copper, selenium, zinc) are essential to maintain the

metabolism of the human body. However, at higher concentrations they can lead to poisoning. Heavy metal poisoning could result, for instance, from drinking-water contamination (e.g. lead pipes), high ambient air concentrations near emission sources.

Metals have characteristic affinities for certain organs and system. The consequences of preferential localization in certain organs of the body are not necessarily bad. As an example, lead (pb) has a great affinity for bone, more than 90% of the lead in the body is localized in bone. Yet, the toxic effect of lead are the result of its presence in much, lower concentrations elsewhere in the body, notably in the hematopoietic system and the central nervous system (Baetz *et al*., 1973).

Metals constitute an important part of the biosphere and many are required for the life processes of animals, including man. A classification of the requirement of metals by man has reported by Peter in 1999.

Metals required in substantial amounts, for which the body has a rather wide tolerance, e.g. sodium and iron, metals required in much smaller amounts and for which the body has quite a narrow tolerance e.g.' Micronutrients' copper and zinc and metals for which we have determined as essential role in the life processes and toxic at low levels, e.g. lead and mercury. Heavy metals are dangerous because they tend to bio accumulate. Bioaccumulation means an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment. Compounds accumulate in living things any time they are taken up and stored faster than they are broken down (metabolized) or excreted. The most hazardous heavy metals are lead, cadmium, copper, chromium, selenium and mercury.

## 2.5 Lead

Lead in the environment arises from both natural and anthropogenic sources; exposure can occur through drinking water, food, air, soil, and dust from old paint containing lead. In humans, exposure to lead can result in a wide range of biological effects depending on the level and duration of exposure, various effects occur over a broad range of doses, with the developing foetus and infant being more sensitive than the adult. High levels of exposure may result in toxic biochemical effects on humans which in turn cause problems in the synthesis of haemoglobin, effects on the kidneys gastrointestinal tract, joints and reproductive system, and acute or chronic damage to the nervous system. Lead is readily absorbed through intestinal tract and deposited in the central nervous system. The presence of lead in the body is indicated by lead blood levels, expressed as micrograms of lead per decilitre of blood (μg/dl). Blood lead levels of 10μg/dl and higher may contribute to decreased cognition, nervous system damage and stunted growth.

Acute toxicity is quite unusual, as lead is a relatively insoluble cumulative poison. Reported symptoms include fatigue, sleep disturbance, and constipation, followed by colic, anaemia, and neuritis. Symptoms of chronic lead poison include loss of appetite, metallic taste, constipation, anaemia, pallor, malaise, weakness, insomnia, headache, muscle and joint pains, tremors, encephalopany, and colic. Some lead – poisoning victims develop weakness in the extensor muscles, known as wrist drop or foot drop. Lead interacts with a number of other metals. A typical detoxification treatment involves chelating of lead with calcium ethylenediamine tetra acetate (EDTA) given parentally. Repeated treatment leach lead out of bone tissue. Lead arthralgia (joint pains) is lead induced gout caused by lead's interference with uric acid excretion by the kidneys. Lead toxicity affects the kidney and causes tubular dysfunction or nephrotoxicity. Lead is associated with the depression of many endocrine functions, particularly the thyroid and adrenal glands. It causes premature deliveries and

spontaneous abortions in humans, as well as chromosome aberrations, but there is no evidence of terogenic or carcinogenic effects.

Lead in the air contributes to lead level in food through deposition of dust and rain containing the metal on crops and the soil. However the presence of lead in petrol, which is emitted from car exhaust, is the most widespread source of contamination of soil and plants.

Lead from the atmosphere that settles on the soil has low mobility and tends to stay in the top inch of the soil. Therefore shallow rooted plants such as grasses and common vegetables are particularly vulnerable to picking up lead contamination that originates from the atmosphere. Cadmium in humans, long-term exposure is associated with renal dysfunction. High exposure can lead to obstructive lung disease and has been linked to lung cancer, and damage to human's respiratory systems. Copper is an essential substance to human life, but in high doses it can cause anaemia, liver and kidney damage, and stomach and intestinal irritation.

## 2.6 Iron

Iron is the most abundant heavy metal. It is essential for the synthesis of chlorophyll. It activates a number of respiratory enzymes in plants. The deficiency of iron results in severe chlorosis of leaves, especially the young leaves. Exposure to iron dust causes respiratory diseases such as chronic bronchitis and ventilation difficulties (Moravic *et. al.*, 1986).

Iron may be toxic to cells because it catalyzes the production of the hydroxyl radical (Heubers, 1991). In iron deficiency, absorption of other heavy metals is increased. Fumes cause siderosis and pneumonia (Butler, 1979).

Most tropical soils are rich in iron, it occurs mainly as pyrites or ferromagnesium minerals such as biotite, horn blende and limonite. Small amounts are present in the soil solution or in

an exchangeable form. In poorly aerated soil, the concentration of ferrous ion ($Fe^{2+}$) may be high enough to reach toxic level.

## 2.7 Cadmium

Cadmium is produced as an inevitable by-product of zinc (or occasionally) refining, since these metals may occur naturally within the raw ore, the most significant use of cadmium is in nickel/cadmium batteries, as rechargeable secondary power source exhibiting high output, long life, low maintenance and high tolerance to physical and electrical stress. Cadmium coatings provide good corrosion resistance, particularly in high stress environment such as marine and aerospace applications where high safety and reliability is required. Other uses of cadmium are as pigments, stabilizers for polyvinyl chloride, in alloys and electronic compounds; cadmium is also present as an impurity in several products and refined petroleum products.

Cadmium derives its toxicological properties from its chemical similarity with zinc, an essential micronutrient for plants, animals and humans. Cadmium is biopersistant and once absorbed by an organism, remains resident for many years, although it is eventually excreted. Uptake of cadmium by plants is greatest from soils and varies with soil properties especially those that control adsorption and also with the plant species and the source of cadmium. The average daily intake for humans is estimated as 0.15µg from air and 1ug from water. Smoking a packet of cigarette can lead to the inhalation of around 2-4µg of cadmium. Airborne cadmium comes primarily from steel industry and waste incineration, followed by volcanic activity and zinc production. There is no evidence of dermal absorption and oral absorption is very low. The effects of exposure to cadmium include vomiting, increased salivation, abdominal pain, and diarrhoea. Acute inhalation is characterized by coughing and tightness in the chest. Chronic exposure produces a variety of effects on kidneys, lungs, heart,

bones, and gonads. Cadmium fumes can damage the olfactory organs. Cadmium toxicity is decreased by the presence of other metals (Csuros and Csuros, 2002).

## 2.8 Manganese

Manganese is an essential element occurring in concentrations hardly toxic to the environment. It is available in plants and in animal cells in high levels especially in mitochondria where it acts as a co-factor for the activation of some enzymes (Schiele, 1991). Manganese deficiency causes disorders in menstrual cycle, still birth, and low birth weight as well as growth impairments in rats, mice, cows etc (Matrone *et al.,* 1977). Manganese salts are potent mutagens in some microorganism or carcinogenic in mammalian systems (Schiele, 1991). Manganese deficiency is manifested by dermatitis, pigment changes, deficiencies in hair growth, hypolidemia, and prothrombin deficiency (Doisy, 1972). Manganese also acts as a catalyst in the formation of chlorophyll. It also increases the availability of calcium, magnesium and phosphorus in soils.

Manganese toxicity to humans has been shown only on exposure to high levels in the air. Inhalation of large doses of manganese compounds, especially the higher oxides, can be lethal. (Csuros and Csuros, 2002). Inhalation of magnesium fumes causes manganese pneumonia, which can be fatal. Chronic manganese toxicity is well known in miners, mill workers, and others exposed to high levels of manganese laden dusts and fumes, and drinkers of well water containing excessive manganese. The usual symptom involves the central nervous system. Characteristic manganese psychosis involves inappropriate laughter, euphoria, impulsiveness, and insomnia, followed by overwhelming somnolence. These symptoms may be accompanied by headache, leg cramp and sexual excitement, followed by lethargy. In the final stage, speech disturbance, masklike facial expression, general

clumsiness and micrography are characteristics. Although patients may become totally disabled, the syndrome is not lethal (Csuros and Csuros, 2002).

## 2.9 Nickel

Nickel is a hard, ductile, malleable metal with atomic number 28, it ranks 24$^{th}$ in abundance in the earth's crust. Because it is quite resistant to corrosion, nickel is often used in plating more active metals. Nickel and chromium are the chief additives to iron in making stainless steel. In combination with copper, it produces a hard, strong, corrosion resistant alloy called monel.

Nickel and its compound have little toxicity. Nickel itch or contact dermatitis is the most commonly seen reaction to nickel compounds especially in women, resulting from use of nickel in costume jewellery, especially earrings. Chronic exposure to nickel causes cancer in the respiratory tract and the lungs (Csuros and Csuros, 2002).

## 2.10 Chromium

Chromium is necessary for the proper utilization of sugars and other carbohydrates by optimizing the production and effects of insulin. It is widely distributed in the body. The RDA is 0.05 to 2mg. Sources include liver, meat, cheese, whole grain, yeast and wine. The effects of excess chromium are not known. Deficit causes impaired insulin function, hence increased insulin secretion and the risk of adult onset diabetes mellitus (Csuros and Csuros, 2002).

## 2.11 Cobalt

Cobalt is relatively rare and is found in ores such as smaltite ($CoAs_2$) and cobaltite (CoAsS). Cobalt is a hard, bluish white metal that is used mainly in alloys, such as stainless steel and stellite (an alloy of iron, copper and tungsten) which is used in surgical instruments. Cobalt is also used to prepare the alloy alnico, which forms powerful magnets. Aqueous solutions of cobalt (II) salts are characteristically rose colored. Cobalt salts, the usual oxidation states II and III are used to give a brilliant blue color to glass, tile, and pottery.

Anhydrous cobalt (II) Chloride ($CoCl_2$) is used in water quality testing and as a heat – sensitive ink. Artificially produced cobalt – 60 is used as a radioactive tracer and cancer treatment agent. Cobalt is a part of vitamin B12 (cyanocobalamin) and is considered an essential nutrient, but concentrations higher 1mg /kg of body weight are regarded as health hazards. (Csuros and Csuros, 2002). Cobalt exhibits toxic effects on the heart, kidneys, and thyroid gland. Consumption of large quantities of coffee or beer may lead to high concentration of cobalt. Cobalt toxicity resulting in heart failure (about 40% mortality) has been reported among heavy beer drinkers who had consumed products containing cobalt additives used as a foam stabilizer ( Csuros and Csuros, 2002).

# CHAPTER THREE

# MATERIALS AND METHOD

## 3.1 Preamble

In the preparation of solution, analytical reagent grade chemicals and distilled water were used. All glassware were washed with detergent and rinsed in water before immersion in 10% nitric acid solution. They were further rinsed with distilled water before drying in the oven.

All samples were oven dried at 105$^{o}$C to a constant weight and were sieved through a 250µm mesh (Ayodele and Gaya, 1994).

## 3.2 Description of the sampling area

The sampling area is a teaching hospital situated in Zaria, Kaduna State. The hospital began medical services at this site in a skeletal way in 2005. Hence, the hospital waste site is virtually new as medical services are just taking proper shape see figure 3.1

## 3.3 Sample collection.

All samples were collected between the hours of 7:00AM – 9:00AM on 30$^{th}$ August, 2010 for the wet season and on the 15$^{th}$ March, 2010 for the dry season.

### 3.3.1 Soil sample

Soil samples were collected from two sampling points at the hospital dumpsite at different distances away from the dumpsite at a depth of 5cm within the study area designated as follows:

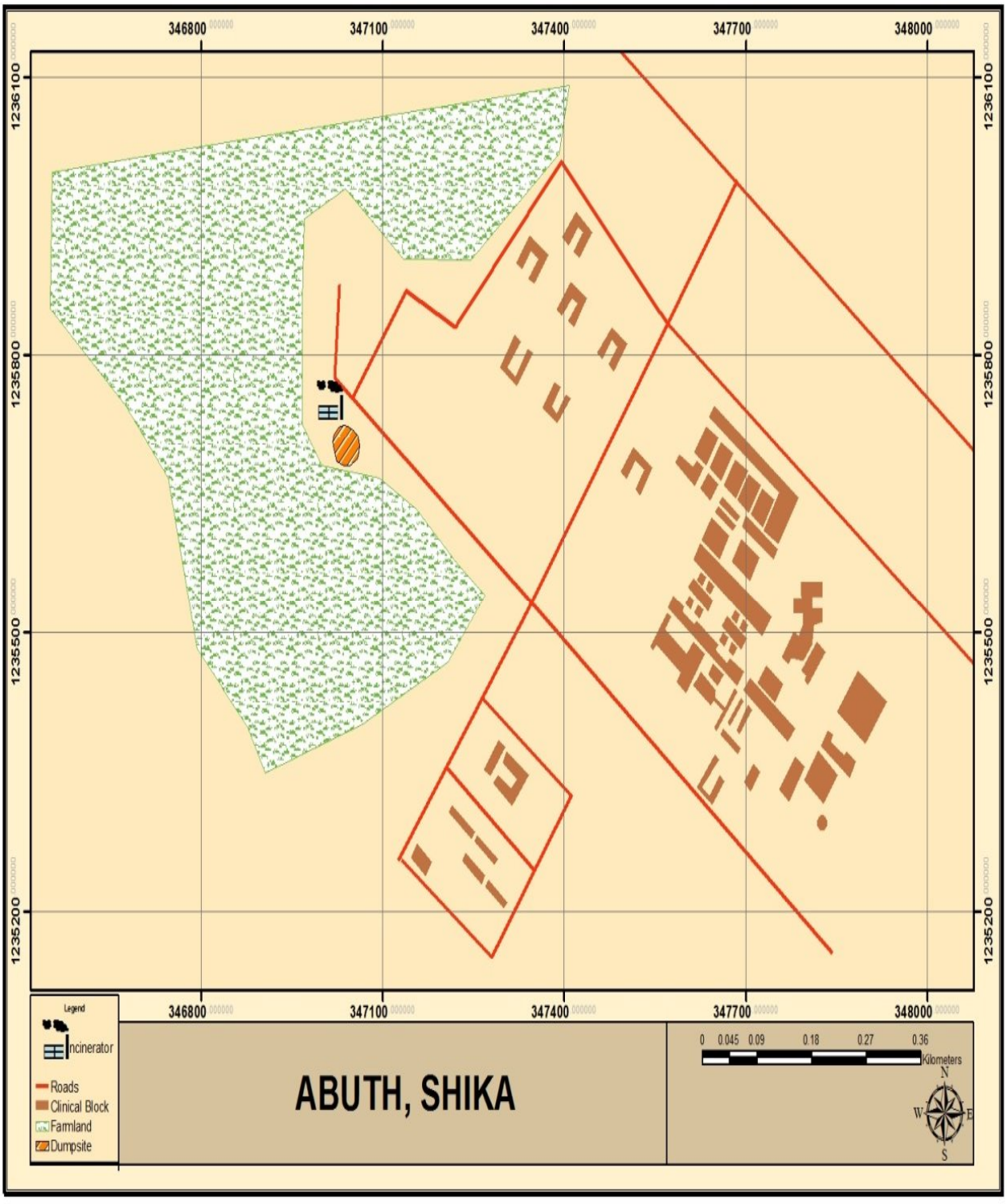



**Figure 3.1 Map of study area showing incinerator and farmland**

D1 is a point on the dumpsite where the samples were collected at 0-5cm, 5-10cm deep.

D2 is a point 5m away from the dumpsite with the same depths.

D3 is a point 10m away from the dumpsite with the same depths

**3.3.2 Crop sample:**

Crop samples collected from the farmland within the vicinity of the dumpsite are tomatoes, guava, banana, and mango fruits while cassava and potatoes tubers were collected.

**3.3.3 Ash sample:**

Ash samples from the mini incinerator were taken at random in two points, designated as: A1, and A2 which are first, and second points of collection respectively.

**3.3.4 Control sample:**

Soil sample used as control were collected from Samaru at a public waste dumpsite which is about 7km away from the hospital environment taken at random in two points, designated as: C1, and C2 which are first, and second points of collection respectively.

## 3.4 Sample preparation

### Treatment and Preservation of Sample

Immediately the soil samples were collected they were isolated and packaged in neatly labelled plastic containers that had been washed and rinsed thoroughly with nitric acid and analytical grade pentane in order to remove all heavy metals and organic residue and transported to the laboratory.

## 3.5 Digestion of samples for AAS

Soil samples from each site were homogenized and air – dried in a circulating air in the oven of $30^0$C to a constant weight and passed through a 2mm sieve. 0.3g of soil samples were placed in 100ml beaker. $3cm^3$ of 30% hydrogen peroxide was added following a procedure by Shriadah (1999). This was left to stand for 60 minutes until the vigorous reaction ceased. Thereafter $75cm^3$ of 0.5M solution of HCl was added and the content heated gently at low heat on hot plate for 2hours. The digest was then filtered into a $50cm^3$ standard flask. Duplicate digestion of each sample together with the blank (blank) was also carried out.

The crop samples mango, guava, banana and tomatoes were washed with tap water ( Burton and Patterson 1979 ) and thereafter with distilled water, sized in nearly uniform size to facilitate drying of the pieces at the same rate and then dried in an oven at 105$^{o}$C for 24hours, until they were brittle and crisp (APHA, 1992). At this stage, no micro organism can grow and care was taken to avoid any source of contamination. The dried samples were grinded into fine particles using clean acid washed mortar and pestle. The procedure according to Awofolu (2005) was used for digestion of plant samples. 0.3g of sieved samples was then weighed into 100cm$^3$ beaker. A mixture of 5cm$^3$ concentrated trioxonitrate (V) acid and 2cm$^3$ perchloric acid was added and this was digested on low heat hot plate for 15mins, at 70$^{o}$C until a light coloured solution was obtained. The sample solution was not allowed to dry during digestion. The digest was allowed to cool, filtered into 50ml standard flask. Duplicate digestion of each sample was carried out. Quantitation of metallic content of digested sample was carried out with Atomic absorption spectrophotometer.

### 3.6 Digestion of sample for GC/MS analysis

Liquid-liquid solvent extraction was used to extract the organic compound present in the soil, ash and crop sample analyzed. The soil and ash samples (1.0g of each) were measured carefully and placed in a beaker and chloroform was added; the mixture was then shaken vigorously and allowed to settle for 1hour before they were separated from the extracting solvent using 2mm sieve. They were carefully poured in a neat container that had been washed and rinsed as described above. Crop samples such as tomatoes, cassava, and potatoes were washed and rinsed and were sized into nearly uniform sizes, and were grinded until they form paste to allow proper percolation of the extracting solvent (Burton and Patterson, 1979). Chloroform was added, shaken vigorously and left for 1hour to allow much extraction of the organic compound. The extracted compounds were then transported to Usman Danfodio University Sokoto, Sokoto state for GC/MS analysis.

### 3.7 Preparation of standard solutions for AAS

**Preamble**

Standard stock solutions for the determination of heavy metals were prepared from high purity metal compounds and appropriate volumes were diluted to obtain working solutions used to plot the calibration curves. The preparations were as follows:

**a. Lead stock solution**

A portion (0.1599g) of lead nitrate $Pb(NO_3)_2$ was dissolved in $20cm^3$ of 1% v/v $HNO_3$ and made up to $1000cm^3$ with distilled water. A working volume of 2.0, 4.0, 6.0, 8.0ppm was prepared by diluting 2, 4, 6, and $8cm^3$ of the stock solution respectively to a $1000cm^3$ mark in a volumetric flask.

**b. Chromium stock solution**

A portion (2.828g) of heptaoxodichromate vi ($K_2Cr_2O_7$) was dissolved in water and made up to $1000cm^3$ . A working solution of 1, 2, 3, 4 and 5ppm were prepared by diluting 1, 2, 3 and $4cm^3$ of stock respectively to $1000cm^3$ mark in a volumetric flask.

**c. Cadmium stock solution**

A portion (2.059g) of anhydrous cadmium sulphate $CdSO_4.H_2O$ was dissolved in distilled water and made up to $1000cm^3$. 0.25, 0.50, 1.0, 2.0 and 4.0ppm working solutions were prepared by diluting 0.25, 0.50, 1.0, and $2.0cm^3$ of stock respectively to $1000cm^3$ in a volumetric flask.

**d. Iron stock solution**

A portion (5.1579g) of ammonium iron II sulphate Fe $(NH_4)_2$ $(SO_4)_2.6H_2O$ was dissolved in water. This was made up to 1000$cm^3$ with distilled water.1, 2, 3, and 6ppm ,working solutions were prepared by diluting 1.0, 2.0, 3.0 and 6.0$cm^3$ stock respectively to 1000$cm^3$ mark in volumetric flask.

**e. Manganese stock solution**

A portion (4.144g) of potassium tetraoxomanganate VII $KMnO_4$ was dissolved in distilled water and made up to 1000$cm^3$. 0.25, 0.50, 1.0, and 2.0ppm working solutions were prepared by diluting 0. 25, 0.5, 1.0, and 2.0$cm^3$ of stock respectively to 1000$cm^3$ mark in volumetric flask.

**f. Nickel stock solution**

A portion (4.648g) of Nickel sulphate $NiSO_4.6H_2O$ was dissolved in distilled water and made up to 1000$cm^3$. 0.5, 1.0, 2.0, and 4.0ppm working solutions were prepared by diluting 0.5, 1.0, 2.0 and 4.0$cm^3$ of stock solution to 1000$cm^3$ in a volumetric flask.

**g. Cobalt stock solution**

A portion (0.4770g) of dry cobalt sulphate $CoSO_4.7H_2O$ was dissolved in distilled water and made up to 1000$cm^3$. A working solution of 1, 2, 3, 4 and 5ppm were prepared by diluting 1, 2, 3 and 4$cm^3$ of stock respectively to 1000$cm^3$ mark in a volumetric flask.

**3.7 Determination of pH**

Soil pH was measured in a 1:5 soil to water ratio (Rayment and Higginson., 1992). A portion (0.5g) of air dried soil was measured into a plastic sample bottle and 2.5$cm^3$ of de-ionized water was measured into the plastic sample bottle. The bottle was placed on a mechanical shaker and was allowed to stand for 1hour. The suspension was stirred and the electrode

immersed into the soil suspension. Readings were taken after 30 seconds. The electrode was carefully removed from the suspension, and was rinsed with distilled water in a separate beaker and excess water was dried with a tissue.

### 3.8 Determination of organic carbon in soil

In the quantitative determination of soil organic matter, usually the organic carbon content is determined or measured and not the total carbon content of the soils. The soil organic matter content may then be obtained by multiplying the organic carbon concentration by a factor that varies from 1.724 to 2.0 (Tan, 1996). In ordinary routine research, Walkley–Black rapid titration method which measures only the decomposed fraction of soil organic matter is used; in this wet combustion method, the soil is digested with $K_2Cr_2O_7$ and $H_2SO_4$ making use of the heat of dilution of $H_2SO_4$. The excess of Chromic acid, not reduced by the soil organic matter is determined by titration with standard $FeSO_4.7H_2O$.

The organic matter of the soil samples was determined by the method of Walkely and Black wet combustion method (1934). A portion (1g) of the soil sample (passed 0.5 mm sieve) was weighed into 250 $cm^3$ conical flask. 10 $cm^3$ of 0.17m $K_2Cr_2O_7$ solution was accurately pipetted into the flask and the soil was dispersed by swirling gently. 20 $cm^3$ of conc. $H_2SO_4$ was added rapidly by the use of an automatic pipette, and the stream was directed into the suspension. Continuous swirling of the flask was maintained gently until soil and reagents were mixed, and more vigorous swirling was maintained for a minute. The flask was rotated again and allowed to stand on a sheet of asbestos for about 30 minutes. 100 $cm^3$ of distilled water was added after standing for 30 minutes. Three to four drops of indicator was added and titration was done with 0.5 m $FeSO_4$ solution. As the end point was approached, the titrant took on a greenish cast and then changed to dark green. At this point the titrant was added drop wisely until the colour changed sharply from blue to red in reflected light against

a white background. The blank titration was made in the same manner without the soil sample to standardize the dichromate.

The results were calculated according to the following formula:

Organic carbon in soil (%) =

$$\frac{MeK_2Cr_2O_7 - MeFeSO_4 \times 0.003 \times 100 \times F}{\text{Mass(g) of soil (dried soil)}}$$

Where F = correction factor 1.33

Me = molarity of titrant in $cm^3$ or ml of solution used

% organic matter in soil = % organic carbon × 1.729

### 3.9 Particle size distribution

Particle size distribution was determined by the hydrometer method as described by Bauyocos (1951). A portion (50g) of 2mm sieved soil was weighed into a 250$cm^3$ plastic beaker. 100 $cm^3$ of 50% of sodium hematophosphate (calgon) solution was added to the soil mixture and stirred with glass rod. 100 $cm^3$ of distilled water was added to the mixture, stirred and allowed to stand for 30 minutes with occasional stirring. It was transferred to a 250 $cm^3$ plastic container and shaken on mechanical shaker for 10 minutes and then into 1000 $cm^3$ measuring cylinder and made up to mark with distilled water. Before the hydrometer reading was taken, the suspension in the cylinder was mixed vigorously using a long handle plunger making sure that the soil at the bottom was thoroughly disturbed. Hydrometer readings at 40 seconds and 2 hours were taken. The hydrometer was then removed and the temperature of suspension was recorded with a thermometer. A blank consisting of 0%

calgon in 100 $cm^3$ of distilled water was made, diluted to 1000 $cm^3$ in a measuring cylinder and hydrometer temperature readings taken.

The corrected hydrometer readings C(g/l) were obtained by subtracting the blank reading R(g/l) from the hydrometer readings in the soil suspensions R(g/l) and adding 0.36 g/l for every degree above $20^0$C.

$$\% \text{ Clays} = \frac{(\text{Corrected 2 hours reading} - \text{Blank}) \times 100}{\text{Weight of soil taken}}$$

$$\% \text{ Silt} = \frac{(\text{Corrected 40 sec readings} - \text{Blank}) \times 100}{\text{Weight of soil taken}}$$

% Sand = 100 – (% Clay + % Silt)

Corrected readings (g/ l) = R-RL+(0.36T)

R= Hydrometer reading of soil suspension

RL= Balance readings

0.36 g/ l is added to soil suspension readings for every degree above $20^0$C.



**Figure 3.2** **Burning hospital waste**



**Figure 3.3** **View of the incinerator**



**Figure 3.4** **Burnt wastes in the incinerator**

## 3.10 **Atomic Absorption Spectrometry (AAS)**

Atomic absorption has proved to be one of the most widely used and successful techniques fo trace elemental and heavy metal analysis. It is a quantitative, sensitive, specific, simple and rapid method for determining metals in the periodic table in microgram per – millilitre range or even lower concentration (Wine, 1976). The procedure is concerned with determination of concentration of a substance by measurement of the relative absorption of light with respect to a known concentration of the substance (Vogel, 1996).

### Principle of AAS

Atomic absorption spectrometry is an analytical method based on the absorption of ultraviolet or visible light by gaseous atoms. The sample containing metallic compound is converted into atomic vapour by spraying the sample solution into the flame. Some of these gaseous metal atoms may be excited but much larger number of the gaseous metal will normally remain in the ground state. These ground state atoms are capable of absorbing radiant energy of their own specific resonance wavelength. Hence, if light of the resonance wavelength is passed through the flame containing the atom, that part of the light will be absorbed. The extent of absorption is proportional to the number of the ground state atoms present in the flame (Vogel, 1996). The great advantage of the method over other procedures is its high degree of freedom from interference from its environment (i.e. by the presence of other elements).The method is also dependent of flame temperature since it involves atoms in the ground state. UNICAM 969 atomic absorptions spectrophotometer model was used. The operation conditions for the spectrometer used for the heavy metals analysis is as shown in table 3.1

**Table 3.1: The operating condition used for the spectrometer.**

| Element | Wavelength(nm) | Band pass(nm) | Flame type | Uptake time(seconds) |
|---|---|---|---|---|
| Lead | 283.0 | 0.5 | Air/Acetylene | 4 |
| Cadmium | 228.8 | 0.5 | Air/Acetylene | 4 |
| Zinc | 213.0 | 0.5 | Air/Acetylene | 4 |
| Iron | 248.3 | 0.5 | Air/Acetylene | 4 |
| Copper | 324.8 | 0.5 | Air/Acetylene | 4 |
| Cobalt | 240.7 | 0.2 | Air/Acetylene | 4 |
| Nickel | 232.0 | 0.2 | Air/Acetylene | 4 |
| Manganese | 279.5 | 0.2 | Air/Acetylene | 4 |

## 3.12 Gas Chromatography/ Mass Spectroscopy

### A General Overview of Chromatography

The chromatographic separation relies on the interaction of the sample with a mobile phase and a stationary phase within the GC instrument column. The sample is carried through the column by the mobile phase, typically an inert gas. However, the sample is slowed in its travel through the column as the sample molecule repeatedly adsorbs and desorbs from the stationary phase in the column. The affinity of a particular molecule for a stationary phase determines the retention time of that constituent in the column. The molecule for each component of the sample will travel through the column at nearly the same rate and exit (elute) from the column within a narrow time band that is specific of the component.

Gas chromatography–mass spectroscopy (GC-MS) is the marriage of two analytical methods into a versatile technique for the identification of complex volatile materials. As the name implies, it is actually two techniques that are combined to form a single method of analyzing mixtures of chemicals. Gas chromatography effectively separates the different constituents of the sample while the mass spectroscopy characterizes (identify) each of the components individually. By combining the two techniques, an analytical chemist can both qualitatively and quantitatively evaluate a solution containing a number of chemicals.

## 3.13 Description of the Technique:

The typical GC capillary column consists of small diameter tube with a thin film of high-molecular weight polymer coated on the inside. The polymer is the stationary phase for the chromatographic process. The mobile phase can be any inert gas, but is typically helium. The instrument also includes the heated injection port to vaporize all volatile constituents of the sample. The capillary column is held in an oven that can be programmed to increase the temperature gradually, this helps the separation. As the temperature of the oven increases,

those components with low boiling points elute from the column sooner than those with higher boiling points.

As the compounds are separated, they elute from the column and enter a detector which create electronic signal of the compound detected. The signal is then processed by a computer. While the instrument is still running, the computer generates a graph from the signal, called **chromatogram**. Each peak in the chromatogram represents the signal created when a compound elutes from the GC column into the detector.

As a sample constituent elutes from the GC column, it enters the ionization chamber of the mass spectrometer where they are bombarded with a stream of electrons causing them to break apart into fragments. When an electron impacts with a sample it results in the loss of an electron from the molecule forming a positive ion. Some of the molecular ions are further fragmented into daughter ions and neutral fragments.

The positive ions are then repelled out of the ionization chamber by a small positive charge within the chamber. Negative ions are also formed by the electron impact, but are not analyzed. The positive ions are separated according to their masses by a mass analyzer. The mass analyzer most commonly used in GC-MS is the **quadruple filter**, in which the ions pass by four hyperbolic magnetic poles created by a radio frequency field. The magnetic poles separate the ions by their mass/charge ratio, successfully focusing ions with increasing mass into a detector for counting. The analyzer scans step-wise through a set range of mass value to evaluate the relative abundance of ions at each mass value.

The computer records a graph of each scan. This graph is referred to as **mass spectrum.** The mass spectrum produced by a given chemical compound is essentially the same every time; therefore the mass spectrum is essentially the fingerprint of every molecule which can be used to identify the compound. The computer on the GC-MS has a library of spectra that can be used to identify an unknown chemical in the sample mixture. The library compares the

mass spectrum from a sample component with the mass spectra in the library. It reports a list of likely identifications along with the statistical probability of the match.

When GC is combined with MS, a powerful analytical tool is created. A researcher can take an organic solution, inject it into the instrument, separate the individual components, and identify each of them. Furthermore, the researcher can determine the quantity (concentration) of each of the components.

### 3.14 Statistical Analysis

The data obtained in this study were analysed using analysis of variance (one way ANOVA) to conduct a test of significance at $p<0.05$ between pairs of data (both one tail and two tail analysis) also student t-test was conducted using SPSS.

The student t-test tells if the variation between two groups is "significant" P reports the significant level. A significant level of 0.05 was chosen. That is, we are about 95% confident in the result.

# CHAPTER FOUR

# RESULT AND DISCUSSION

## 4.1.0 Organic Contaminant

The GC/MS spectra of the soil, ash and food crops showed the presence of the butylated hydroxytoluene, 1,2-benzenedicarboxylic acid, methylester, 1,2-benzenedicarboxylic acid, mono (2ethylhexyl) ester, ethylbenzene, o-xylene and diethylphthalate organic contaminants; Table 4.1 and 4.2 for both wet and dry seasons respectively.

### 4.1.1 Soil

The dump soil sample showed the presence of 1,2-benzenedicarboxylic acid, diisooctyl ester at 0.7916mg/kg concentration while outside the dumpsite 5m away, the dump soil showed the presence of diethyl phthalate with 0.0246mg/kg concentration during the dry season.

While for the wet season the dump soil showed the presence of octadecanoic acid (0.1270mg/kg), n-hexadecanoic acid (0.0965mg/kg) and 1,2- benzenedicarbxylic acid, diisooctyl ester (0.1191mg/kg) and at another distance outside the dumpsite 5m away, it showed the presence of octadecanoic acid (0.2041mg/kg).

The concentration of these organic contaminants poses serious health risk to the environment. Report showed that medical devices constitute a special, but significant source of exposure to 1,2- benzenedicarboxylic acid, diisooctyl ester. It is used in blood storage bags, tubing and other devices. High exposures can occur to individuals receiving blood transfusion, undergoing major surgery, or undergoing kidney dialysis. It has been reported that 1,2-benzenedicarboxylic acid, diisooctyl ester are used in some enteric coated or time-release medication (Dreyfus 2010).

**Table 4.1 Organic contaminants identified in the study area during the dry season**

| Sample description | Organic contaminant | Concentration (mg/kg) |
|---|---|---|
| Dumpsite | 1,2-Benzenedicarboxylic acid, diisooctylester | 0.7916 |
| Outside dump(5m) | Diethyl phthalate | 0.0246 |
| Incinerator ash | Octadecanoic acid, methylester | 0.0371 |
| | Octadecanoic acid | 0.0926 |
| Potatoes | Diethyl phthalate | 0.0214 |
| Cassava | Butylated hydroxytoluene | 0.051 |
| | 1,2-Benzenedicarboxylic acid, diisooctylester | 0.2008 |
| Tomatoes | Butylated hydroxytoluene | 0.5924 |

**Table 4.2 Organic contaminants identified in the study area during the wet season**

| Sample description | Organic contaminant | Concentration (mg/kg) |
|---|---|---|
| Dumpsite | Octadecanoic acid | 0.1270 |
| | n- hexadecanoic acid | 0.0965 |
| | 1,2-benzenedicarboxylic acid, diisooctylester | 0.1191 |
| Outside dump(5m) | Octadecanoic acid | 0.2041 |
| | n- hexadecanoic acid | 0.1391 |
| Incinerator ash | Octadecanoic acid, methylester | 0.1156 |
| | Octadecanoic acid | 0.1726 |
| | 1,2-benzenedicarboxylic acid, diisooctylester | 0.2103 |
| Potatoes | p-xylene | 0.0652 |
| | 1,2-benzenedicarboxylic acid, mono(2-ethylhexyl) ester | 0.7177 |
| Cassava | Ethyl benzene | 0.0523 |
| | o-xylene | 0.1680 |
| Tomatoes | Ethyl benzene | 0.0084 |
| | o-xylene | 0.0460 |
| | p-xylene | 0.0286 |

Recently, it has been suggested that 1,2-benzenedicarboxylic,diisooctyl may contribute to the occurrence of the "testicular dysgenesis syndrome" in humans, that is, testicular germ cell cancer, Cryptorchidism, hypospadia, and low sperm count (Mahood *et al,* 2007). Also the presence of octadecanoic acid, methyl ester and n- hexadecanoic acid, in the environment will lead to serious health damage by consumption of food product grown on such environment (Overton, 1994). Environmental health and safety commission USA report (2000) shows that ingestion of octadecanoic acid in foods causes intestinal obstruction and irritation of gastro – intestinal tract.

Ostehout,(2010) reported that n- hexadecanoic acid consumption in foods when contaminated with other toxic impurities may cause cancer and neurotoxicity. The organic contaminant present in the soil analysed in both season varied except 1,2 – benzenedicarboxylic acid that is common in both seasons. The concentration of 1,2 – benzenedicarboxylic acid, diisooctyl ester in the dry season is higher than that of the wet season. The concentration is 0.7916mg/kg while it is 0.1191mg/kg in the wet season. This may be due to the effect of erosion which may reduce the concentration of this compound in the wet season. The concentration of all the organic contaminant present in the soil analysed is lower than the maximum permissible limit (FAO/WHO, 2001).

### 4.1.2 Ash

The incinerator ash showed the presence of octadecanoic acid methyl ester (0,0371 mg/kg), octadecanoic acid (0.0926 mg/kg) during the dry season. The incinerator ash showed the following organic contaminants in the wet season: octadecanoic acid methyl ester (0.0844mg/kg), octadecanoic acid (0.1726mg/kg), 1,2 – benzenedicarboxylic acid, diisooctyl ester (0.2103mg/kg) and octedecanoic acid methyl ester (0.1156mg/kg).

Report showed that medical devices constitute a special, but significant source of exposure to 1,2- benzenedicarboxylic acid, diisooctyl ester. It is used in blood storage bags, tubing and other devices. It has been reported that 1,2-benzenedicarboxylic acid, diisooctyl ester are used in some enteric coated or time-release medication (Dreyfus 2010). Recently, it has been suggested that 1,2-benzenedicarboxylic acid, diisooctyl-ester may contribute to the occurrence of the "testicular dysgenesis syndrome" in humans, that is, testicular germ cell cancer, Cryptorchidism, hypospadia, and low sperm count (Mahood *et al*, 2007). The organic contaminant present in the ash analysed in both seasons is almost the same, although the organic contaminant in the dry season is lower in concentration than that of the wet season.

### 4.1.3 Food crops

Potatoes showed the presence of p – xylene (0.0652mg/kg) and 1,2 – benzenedicaboxilic acid, mono(2-ethyl hexyl) ester (0.7177mg/kg) in the wet season while potatoes show the presence of diethyl phthalate (0.0214mg/kg) in the dry season. Report showed that personal care product such as lotions, perfumes and nail polish may contain lower molecular weight phthalate. Many product with fragrances, such as scented candles and room fresheners also contain lower molecular weight phthalates. Diethyl phthalates are a family of high production volume chemicals that are used as plasticizers and solvents in a variety consumer products, cosmetics and medical devices. Although diethyl phthalate are not acutely toxic, chronic exposure result in a number of adverse effects in animal studies (Dreyfus 2010). Chronic organ toxicity including histopathological effects in liver and kidney is the most common effect of diethyl phthalate (Osterhout 2010).

The organic contaminant 1,2–benzenedicarboxylic acid, mono (2 – ethyl hexyl) ester has the highest concentration of 0.7177mg/kg which is more than the average daily intake of 0.058mg/kg (David *et al*, 2000a, ECB, 2008).

Cassava showed the presence of ethylbenzene (0.0523mg/kg), o-xylene (0.1680mg/kg) in the wet season. While C2 (cassava) in the dry season showed the presence of butylated hydroxtoluene (0.051mg/kg) and 1,2 – benzene dicarboxylic, diisooctyl ester (0.2008mg/kg). Studies showed that butylated hydroxytoluene is a lipophilic (fat soluble) organic compound that is primarily used as an antioxidant food additives, as well as an antioxidant additives in cosmetics, pharmaceuticals and embalming fluid (Benjamin 1986). Reporst claim that butylated hydroxytoluene could produce hyperactivity in some children. It is also linked to cause cancer when consumed in foods (ASTDR 1995). Ethyl benzene and o-xylene are alkyl benzene and poly-aromatic hydrocarbons (PAHs) which are components of crude oil or petroleum producst used in the hospital. They are considered as wide spread environmental pollutant (Mackay 1988, Wand and Fingas 1995). People's exposure to ethyl benzene at high level above 0.054mg/kg in the air for short period have complained of eye and throat irritation, also it causes decrease in movement and dizziness.

Tomatoes showed the presence of ethyl benzene (0.0084mg/kg), o-xylene (0.0460mg/kg) and p-xylene (0.0286mg/kg) in the wet season while sample tomatoes indicated the presence of butylated hydroxtoluene (0.5924mg/kg) in the dry season. The presence of ethyl benzene, p-xylene and o-xylene is prominent in the tomatoes analyzed in the wet season. Report showed that xylene is used in histology for cleaning the tissue following dehydration in preparation for paraffin wax infiltration. It is also used in the laboratory to make bath with dry ice to cool reaction vessels to low temperature when required. Exposure of people to high levels of xylene above 0.1680mg/kg for short periods can cause irritation of the skin, eyes,

nose and throat, difficulty in breathing and other related problems with the lung (Clark et al., 2010). Environmental protection agency (EPA) has 0.7mg/kg concentration of ethyl benzene for a year as the acceptable level of exposure in drinking water for an average body weight adult (ATSDR, 1999). All the organic contaminants analyzed in tomatoes sample are less than the average permissible level. Tomatoes and cassava showed low concentration for all the organic contaminants analysed in the wet season while potatoes showed high concentration of organic contaminant in the dry season. 1,2-benzenedicarboxylic acid, mono(2-ethyl hexyl) ester in the wet season potatoes has very high concentration of 0.7177mg/kg closely followed by buthylated hydroxytoluene in the dry season tomatoes(0.5924mg/kg).

The entire sample collected for this analysis showed low concentration below the international accepted levels with exception of potatoes (0.7177mg/kg) collected in the wet season which is higher than the international accepted average daily intake of 0.058mg/kg. Continuous exposure or consumption of foods that contain this organic contaminant will eventually cause health problem.

### 4.2.0 Heavy metals

Ducan one way analysis of variance (ANOVA) was used to conduct a test of significance at $p<0.05$ i.e. 95% confidence limit between pairs of data i.e. wet season and dry season also student t-test was used to test for significance. The statistical result is as shown below:

### 4.2.1 Soil

Lead has mean concentration (Table 4.3) of 0.323mg/kg during the wet season and 0.344mg/kg for the dry season on the dump soil at (0-5cm) depth. The concentration of lead at another depth (5-10cm) at the same point of soil collection is 0.305mg/kg for wet season and 0.256mg/kg for the dry season see table 4.3. Although statistics shows that there is no significant difference in the mean concentration of the metals in the two seasons. Fig 4.1 and 4.2 show the metals concentration in the soil at the dump. The concentration of lead outside the dump (5m away) at (0-5cm) depth is 0.255mg/kg for the wet and 0.260mg/g for the dry season, while at another dept (5-10cm) (Table 4.4) the concentration of lead is 0.171mg/kg for wet and 0.172mg/kg for dry season. This implies that the concentration of lead decreases as the point of sample collection get deeper into the soil, it also decreased with increased distance from the main dumpsite.

Of all the metals analysed iron has the highest mean concentration of 0.807mg/kg for both the dry and wet seasons. Student t-test showed that there is no significant difference in the concentration of manganese, cadmium, and chromium in the two seasons. Nickel showed the lowest mean concentration of 0.040mg/kg for wet and 0.038mg/kg for dry season.

Fig. 4.3 and 4.4 shows the metal concentration in the soil outside the dump (10m away).

**Table 4.3: Concentration (mg/kg) of heavy metals on the dump soil for the wet and dry seasons at 0-5cm and 5-10cm depth**

| Metal | Wet(0-5cm) | Dry(0-5cm) | Wet(5-10cm) | Dry(5-10cm) |
|---|---|---|---|---|
| Pb | $0.323\pm0.038^{a}$ | $0.344\pm0.005^{a}$ | $0.305\pm0.053^{a}$ | $0.256\pm0.002^{a}$ |
| Fe | $0.807\pm0.002^{a}$ | $0.807\pm0.001^{a}$ | $0.764\pm0.003^{a}$ | $0.765\pm0.001^{a}$ |
| Mn | $0.134\pm0.002^{a}$ | $0.134\pm0.004^{a}$ | $0.091\pm0.001^{a}$ | $0.092\pm0.002^{a}$ |
| Cd | $0.045\pm0.002^{a}$ | $0.044\pm0.002^{a}$ | $0.027\pm0.001^{a}$ | $0.027\pm0.001^{a}$ |
| Cr | $0.076\pm0.001^{a}$ | $0.076\pm0.001^{a}$ | $0.019\pm0.001^{a}$ | $0.019\pm0.001^{a}$ |
| Ni | $0.040\pm0.004^{a}$ | $0.038\pm0.001^{a}$ | $0.015\pm0.006^{a}$ | $0.013\pm0.001^{a}$ |
| Co | $0.067\pm0.001^{a}$ | $0.061\pm0.001^{a}$ | $0.033\pm0.001^{a}$ | $0.032\pm0.002^{a}$ |

Values with different superscript across the row for wet and dry season pairs are significantly different ($p< 0.05$).

Values are mean± SD.

Mean sample size=3.14

**Table 4.4: Concentration (mg/kg) of heavy metals outside the dump soil (5m) for the wet and dry seasons at 0-5cm and 5-10cm depth**

| Metal/season | Wet(0-5cm) | Dry(0-5cm) | Wet(5-10cm) | Dry(5-10cm) |
|---|---|---|---|---|
| Pb | $0.255\pm0.001^{a}$ | $0.260\pm0.006^{a}$ | $0.171\pm0.001^{a}$ | $0.172\pm0.002^{a}$ |
| Fe | $0.721\pm0.011^{a}$ | $0.716\pm0.136^{a}$ | $0.681\pm0.001^{a}$ | $0.683\pm0.002^{a}$ |
| Mn | $0.097\pm0.001^{a}$ | $0.090\pm0.012^{a}$ | $0.073\pm0.001^{a}$ | $0.066\pm0.002^{a}$ |
| Cd | $0.026\pm0.002^{a}$ | $0.026\pm0.000^{a}$ | $0.027\pm0.001^{a}$ | $0.028\pm0.002^{a}$ |
| Cr | $0.035\pm0.001^{a}$ | $0.036\pm0.002^{a}$ | $0.026\pm0.011^{a}$ | $0.026\pm0.011^{a}$ |
| Ni | $0.025\pm0.001^{a}$ | $0.023\pm0.001^{a}$ | $0.018\pm0.001^{a}$ | $0.018\pm0.002^{a}$ |
| Co | $0.045\pm0.001^{a}$ | $0.043\pm0.001^{a}$ | $0.027\pm0.001^{a}$ | $0.025\pm0.001^{a}$ |

Values with different superscript across the row for wet and dry season pairs are significantly different ($p< 0.05$).

Values are mean± SD.

Mean sample size=3.14

**Table 4.5: Concentration (mg/kg) of heavy metals outside the dump soil (10m) for the wet and dry seasons at 0-5cm and 5-10cm depth**

| Metal/season | Wet(0-5cm) | Dry(0-5cm) | Wet(5-10cm) | Dry(5-10cm) |
|---|---|---|---|---|
| Pb | 0.252±0.001[a] | 0.255±0.006[a] | 0.171±0.001[a] | 0.170±0.002[a] |
| Fe | 0.710±0.011[a] | 0.712±0.136[a] | 0.678±0.001[a] | 0.680±0.002[a] |
| Mn | 0.094±0.001[a] | 0.090±0.012[a] | 0.070±0.001[a] | 0.065±0.002[a] |
| Cd | 0.024±0.002[a] | 0.025±0.000[a] | 0.025±0.001[a] | 0.026±0.002[a] |
| Cr | 0.033±0.001[a] | 0.033±0.002[a] | 0.024±0.011[a] | 0.022±0.011[a] |
| Ni | 0.025±0.001[a] | 0.023±0.001[a] | 0.018±0.001[a] | 0.016±0.002[a] |
| Co | 0.042±0.001[a] | 0.040±0.001[a] | 0.027±0.001[a] | 0.020±0.001[a] |

Values with different superscript across the row for wet and dry season pairs are significantly different ($p < 0.05$).

Values are mean± SD.

Mean sample size=3.14

Iron has the highest mean concentration of 0.721mg/kg and 0.716mg/kg for both wet and dry season respectively among all the metals analysed at 0-5cm depth while at depth 5-10cm the concentration of iron is 0.681 and 0.683mg/kg for both wet and dry seasons respectively. The implication from this result is that the concentration of almost all the metals analysed decreased as the depth and distance of sample collection increased. Nickel also has the lowest concentration of 0.018mg/kg for both seasons. Student t- test for the result recorded shows that there is no significant difference in the concentration of lead in both seasons.

Heavy metals exact a broad range of toxic effects on humans, terrestrial and aquatic life and plants. A number of these metals also have the potential to bio-accumulate, including cadmium, chromium, lead, mercury and zinc (USPHS 1997, Kimbrough *et al.,* 1999, MINDEC 1995). In addition, certain forms of cadmium and chromium have carcinogenic properties (USPHS 1998). From result of these metals in Table 4.3, 4.4 and 4.5 shows that seasonal variations do not significantly affect the concentration of the heavy metals.

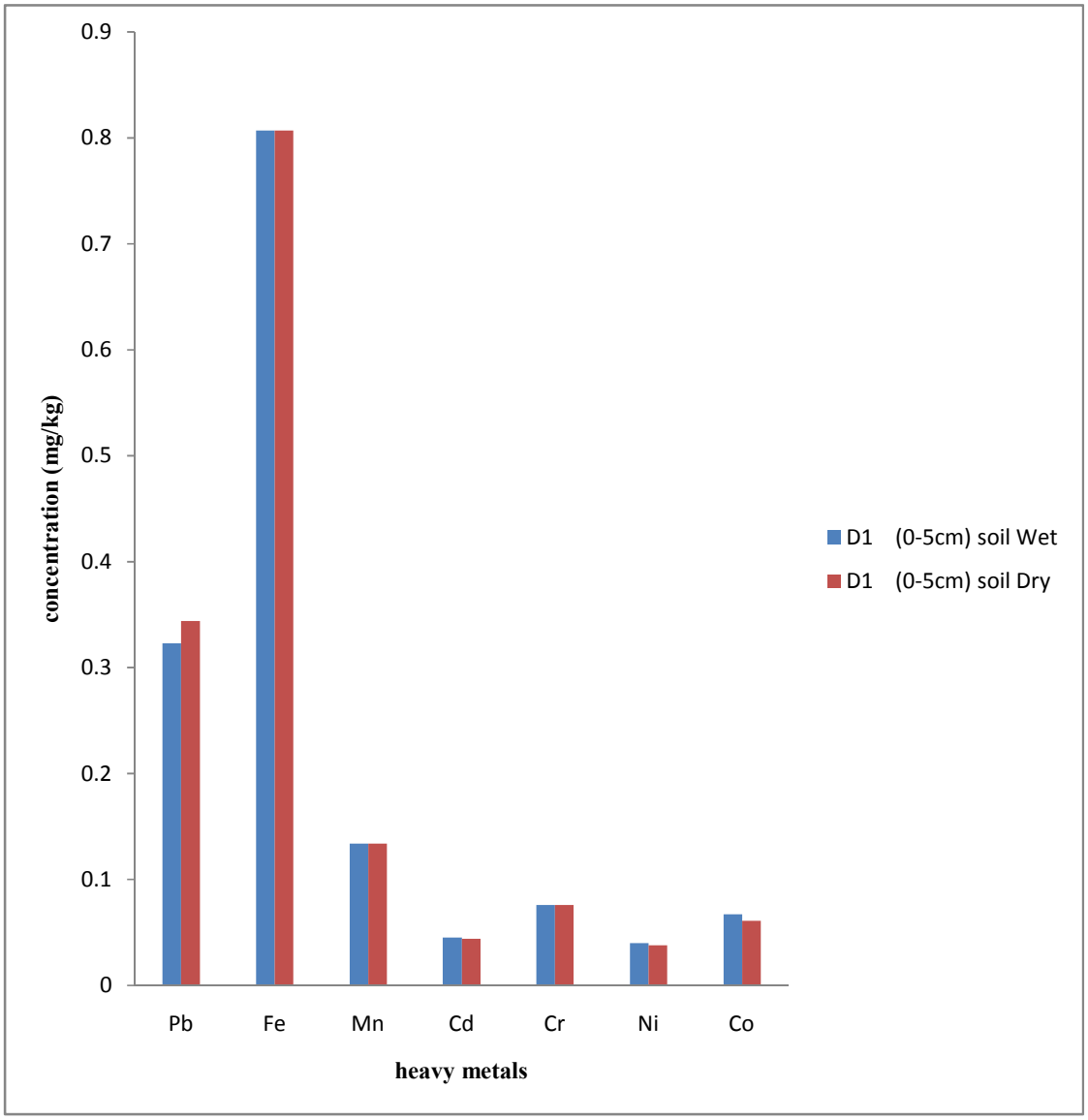



**Fig 4.1 Concentration (mg/kg) of heavy metals on the dump soil for the wet and dry seasons**

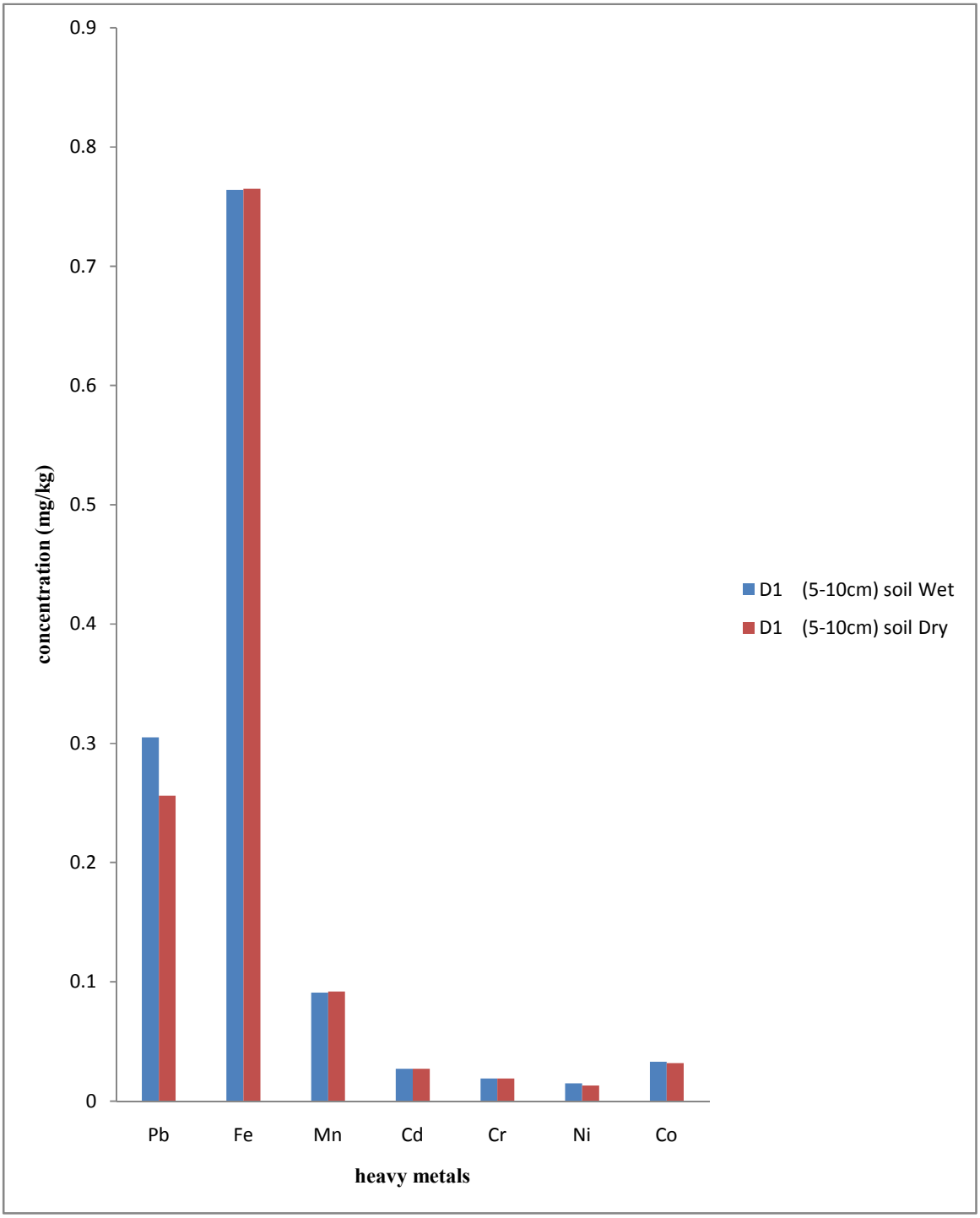



**Fig 4.2 Concentration (mg/kg) of heavy metals on the dump soil (5-10cm) depth for the wet and dry seasons**

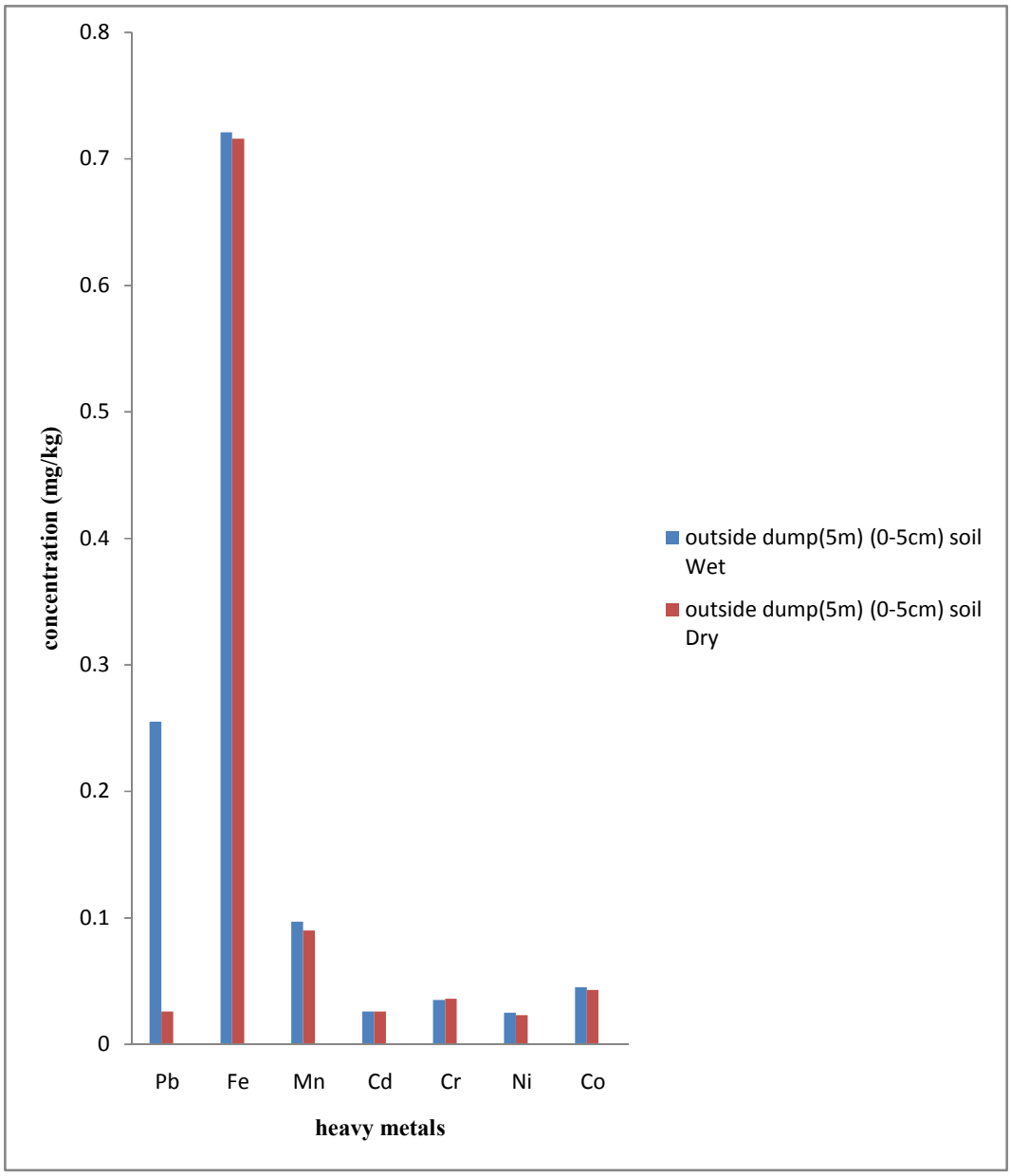



**Fig 4.3 Concentration (mg/kg) of heavy metals outside the dump (5m away) for the wet and dry seasons**

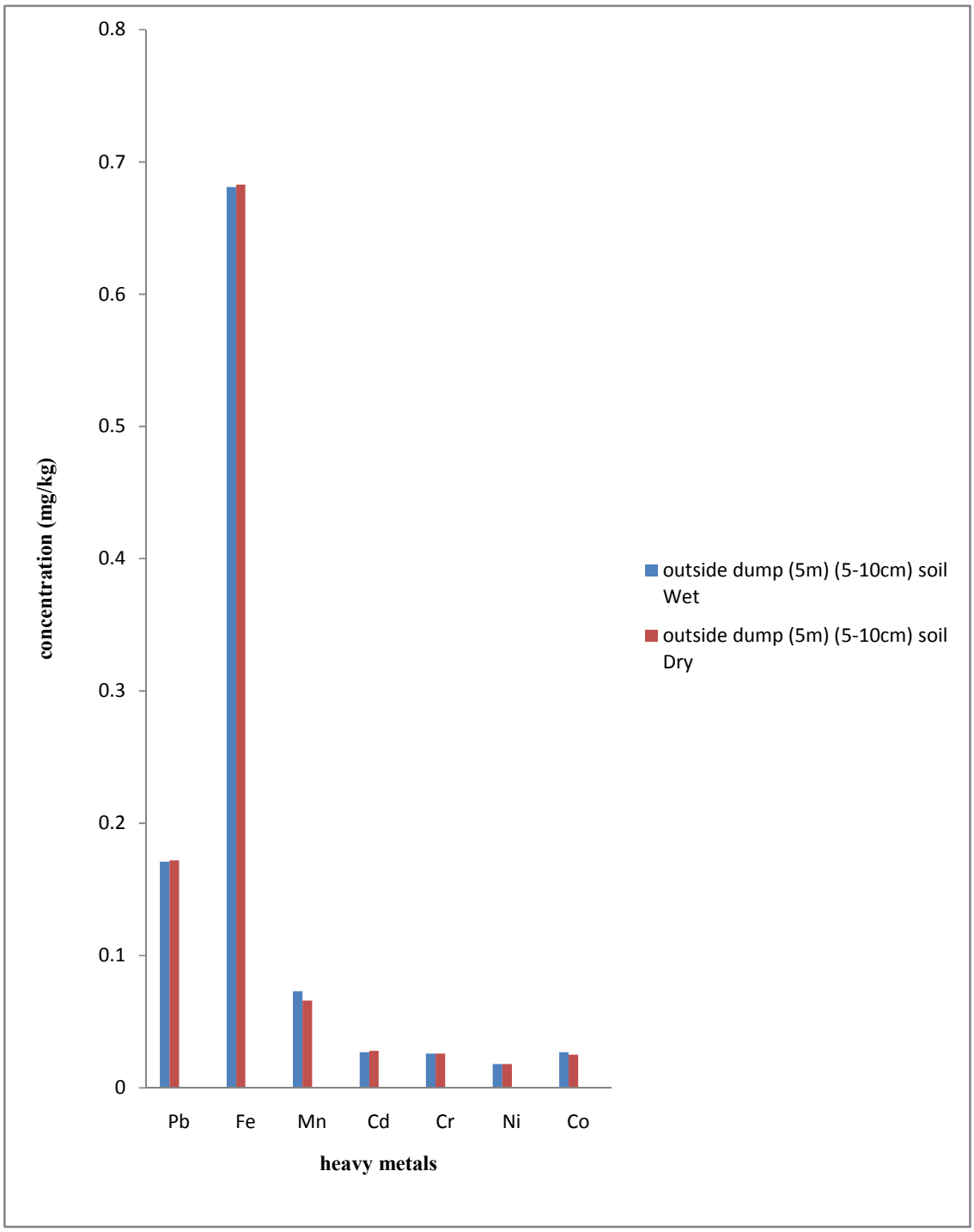



**Fig 4.4 Concentration (mg/kg) of heavy metals outside the dump (5m away) at 5-10cm depth for the wet and dry seasons**

### 4.2.2 Incinerator Ash

Lead had the highest mean concentration of 0.384mg/kg of all the metals analysed (fig.4.5). Both seasons showed high concentration of lead closely followed by iron with concentration of 0.284mg/kg. Chromium showed lowest mean concentration of 0.002mg/kg during the dry season to 0.005mg/kg for wet season. The concentration of manganese is 0.115mg/kg (wet season) and 0.116mg/kg for the dry season, while the concentration of cadmium 0.036mg/kg in the wet season is not significantly different from the concentration during the dry season 0.039mg/kg. The concentration of nickel was almost the same during both seasons. The concentration of cobalt ranged from 0.043mg/kg in the wet season to 0.044mg/kg for the dry season. This result is in line with the report of Dempsey and Oppelt, 1993 that heavy metals are not destroyed by incineration but is simply concentrated in the remaining ashes, or released to the environment via stack emission. The concentrations of heavy metals in the ashes are dependent on the amounts of these metals in the wastes being incinerated. Heavy metals can remain in their original form during incineration or may react to form new compounds such as metal oxides, chlorides or fluorides (Dempsey and Oppelt 1993). Student t-test for the result showed that there is no significant difference in the concentration of all the metals analysed for both the wet and dry season

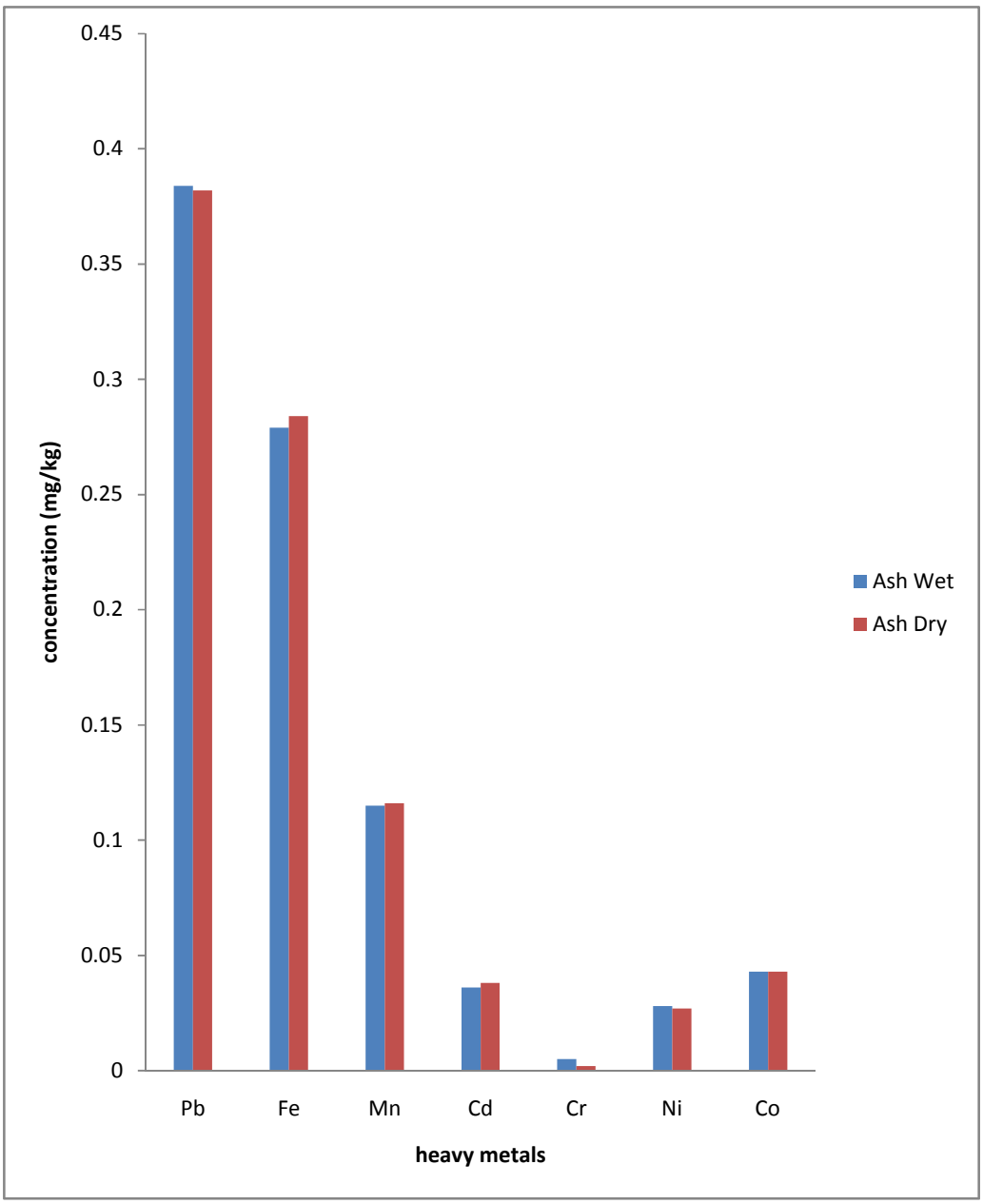



**Fig 4.5 Metal concentration in the incinerator ash**

### 4.2.3 Metal concentration in the food crops analysed

Tomatoes had the highest iron mean concentration of 0.467mg/kg among all the fruit analyzed. This is closely followed by lead which has concentration of 0.181mg/kg in tomatoes. Also the concentration of manganese (0.064mg/kg), cadmium (0.081mg/kg), chromium (0.055mg/kg), nickel (0.033mg/kg) and cobalt (0.046mg/kg) in tomatoes are higher than all other metals in vegetables analyzed for heavy metals.

Guava has the lowest mean concentration of cobalt (0.009mg/kg) and (0.016mg/kg) for both wet and dry seasons respectively.

Banana had iron concentration of 0.355mg/kg for both seasons which is significantly higher than all the other food crops analysed for heavy metals.

Mango had lead concentration of 0.082mg/kg for wet season and 0.086mg/kg for dry season. Cobalt showed the lowest concentration of 0.020mg/kg and 0.021mg/kg for wet and dry season respectively among all the heavy metals analysed in the mango fruit.

The mean concentration and seasonal level of lead in all the sources/fruit analyzed are below WHO and USEPA recommended maximum permissible level. Heavy metals exact a broad range toxic effects on humans, terrestrial and aquatic life and plants. A number of these metals also have the potential to bio-accumulate, including cadmium, chromium, lead, mercury and zinc (USPHS 1997, Kimbrough *et al*., 1999, MINDEC 1995). In addition, certain forms of cadmium and chromium have carcinogenic properties (USPHS 1998).

Even though the concentration of all the heavy metals analyzed fall below the critical permissible concentration level, consumption of such fruit will accumulate over time and consequently cause harm to human health.

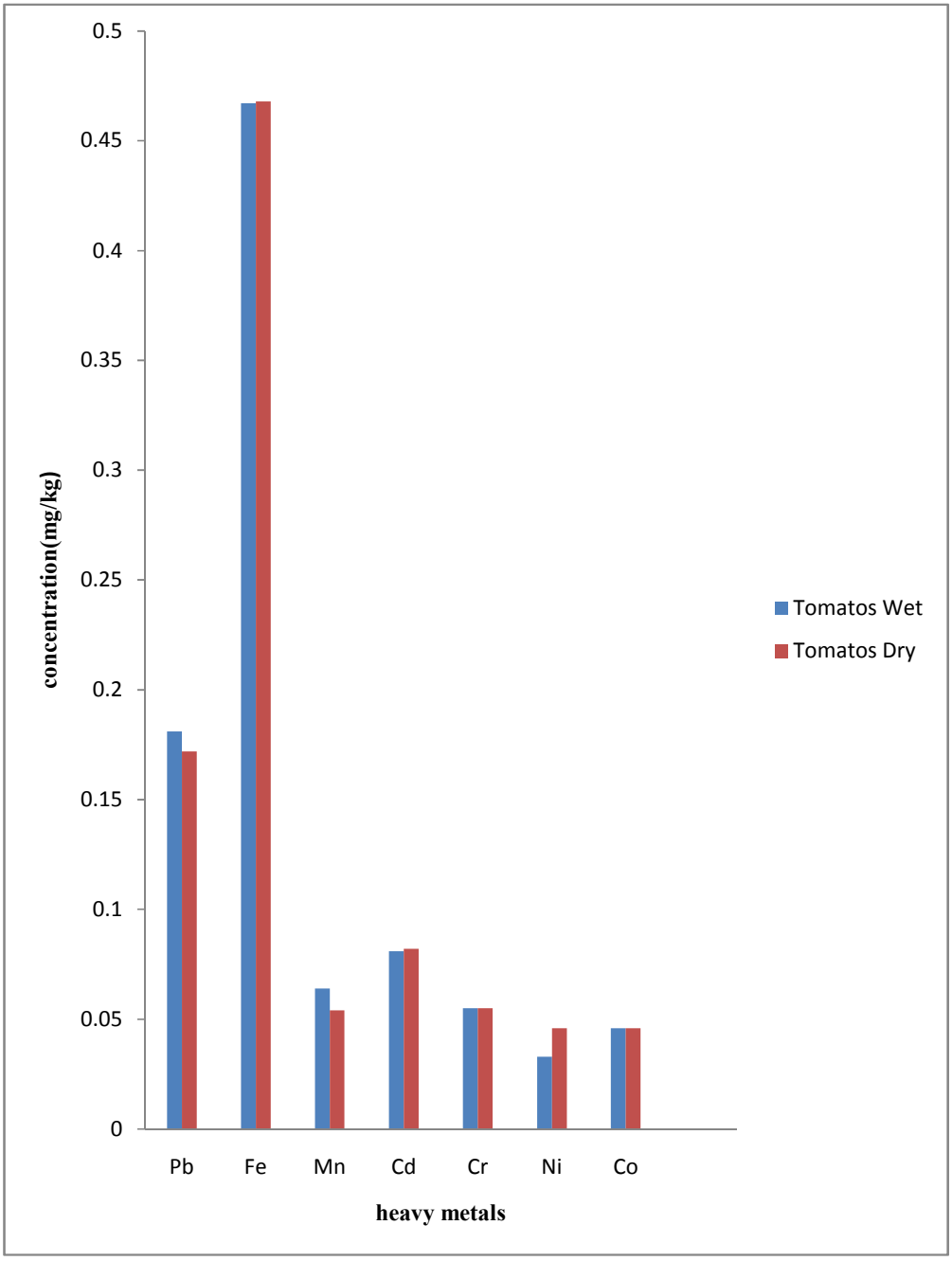



**Figure 4.6 Concentration (mg/kg) of heavy metals for the wet and dry seasons in tomatoes**

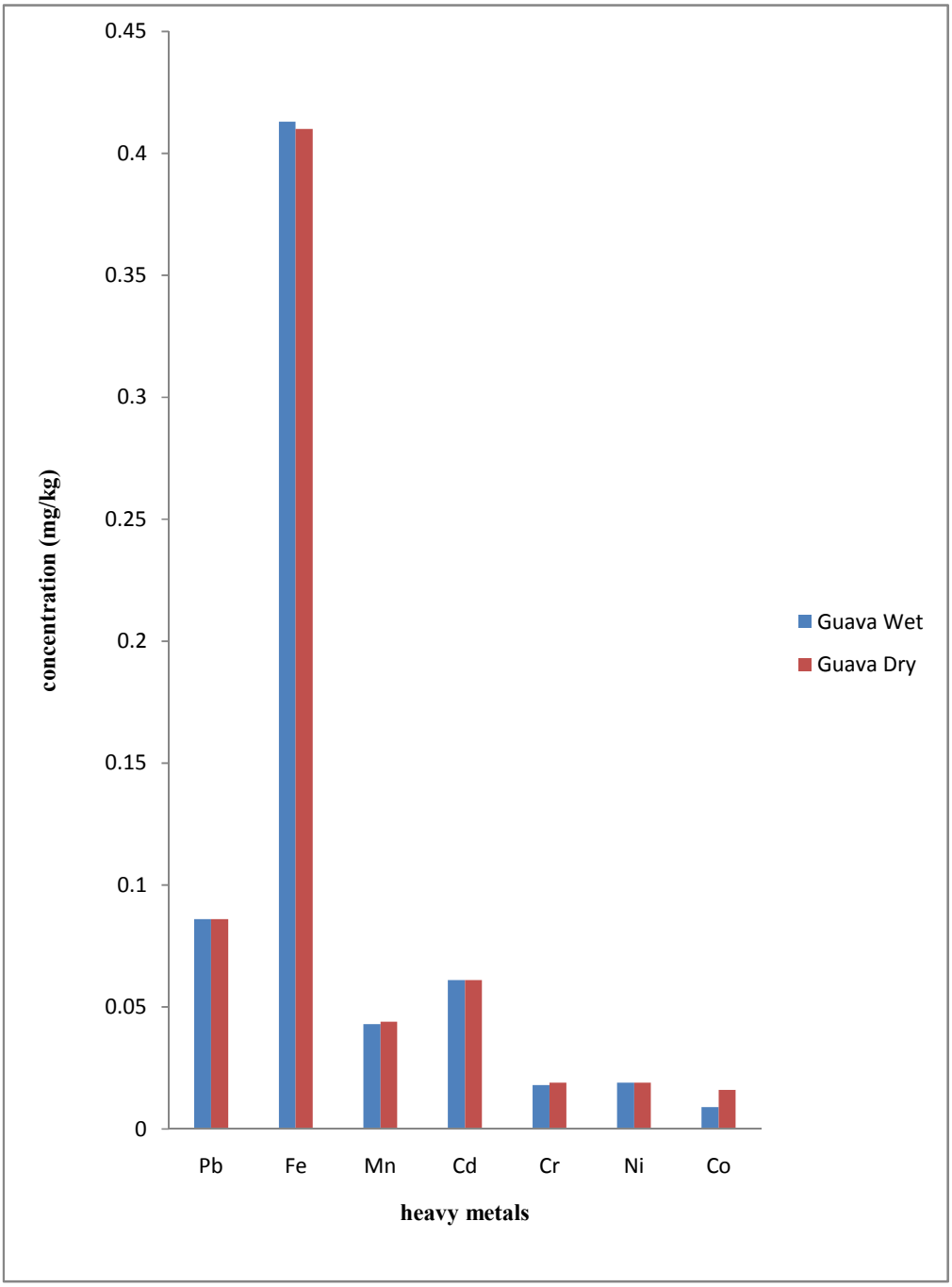



**Fig 4.7 Concentration (mg/kg) of heavy metals for the wet and dry season's guava**

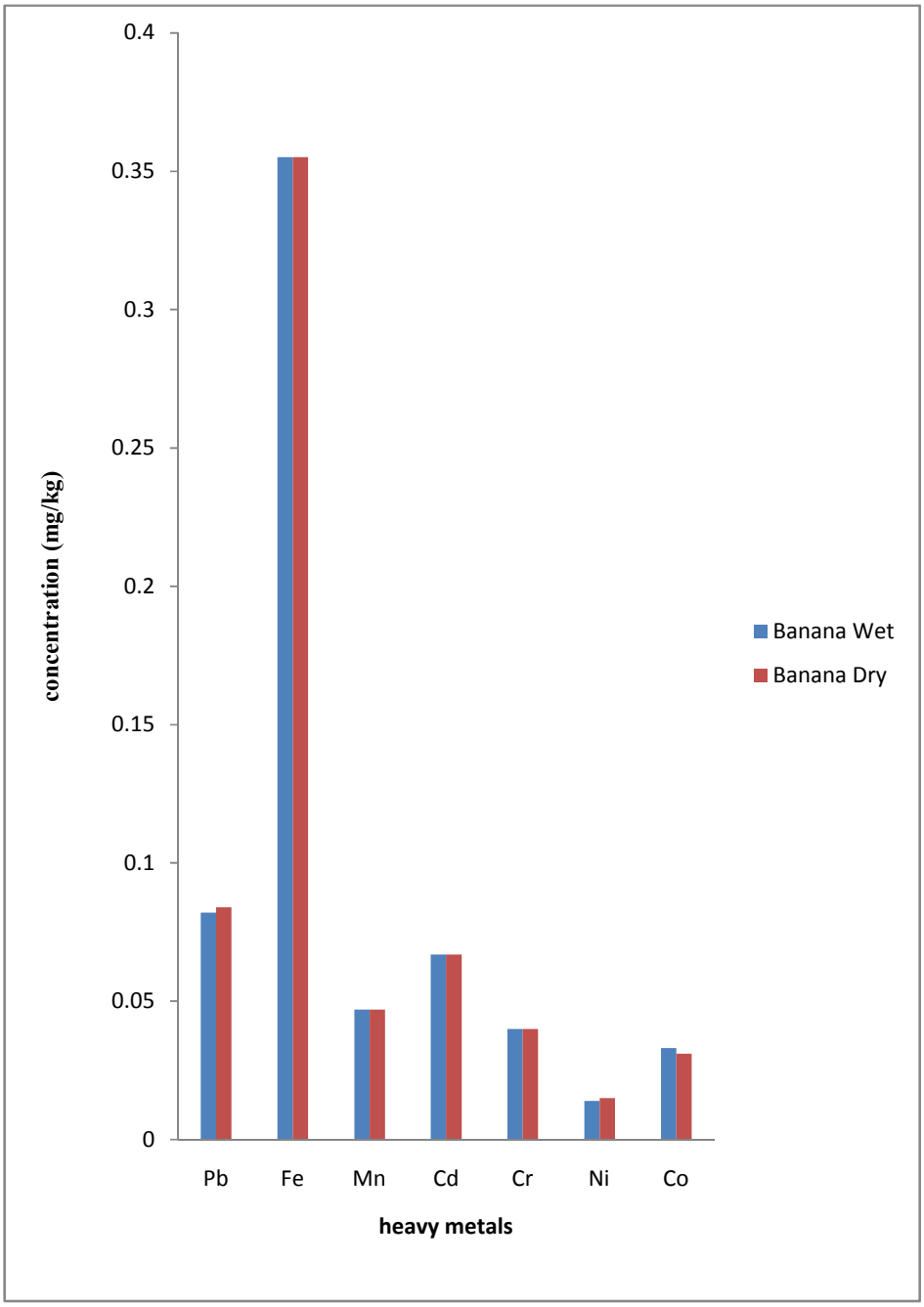



**Fig 4.8 Concentration (mg/kg) of heavy metals for the wet and dry seasons in banana**

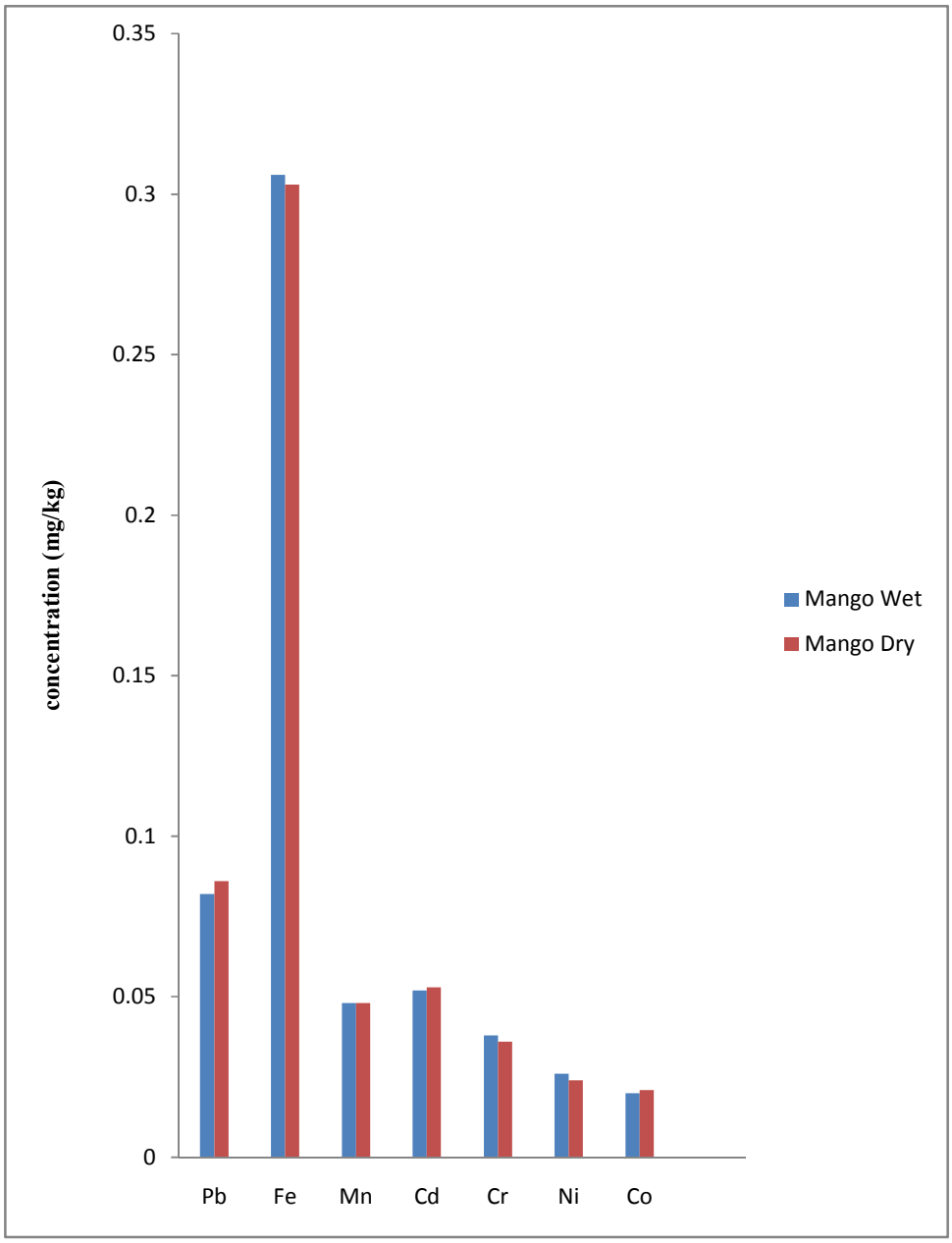



**Fig4.9 Concentration (mg/kg) of heavy metals for the wet and dry seasons in mango**

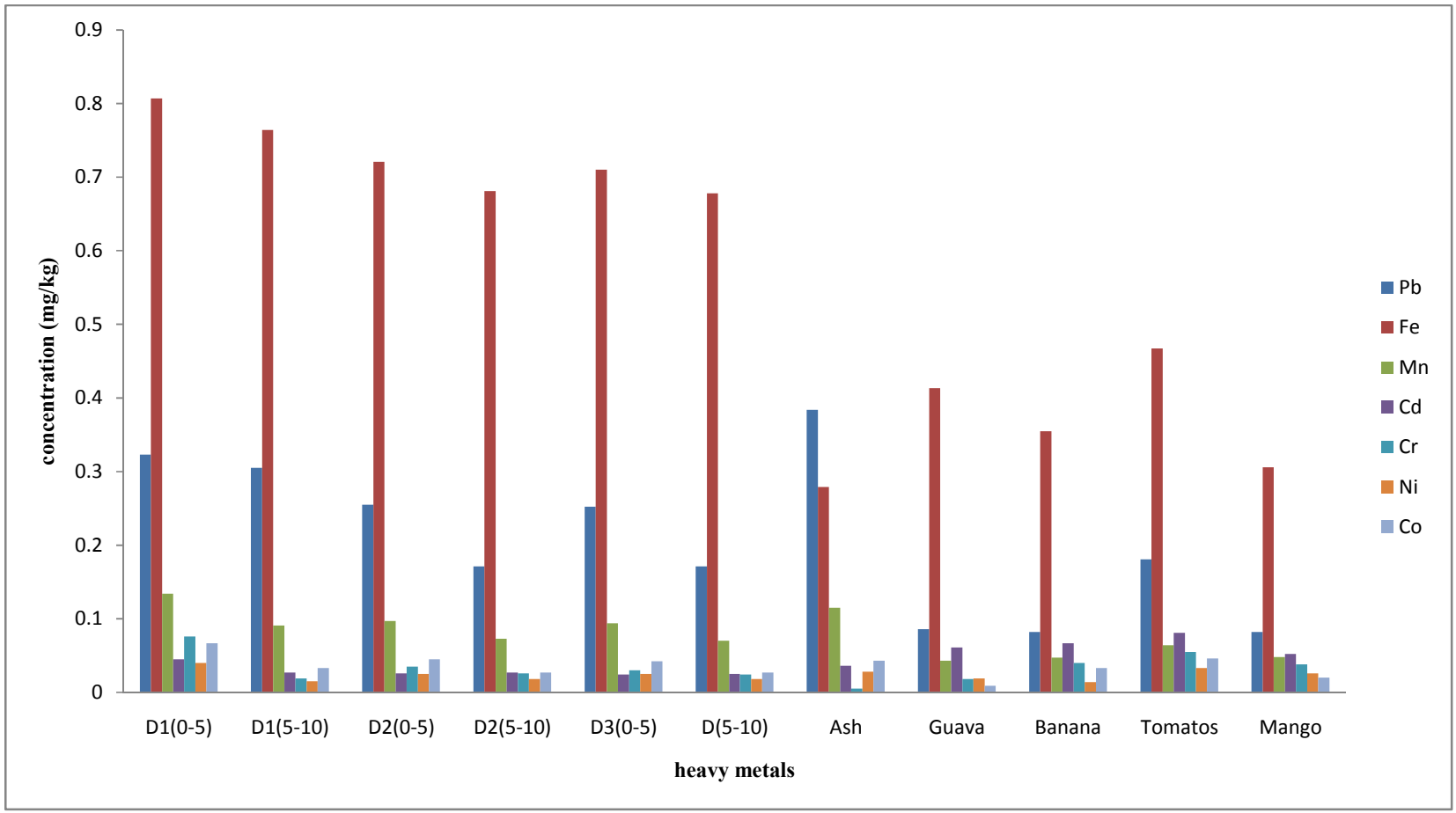



**Fig. 4.10 Metal concentration of the dump soil, incinerator ash and food crop analyzed for wet season**

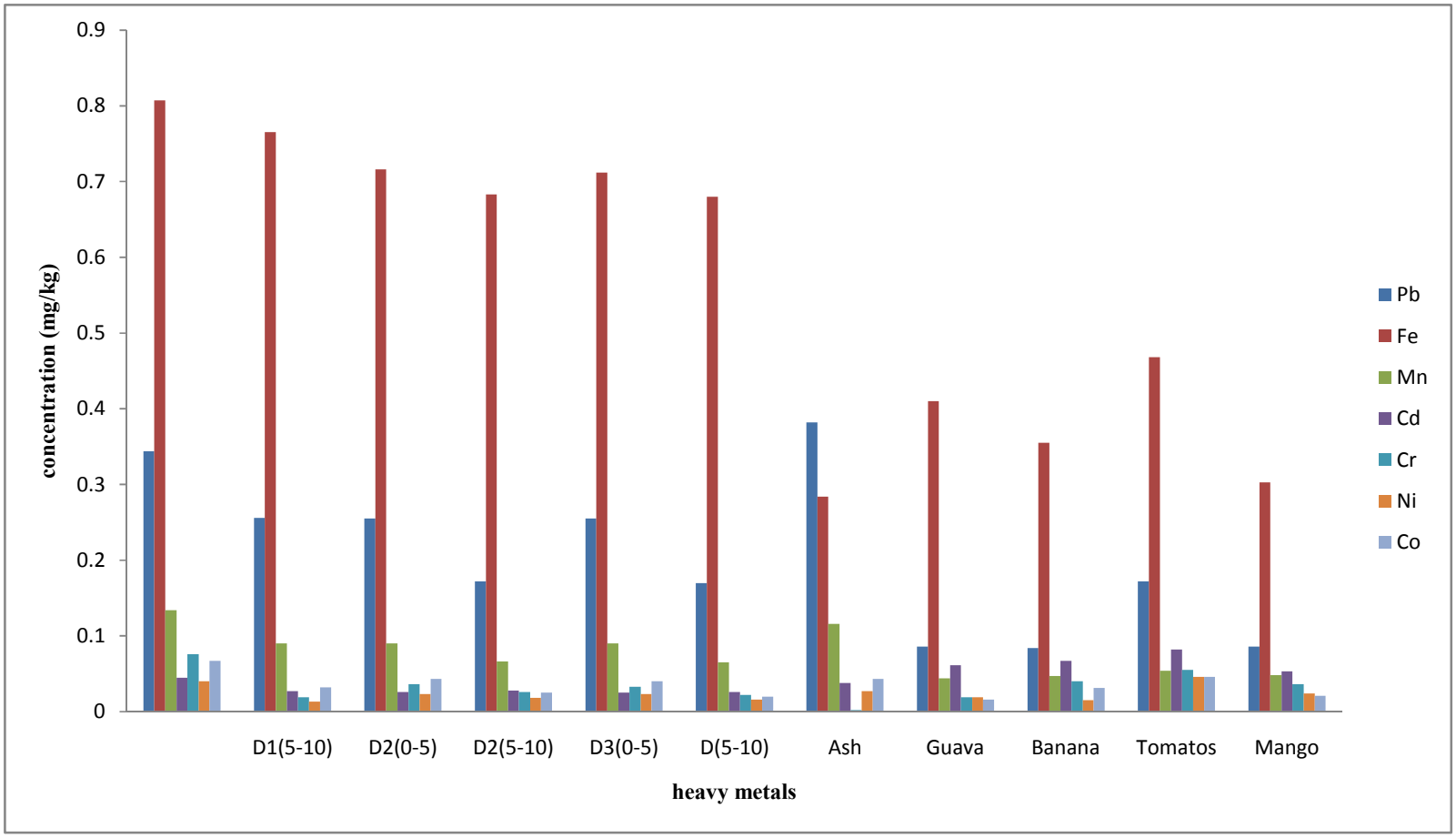



**Fig.4.11 Metal concentration of the dump soil, incinerator ash and food crop analyzed for dry season**

### 4.2.6 Physicochemical parameters of the farmland soil

| | Min | Max | Mean |
|---|---|---|---|
| pH | 4.40 | 6.90 | 5.65 |
| %Organic carbon | 0.25 | 0.29 | 0.27 |
| % silt | 10 | 12 | 11 |
| % sand | 28 | 36 | 32 |
| % clay | 6 | 8 | 7 |

Texture class: sand-loam

Generally, all samples from the study site were dominated by high average % sand fraction followed by % silt and finally % clay as shown in the table 4.14 Soil pH is 5.65 indicative of slightly acidic environment. % Organic carbon was generally low in the study site.

# CHAPTER FIVE

# SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATION

## 5.1 Summary of findings

Contamination level of a hospital waste dumpsite environment and vegetation were investigated for organic contaminants and toxic heavy metals concentration during the wet and dry season. The results exhibited a range of concentrations between the wet and the dry season. The result indicated that numerous organic contaminant are present in the hospital waste dumpsite and consequently in the vegetation within the vicinity of the dumpsite.

The result of t-test and ducal ANOVA test at $p<0.05$ i.e. at 95% confidence limit indicates no significant difference in the two study seasons except for iron.

The metal analysis showed the same order of relative abundance as Fe>Pb>Mn>Cr>Cd>Co>Ni for wet season and dry seasons.

The results also showed hospital waste as a major source of the metals pollution in the environment.

## 5.2 CONCLUSION

In general, the following organic contaminants was observed in the study area : butylated hydroxytoluene, 1,2-benzenedicarboxylic acid, methylester, 1,2-benzenedicarboxylic acid, mono (2ethylhexyl) ester, ethylbenzene, o-xylene and diethylphthalate

Higher levels of iron metals were observed for the soil samples and food crops in the vegetation located within the vicinity of the hospital waste dumpsite, which as mentioned before, can be explained due to the soil's natural composition.

All values were within the accepted levels by the concerning regulatory agencies.

## 5.3 RECOMENDATION.

The analysis of the samples from the hospital incinerator shows the levels of pollutants in ashes formed as a result of the incineration of waste at this facility. In addition to these ash outputs, a range of pollutants will also be released to air via the incinerator chimneys. It is highly likely that these will include particulates, heavy metals and organic compounds including PAHs, further research should be carried out in this direction.

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## APPENDIX 1

**Concentration (mg/kg) of heavy metals for wet and dry seasons in the incinerator ash**

| Season | Pb | Fe | Mn | Cd | Cr | Ni | Co |
|---|---|---|---|---|---|---|---|
| wet | 0.384±0.066[a] | 0.279±0.047[a] | 0.115±0.236[a] | 0.036±0.010[a] | 0.005±0.001[a] | 0.028±0.003[a] | 0.043±0.008[a] |
| dry | 0.382±0.070[a] | 0.284±0.048[a] | 0.116±0.023[a] | 0.038±0.009[a] | 0.002±0.001[b] | 0.027±0.004[a] | 0.044±0.009[a] |

Values with different superscripts down the column are significantly different ($p < 0.05$).

Values are mean± SD.

Mean sample size=3.14

## APPENDIX 2

**Concentration (mg/kg) of heavy metals for wet and dry season in guava in the farmland.**

| Season | Pb | Fe | Mn | Cd | Cr | Ni | Co |
|---|---|---|---|---|---|---|---|
| wet | 0.086±0.001[a] | 0.413±0.003[a] | 0.043±0.001[a] | 0.061±0.001[a] | 0.018±0.002[a] | 0.019±0.001[a] | 0.009±0.001[a] |
| dry | 0.086±0.002[a] | 0.410±0.005[a] | 0.044±0.001[a] | 0.061±0.001[a] | 0.019±0.001[a] | 0.019±0.002[a] | 0.016±0.015[a] |

Values with different superscripts down the column are significantly different ($p < 0.05$). Values are mean ±SD.

Mean sample size =3.14

## APPENDIX 3

**Concentration (mg/kg) of heavy metals for wet and dry seasons in banana in the farmland**.

| Season | Pb | Fe | Mn | Cd | Cr | Ni | Co |
|---|---|---|---|---|---|---|---|
| wet | 0.082±0.003[a] | 0.355±0.012[a] | 0.047±0.001[a] | 0.067±0.001[a] | 0.040±0.002[a] | 0.014±0.000[a] | 0.033±0.001[a] |
| dry | 0.084±0.002[a] | 0.355±0.013[a] | 0.047±0.001[a] | 0.067±0.001[a] | 0.040±0.001[a] | 0.015±0.002[a] | 0.032±0.001[a] |

Values with different superscripts down the column are significantly different ($p < 0.05$).
Values are mean ±SD.

Mean sample size =3.14

## APPENDIX 4

**Concentration (mg/kg) of heavy metals for the wet and dry seasons in mango**

| Season | Pb | Fe | Mn | Cd | Cr | Ni | Co |
|---|---|---|---|---|---|---|---|
| wet | 0.082±0.005[a] | 0.306±0.009[a] | 0.048±0.000[a] | 0.052±0.002[a] | 0.038±0.000[a] | 0.026±0.000[a] | 0.020±0.002[a] |
| dry | 0.086±0.001[a] | 0.303±0.008[a] | 0.048±0.000[a] | 0.053±0.001[a] | 0.036±0.002[a] | 0.024±0.000[a] | 0.021±0.006[a] |

Values with different superscripts down each column are significantly different ($p < 0.05$).
Values are mean ±SD.

Mean sample size = 3.14

## APPENDIX 5

**Concentration (mg/kg) of heavy metals for wet and dry season in tomatoes in the farmland**.

| Season | Pb | Fe | Mn | Cd | Cr | Ni | Co |
|---|---|---|---|---|---|---|---|
| wet | 0.181±0.016[a] | 0.467±0.043[a] | 0.064±0.002[a] | 0.081±0.001[a] | 0.055±0.001[a] | 0.033±0.022[a] | 0.046±0.002[a] |
| dry | 0.172±0.002[a] | 0.468±0.043[a] | 0.054±0.002[a] | 0.082±0.002[a] | 0.055±0.001[a] | 0.046±0.002[a] | 0.046±0.005[a] |

Values with different superscripts down the column are significantly different ($p < 0.05$).
Values are mean ±SD.

Mean sample size =3.14

## APPENDIX 6

**Table 4.11: Concentration (mg/kg) of heavy metals for the various sources/food crops analysed for wet season.**

| Source/metal | Pb | Fe | Mn | Cd | Cr | Ni | Co |
|---|---|---|---|---|---|---|---|
| Dump(0-5CM) | $0.323\pm0.038^{e}$ | $0.807\pm0.002^{f}$ | $0.134\pm0.002^{e}$ | $0.045\pm0.002^{b}$ | $0.076\pm0.001^{f}$ | $0.040\pm0.001^{d}$ | $0.067\pm0.001^{g}$ |
| Dump(5-10CM) | $0.305\pm0.053^{e}$ | $0.764\pm0.003^{f}$ | $0.094\pm0.001^{c}$ | $0.027\pm0.001^{a}$ | $0.0190\pm0.001^{b}$ | $0.015\pm0.006^{abc}$ | $0.033\pm0.001^{d}$ |
| Outside dump(5m)(0-5CM) | $0.255\pm0.001^{e}$ | $0.721\pm0.011^{g}$ | $0.097\pm0.001^{c}$ | $0.026\pm0.002^{a}$ | $0.035\pm0.000^{d}$ | $0.025\pm0.001^{abcd}$ | $0.045\pm0.002^{f}$ |
| Outside dump(5m)(5-10CM) | $0.171\pm0.011^{d}$ | $0.681\pm0.001^{g}$ | $0.073\pm0.001^{cd}$ | $0.027\pm0.002^{a}$ | $0.026\pm0.001^{b}$ | $0.018\pm0.001^{a}$ | $0.027\pm0.001^{cd}$ |
| Outside dump(10m)(0-5cm) | $0.252\pm0.001^{a}$ | $0.710\pm0.001^{a}$ | $0.094\pm0.001^{a}$ | $0.024\pm0.002^{a}$ | $0.033\pm0.001^{a}$ | $0.025\pm0.001^{a}$ | $0.042\pm0.001^{a}$ |
| Outside dump(10m)(5-10cm) | $0.171\pm0.001^{a}$ | $0.678\pm0.001^{a}$ | $0.070\pm0.001^{a}$ | $0.025\pm0.001^{a}$ | $0.024\pm0.011^{a}$ | $0.018\pm0.001^{a}$ | $0.027\pm0.001^{a}$ |
| Ash | $0.384\pm0.066^{c}$ | $0.279\pm0.046^{d}$ | $0.115\pm0.021^{d}$ | $0.036\pm0.009^{a}$ | $0.005\pm0.003^{a}$ | $0.028\pm0.001^{cd}$ | $0.043\pm0.007^{e}$ |
| Guava | $0.086\pm0.001^{a}$ | $0.413\pm0.003^{c}$ | $0.043\pm0.001^{a}$ | $0.061\pm0.001^{c}$ | $0.018\pm0.002^{b}$ | $0.019\pm0.001^{abc}$ | $0.009\pm0.001^{a}$ |
| Banana | $0.082\pm0.003^{a}$ | $0.355\pm0.012^{b}$ | $0.047\pm0.001^{a}$ | $0.067\pm0.001^{c}$ | $0.040\pm0.002^{d}$ | $0.014\pm0.000^{ab}$ | $0.033\pm0.001^{d}$ |
| Tomatoes | $0.181\pm0.016^{b}$ | $0.367\pm0.043^{b}$ | $0.044\pm0.002^{a}$ | $0.061\pm0.001^{c}$ | $0.055\pm0.001^{e}$ | $0.033\pm0.022^{d}$ | $0.016\pm0.002^{b}$ |
| Mango | $0.082\pm0.005^{a}$ | $0.306\pm0.009^{a}$ | $0.048\pm0.000^{a}$ | $0.052\pm0.002^{b}$ | $0.038\pm0.000^{d}$ | $0.026\pm0.000^{bcd}$ | $0.020\pm0.002^{b}$ |

Values with different superscripts down the column are significantly different ($p< 0.05$).

Values are mean ±SD.

Mean sample size =3.14

## APPENDIX 7

**Table 4.12: Concentration (mg/g) of heavy metals for the various sources/food crops analysed for wet season.**

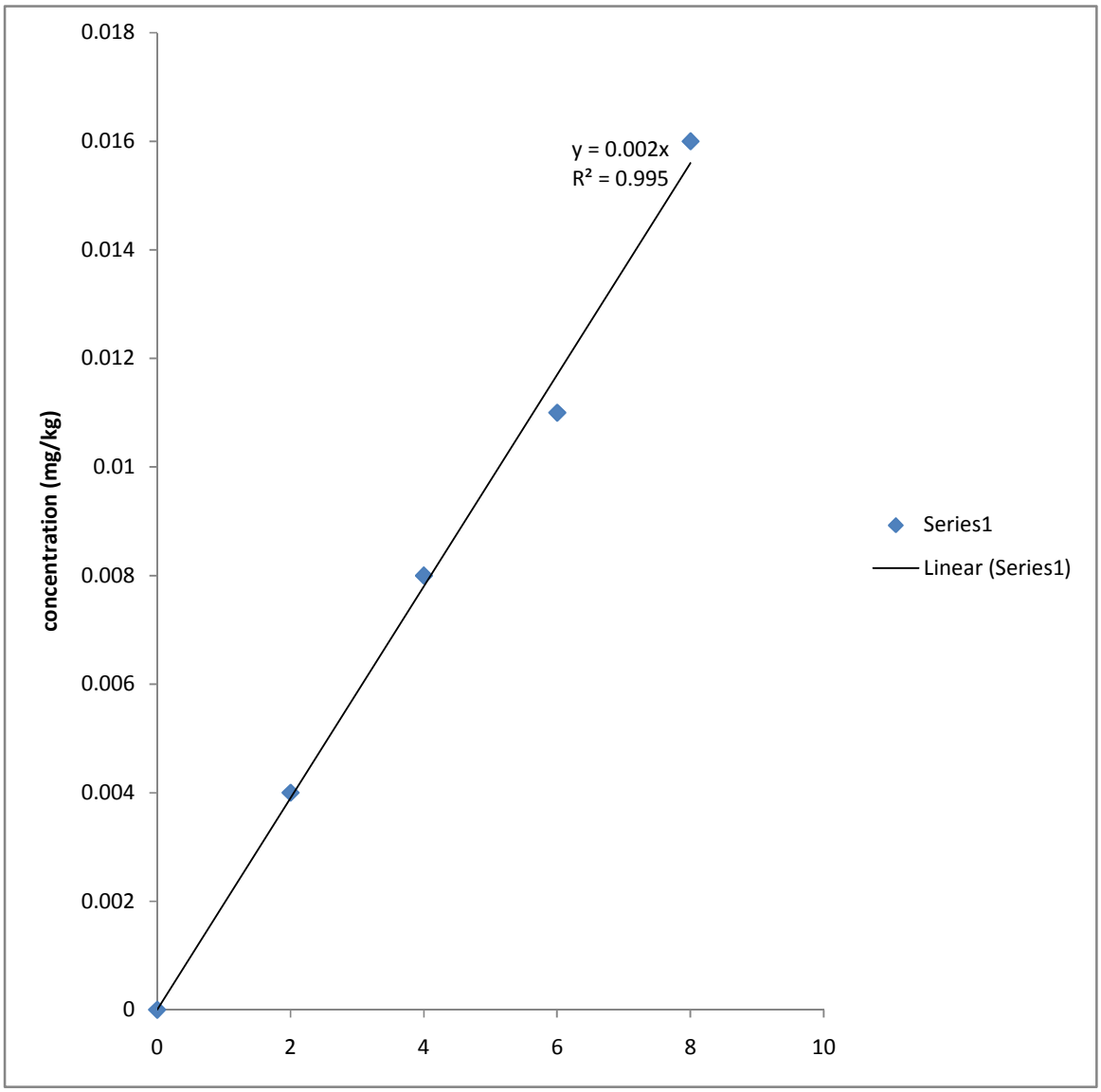
| Source/metal | Pb | Fe | Mn | Cd | Cr | Ni | Co |
|---|---|---|---|---|---|---|---|
| Dump(0-5CM) | $0.323\pm0.038^{e}$ | $0.807\pm0.002^{f}$ | $0.134\pm0.002^{e}$ | $0.045\pm0.002^{b}$ | $0.076\pm0.001^{f}$ | $0.040\pm0.001^{d}$ | $0.067\pm0.001^{g}$ |
| Dump(5-10CM) | $0.305\pm0.053^{e}$ | $0.764\pm0.003^{f}$ | $0.094\pm0.001^{c}$ | $0.027\pm0.001^{a}$ | $0.0190\pm0.001^{b}$ | $0.015\pm0.006^{abc}$ | $0.033\pm0.001^{d}$ |
| Outside dump(5m)(0-5CM) | $0.255\pm0.001^{e}$ | $0.721\pm0.011^{g}$ | $0.097\pm0.001^{c}$ | $0.026\pm0.002^{a}$ | $0.035\pm0.000^{d}$ | $0.025\pm0.001^{abcd}$ | $0.045\pm0.002^{f}$ |
| Outside dump(5m)(5-10CM) | $0.171\pm0.011^{d}$ | $0.681\pm0.001^{g}$ | $0.073\pm0.001^{cd}$ | $0.027\pm0.002^{a}$ | $0.026\pm0.001^{b}$ | $0.018\pm0.001^{a}$ | $0.027\pm0.001^{cd}$ |
| Outside dump(10m)(0-5cm) | $0.255\pm0.006^{a}$ | $0.712\pm0.136^{a}$ | $0.090\pm0.012^{a}$ | $0.025\pm0.000^{a}$ | $0.033\pm0.002^{a}$ | $0.023\pm0.001^{a}$ | $0.040\pm0.001^{a}$ |
| Outside dump(10m)(5-10cm) | $0.170\pm0.002^{a}$ | $0.680\pm0.002^{a}$ | $0.065\pm0.002^{a}$ | $0.026\pm0.002^{a}$ | $0.022\pm0.011^{a}$ | $0.016\pm0.002^{a}$ | $0.020\pm0.001^{a}$ |
| Ash | $0.384\pm0.066^{c}$ | $0.279\pm0.046^{d}$ | $0.115\pm0.021^{d}$ | $0.036\pm0.009^{a}$ | $0.005\pm0.003^{a}$ | $0.028\pm0.001^{cd}$ | $0.043\pm0.007^{e}$ |
| Guava | $0.086\pm0.001^{a}$ | $0.413\pm0.003^{c}$ | $0.043\pm0.001^{a}$ | $0.061\pm0.001^{c}$ | $0.018\pm0.002^{b}$ | $0.019\pm0.001^{abc}$ | $0.009\pm0.001^{a}$ |
| Banana | $0.082\pm0.003^{a}$ | $0.355\pm0.012^{b}$ | $0.047\pm0.001^{a}$ | $0.067\pm0.001^{c}$ | $0.040\pm0.002^{d}$ | $0.014\pm0.000^{ab}$ | $0.033\pm0.001^{d}$ |
| Tomatoes | $0.181\pm0.016^{b}$ | $0.367\pm0.043^{b}$ | $0.044\pm0.002^{a}$ | $0.061\pm0.001^{c}$ | $0.055\pm0.001^{e}$ | $0.033\pm0.022^{d}$ | $0.016\pm0.002^{b}$ |
| Mango | $0.082\pm0.005^{a}$ | $0.306\pm0.009^{a}$ | $0.048\pm0.000^{a}$ | $0.052\pm0.002^{b}$ | $0.038\pm0.000^{d}$ | $0.026\pm0.000^{bcd}$ | $0.020\pm0.002^{b}$ |

Values with different superscripts down the column are significantly different ($p< 0.05$).

Values are mean ±SD.

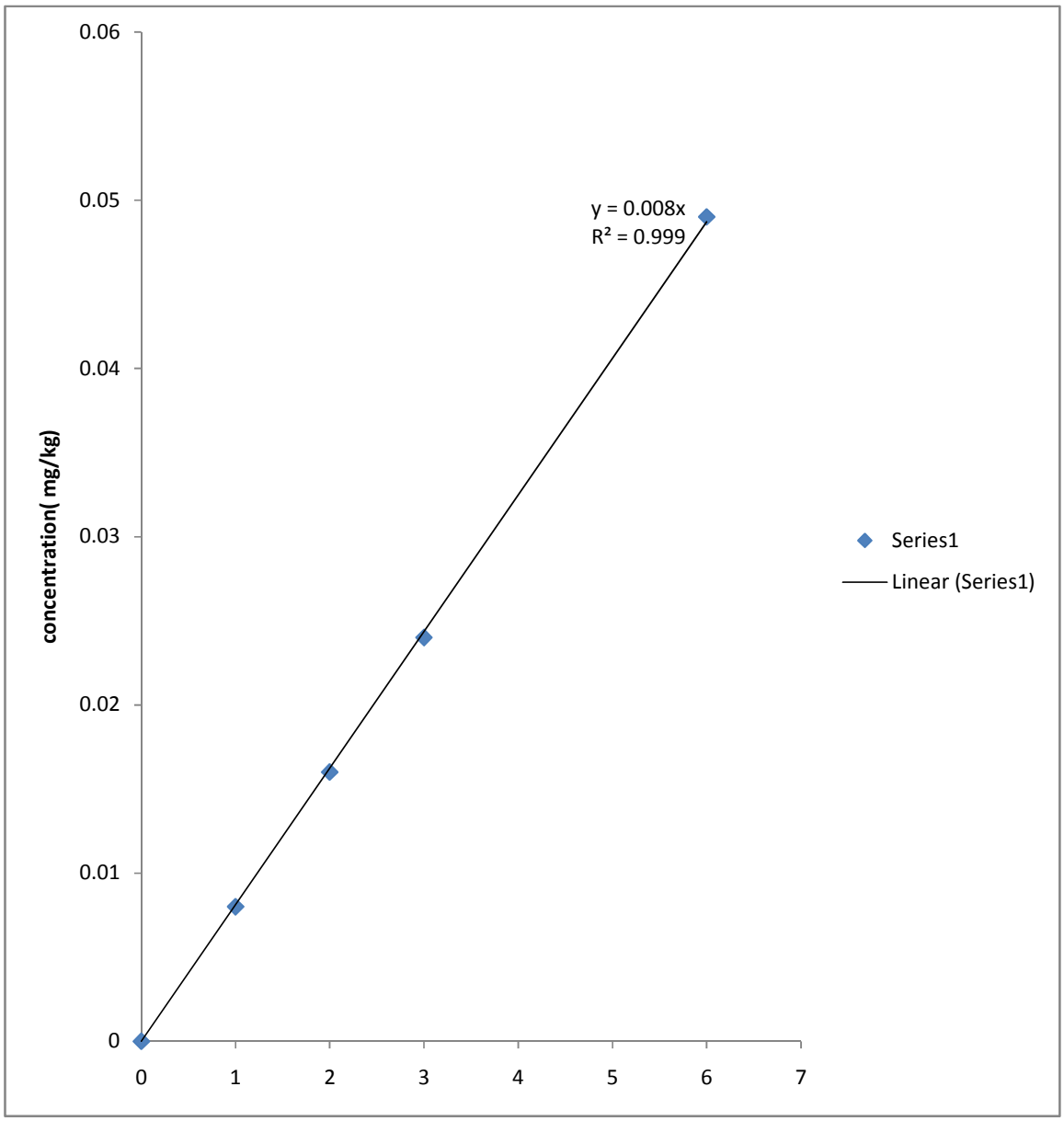
Mean sample size =3.14

## APPENDIX 8



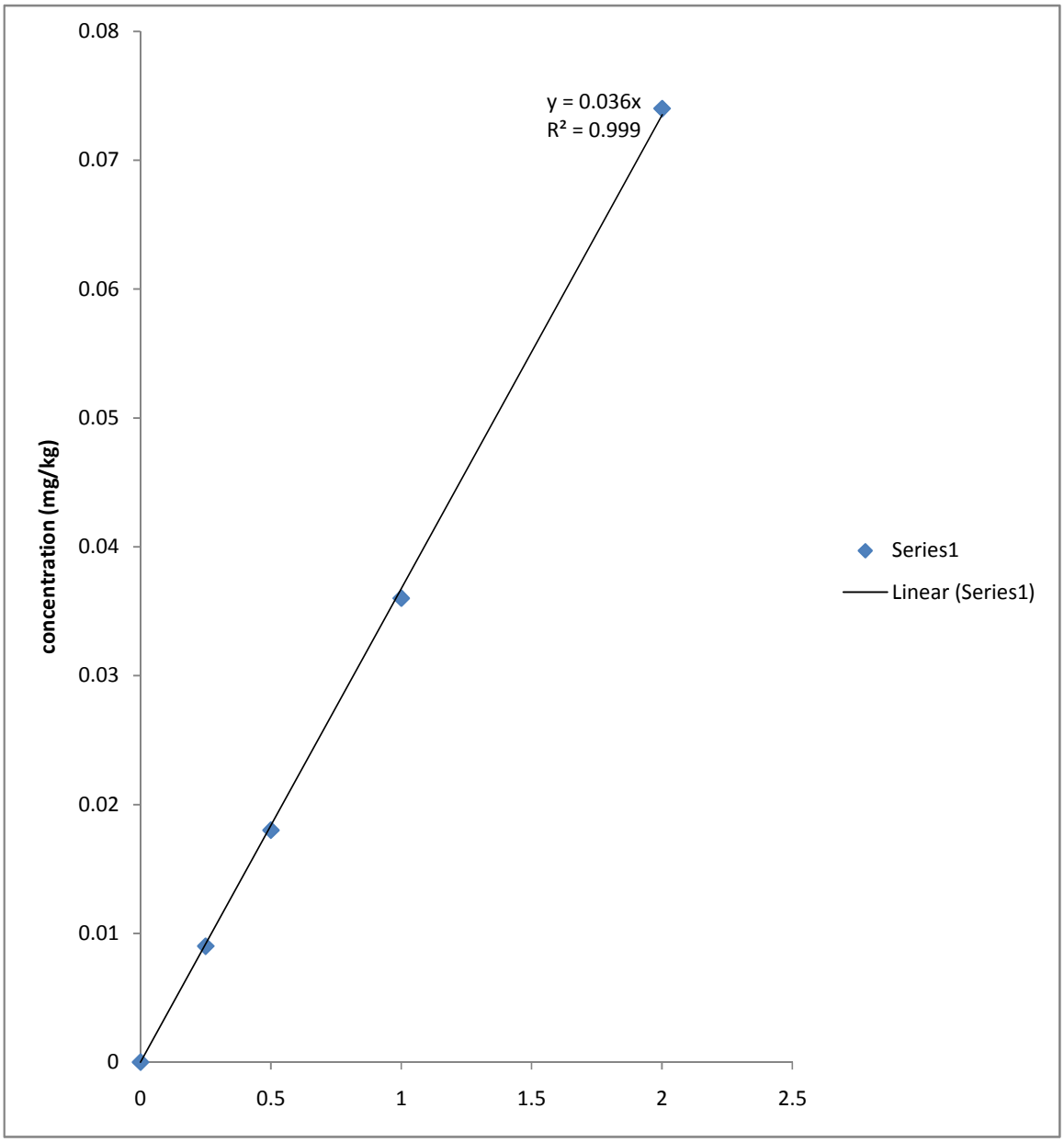

**Calibration curve for standard lead metal**

## APPENDIX 9



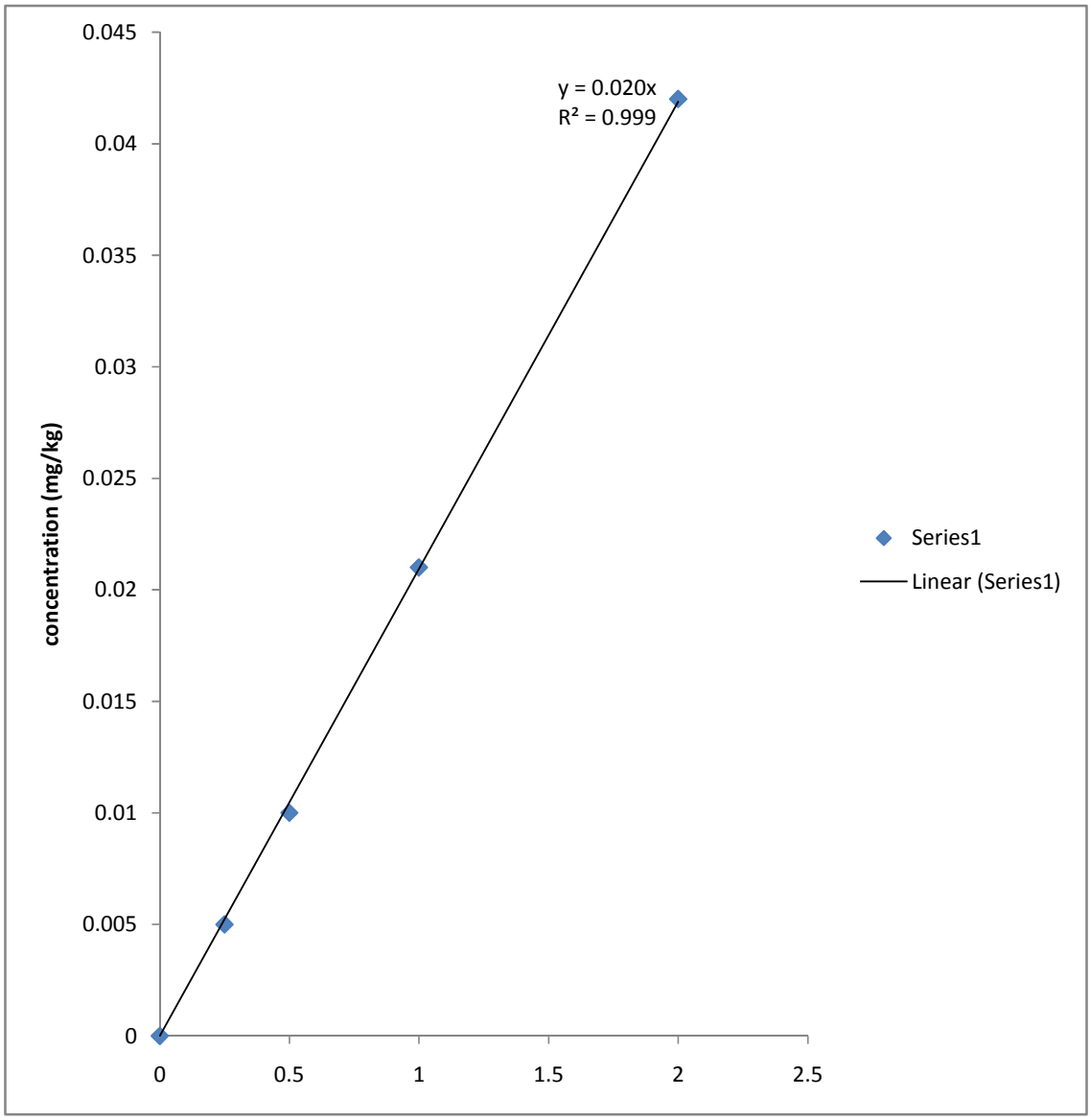

**Calibration curve for standard iron metal**

## APPENDIX 10



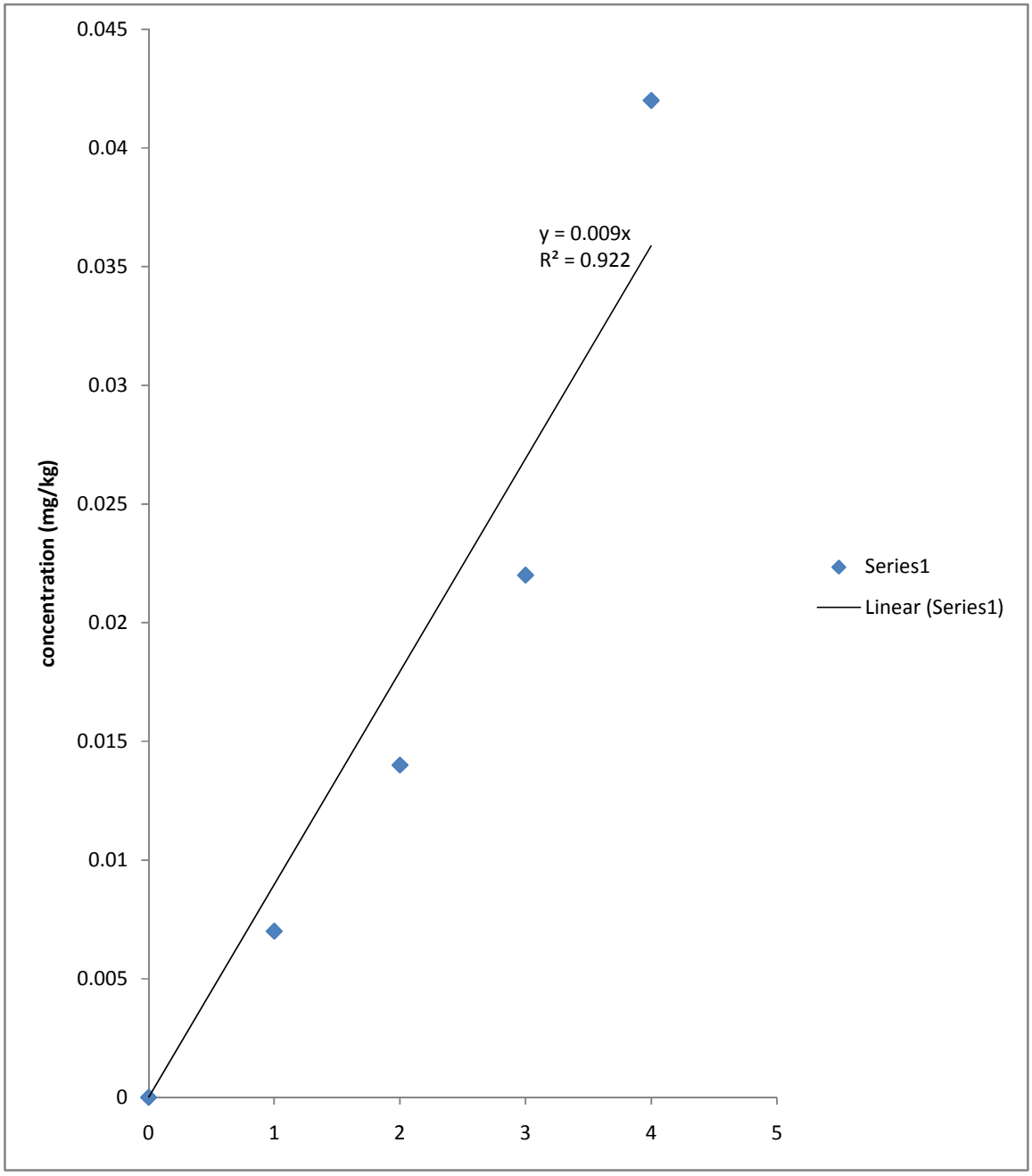

**Calibration curve for standard manganese metal**

## APPENDIX 11



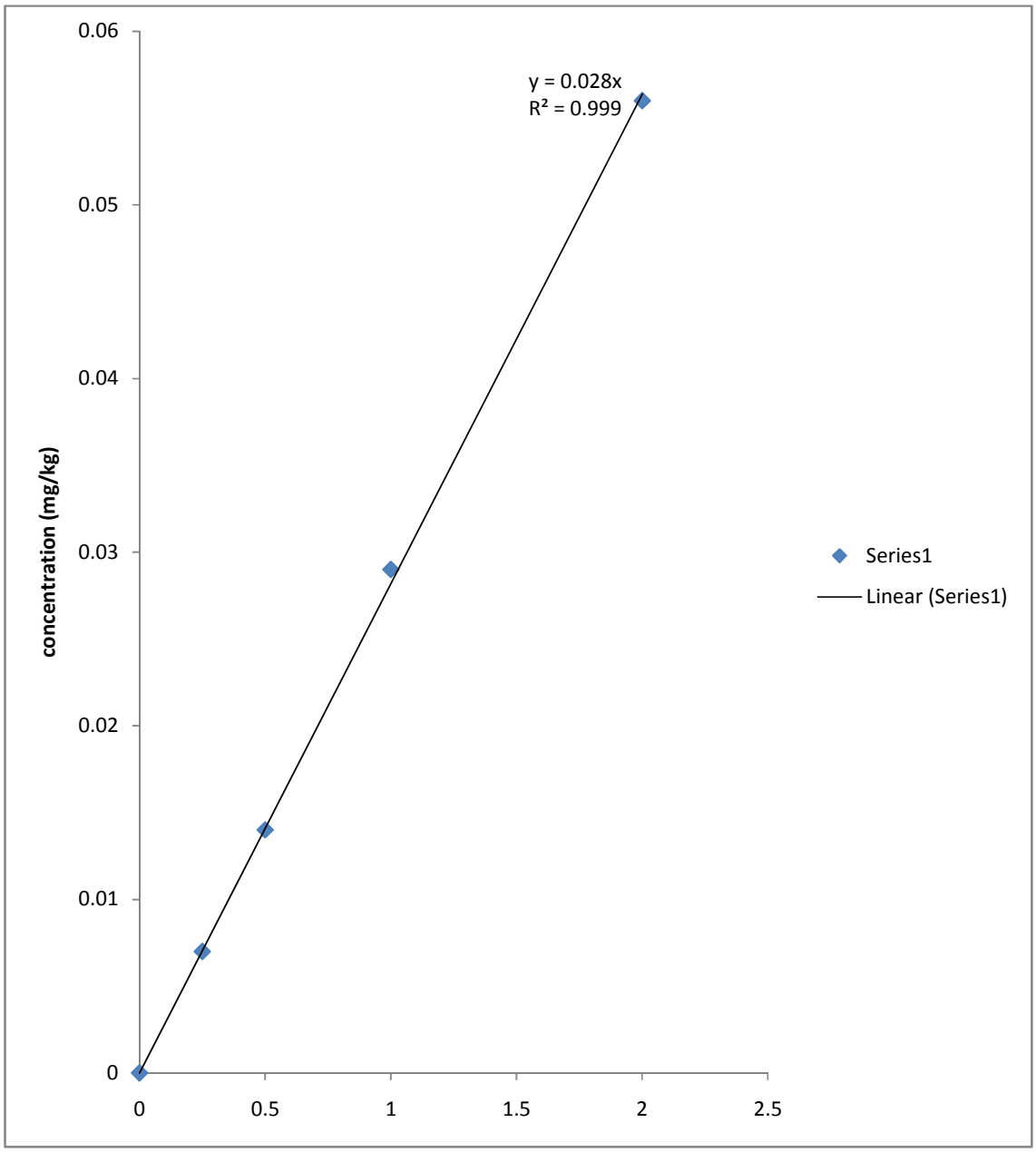

**Calibration curve for standard cadmium metal**

## APPENDIX 12




**Calibration curve for standard chromium metal**

## APPENDIX 13




**Calibration curve for standard cobalt metal**

## APPENDIX 14

**Concentration (mg/kg) of control heavy metals on the dump soil (C1) for the wet and dry seasons at 0-5cm and 5-10cm depth**

| Metal/season | Wet(0-5cm) | Dry(0-5cm) | Wet(5-10cm) | Dry(5-10cm) |
|---|---|---|---|---|
| Pb | $0.240\pm0.001^{a}$ | $0.250\pm0.006^{a}$ | $0.150\pm0.001^{a}$ | $0.162\pm0.002^{a}$ |
| Fe | $0.711\pm0.011^{a}$ | $0.714\pm0.136^{a}$ | $0.650\pm0.001^{a}$ | $0.653\pm0.002^{a}$ |
| Mn | $0.085\pm0.001^{a}$ | $0.084\pm0.012^{a}$ | $0.083\pm0.001^{a}$ | $0.083\pm0.002^{a}$ |
| Cd | $0.021\pm0.002^{a}$ | $0.021\pm0.000^{a}$ | $0.024\pm0.001^{a}$ | $0.023\pm0.002^{a}$ |
| Cr | $0.032\pm0.001^{a}$ | $0.032\pm0.002^{a}$ | $0.030\pm0.011^{a}$ | $0.028\pm0.011^{a}$ |
| Ni | $0.022\pm0.001^{a}$ | $0.020\pm0.001^{a}$ | $0.014\pm0.001^{a}$ | $0.016\pm0.002^{a}$ |
| Co | $0.040\pm0.001^{a}$ | $0.041\pm0.001^{a}$ | $0.022\pm0.001^{a}$ | $0.020\pm0.001^{a}$ |

Values with different superscript across the row for wet and dry season pairs are significantly different ($p< 0.05$).

Values are mean± SD.

Mean sample size=3.14

## APPENDIX 15

**Concentration (mg/kg) of control heavy metals on the dump soil (C2) for the wet and dry seasons at 0-5cm and 5-10cm depth**

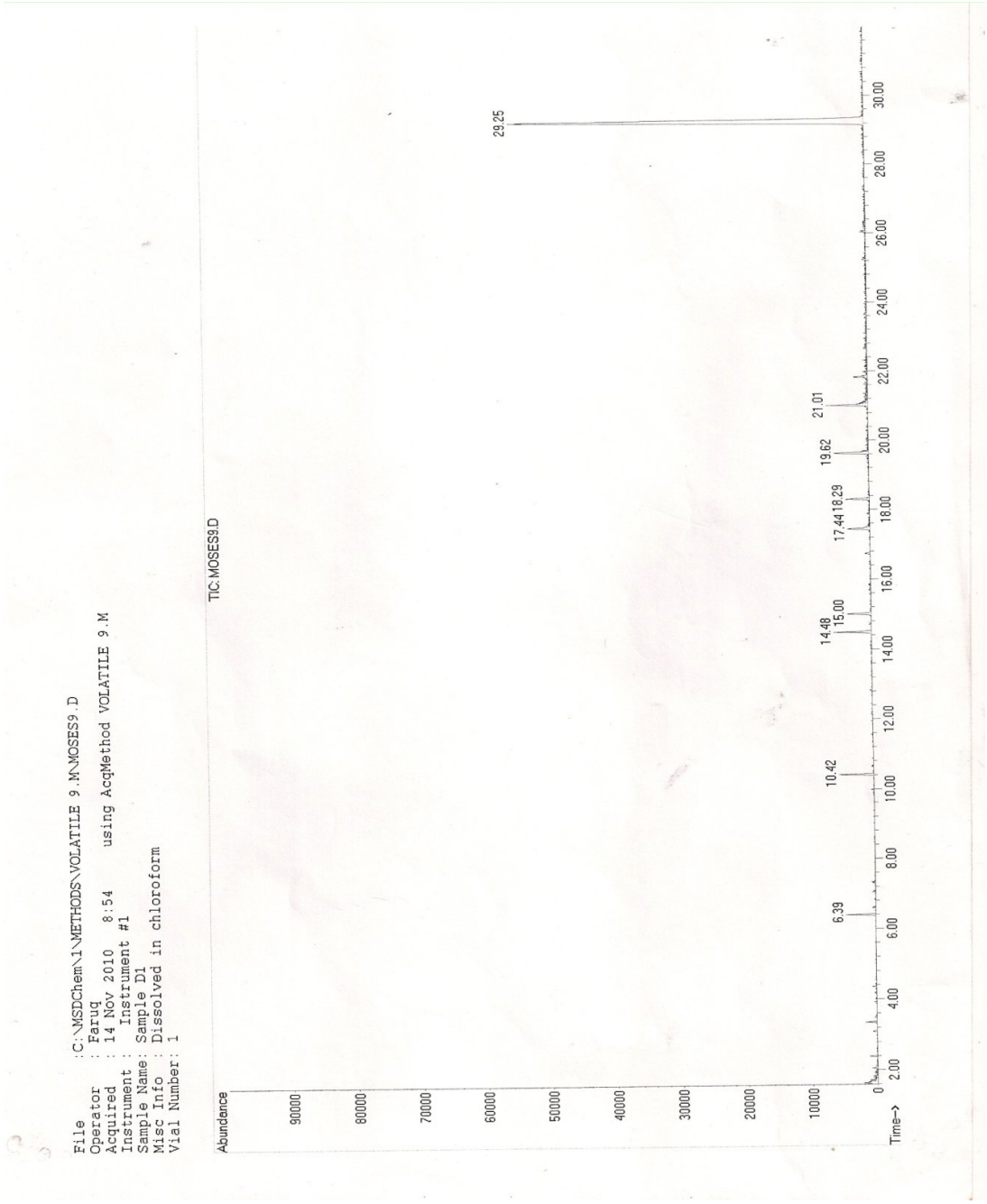
| Metal/season | Wet(0-5cm) | Dry(0-5cm) | Wet(5-10cm) | Dry(5-10cm) |
|---|---|---|---|---|
| Pb | 0.241±0.001[a] | 0.250±0.006[a] | 0.152±0.001[a] | 0.152±0.002[a] |
| Fe | 0.652±0.011[a] | 0.652±0.136[a] | 0.650±0.001[a] | 0.650±0.002[a] |
| Mn | 0.080±0.001[a] | 0.080±0.012[a] | 0.078±0.001[a] | 0.076±0.002[a] |
| Cd | 0.020±0.002[a] | 0.019±0.000[a] | 0.020±0.001[a] | 0.020±0.002[a] |
| Cr | 0.028±0.001[a] | 0.030±0.002[a] | 0.028±0.011[a] | 0.028±0.011[a] |
| Ni | 0.022±0.001[a] | 0.023±0.001[a] | 0.016±0.001[a] | 0.014±0.002[a] |
| Co | 0.041±0.001[a] | 0.043±0.001[a] | 0.025±0.001[a] | 0.022±0.001[a] |

Values with different superscript across the row for wet and dry season pairs are significantly different ($p < 0.05$).

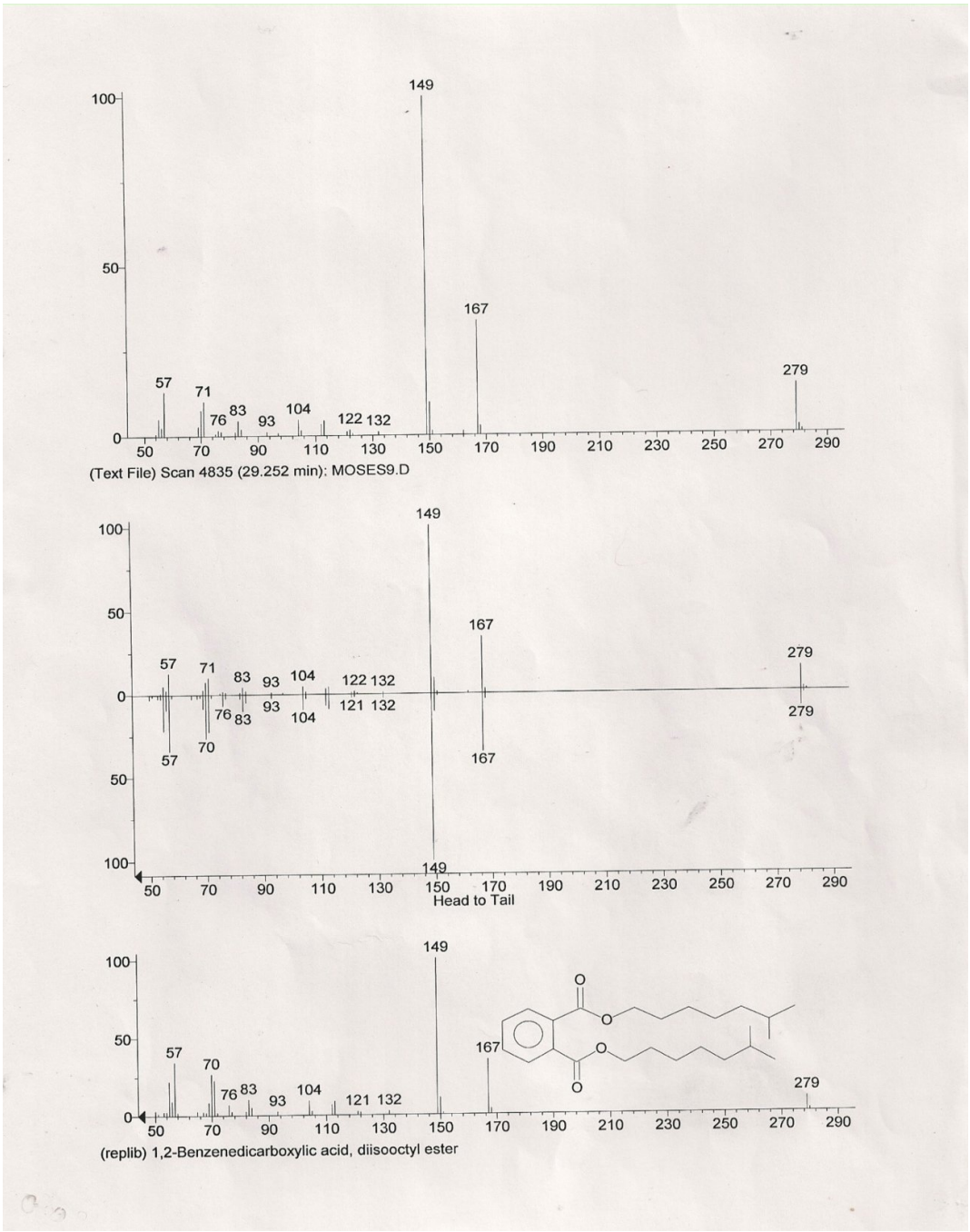
Values are mean± SD.

Mean sample size=3.14

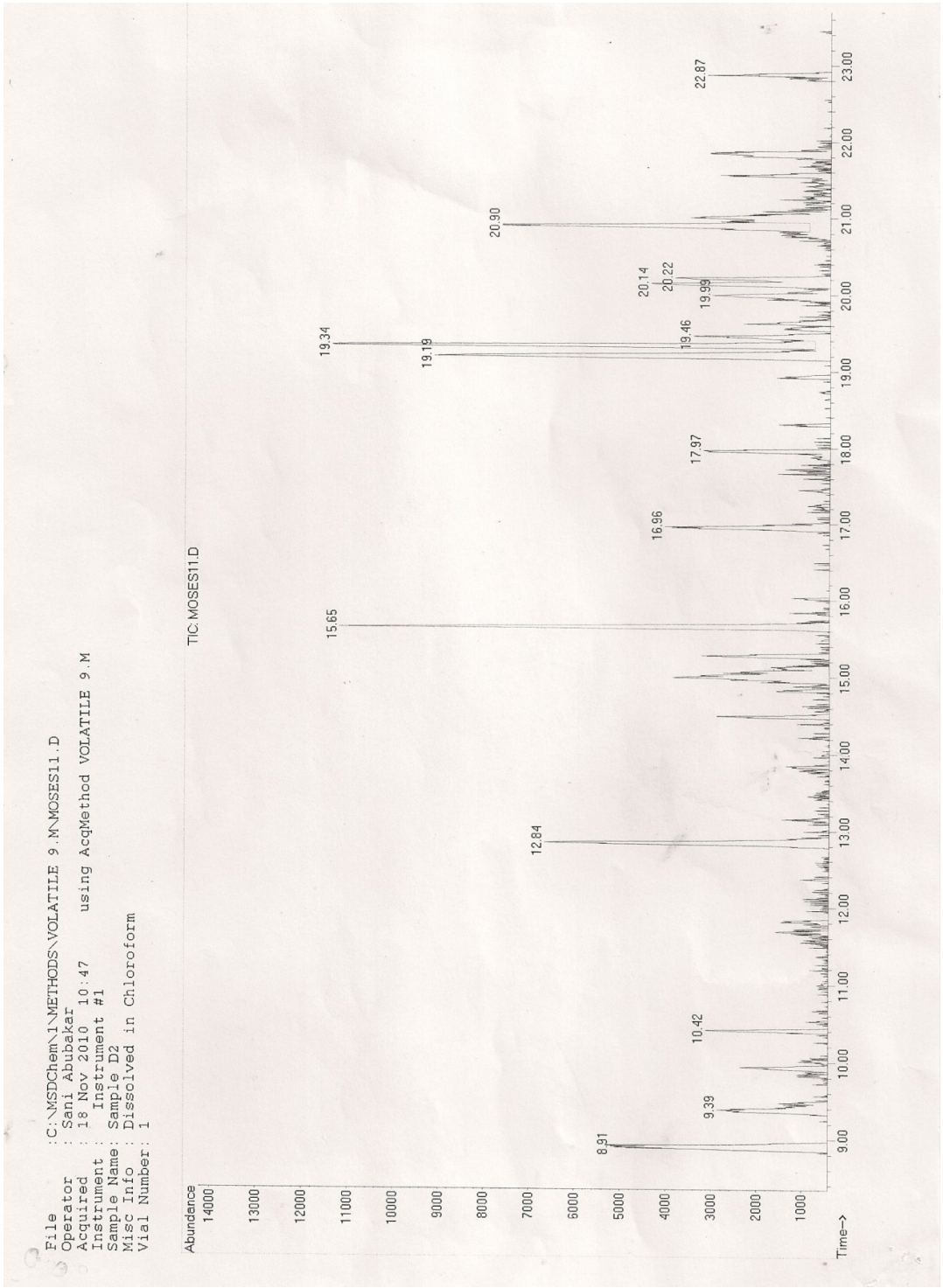
## Appendix 16: GC/MS trace of sample D1 (dry season)



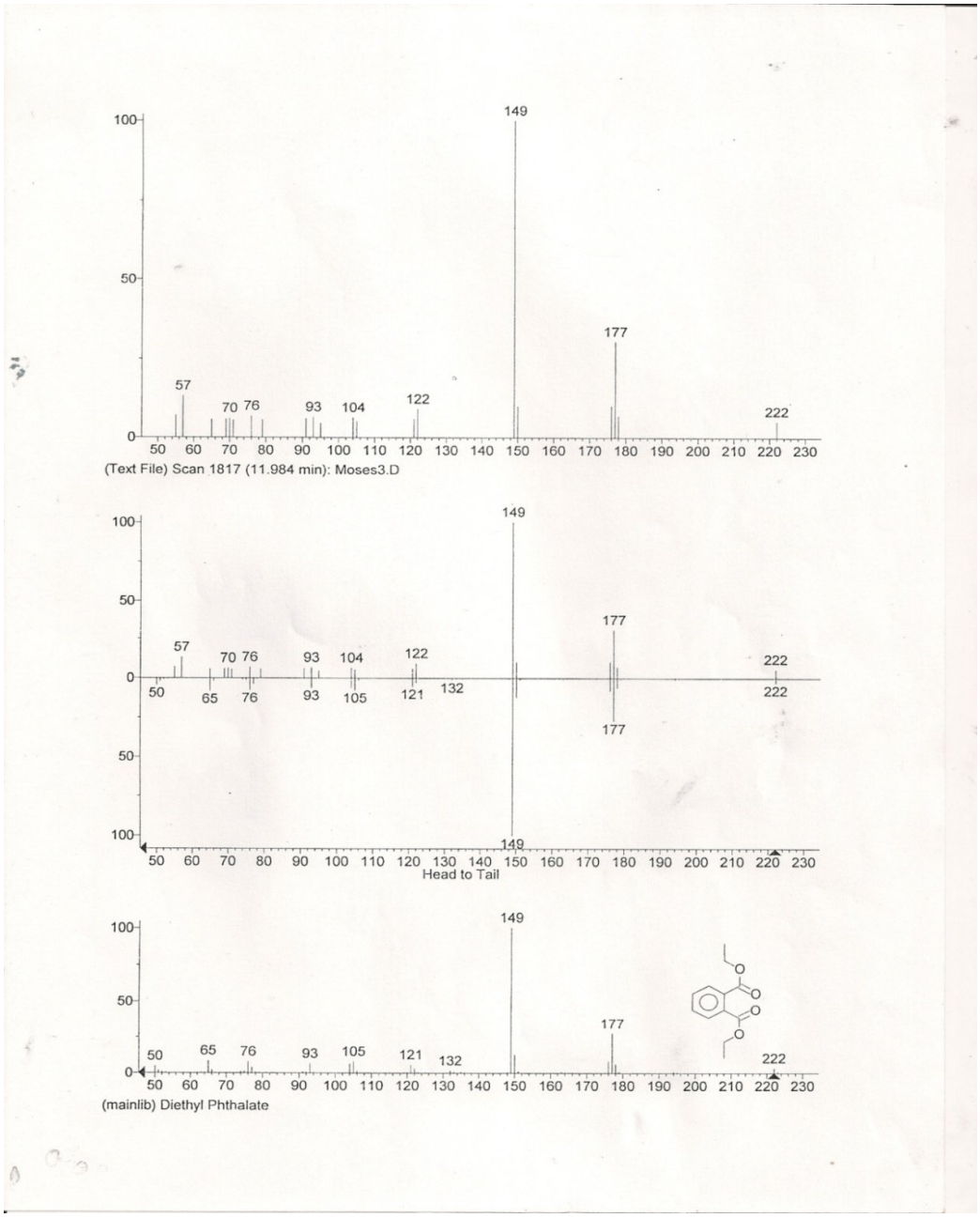
**Appendix 17: GC/MS spectra of sample D1 (dry season)**



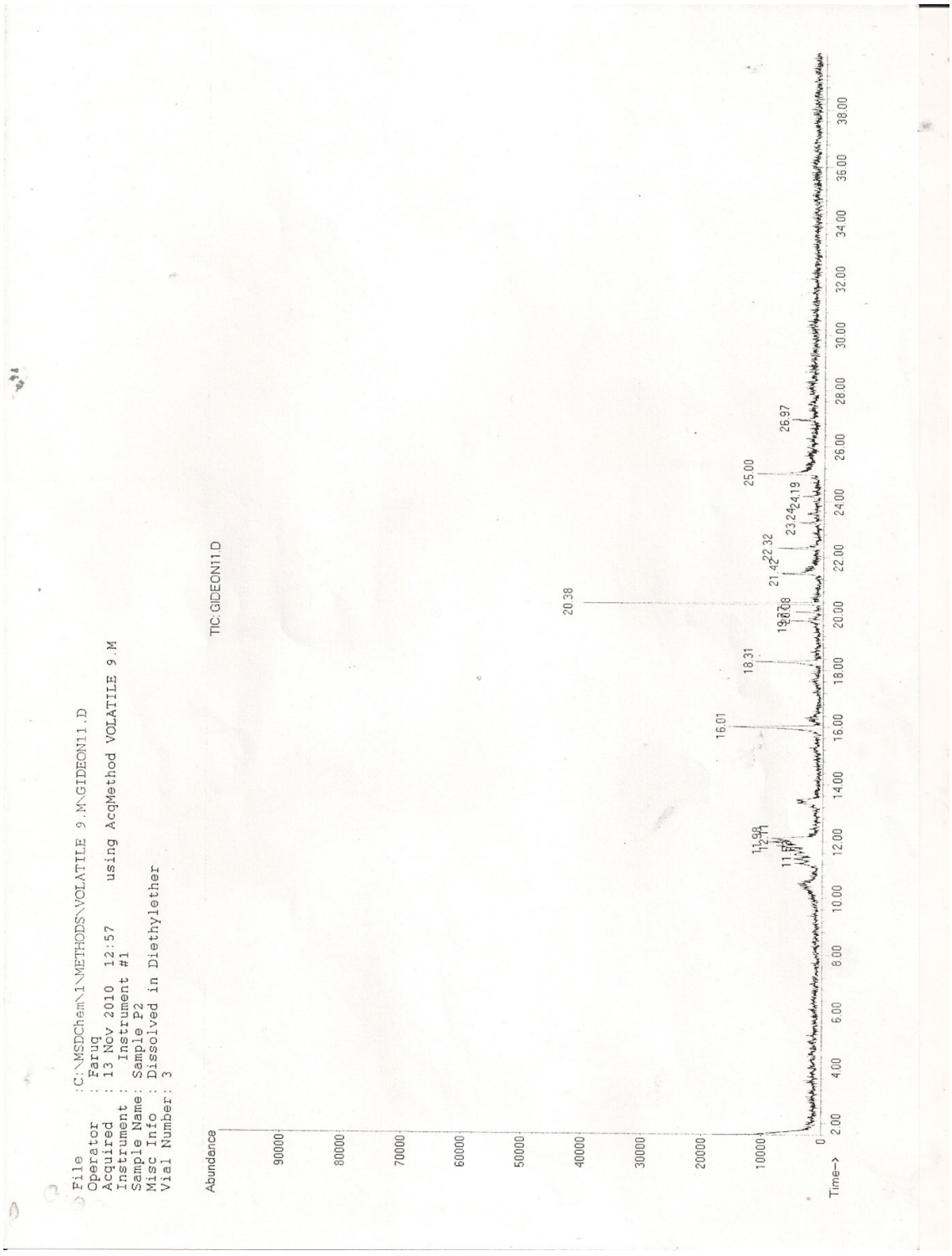
**Appendix 18: GC/MS trace of sample D2 (dry season)**



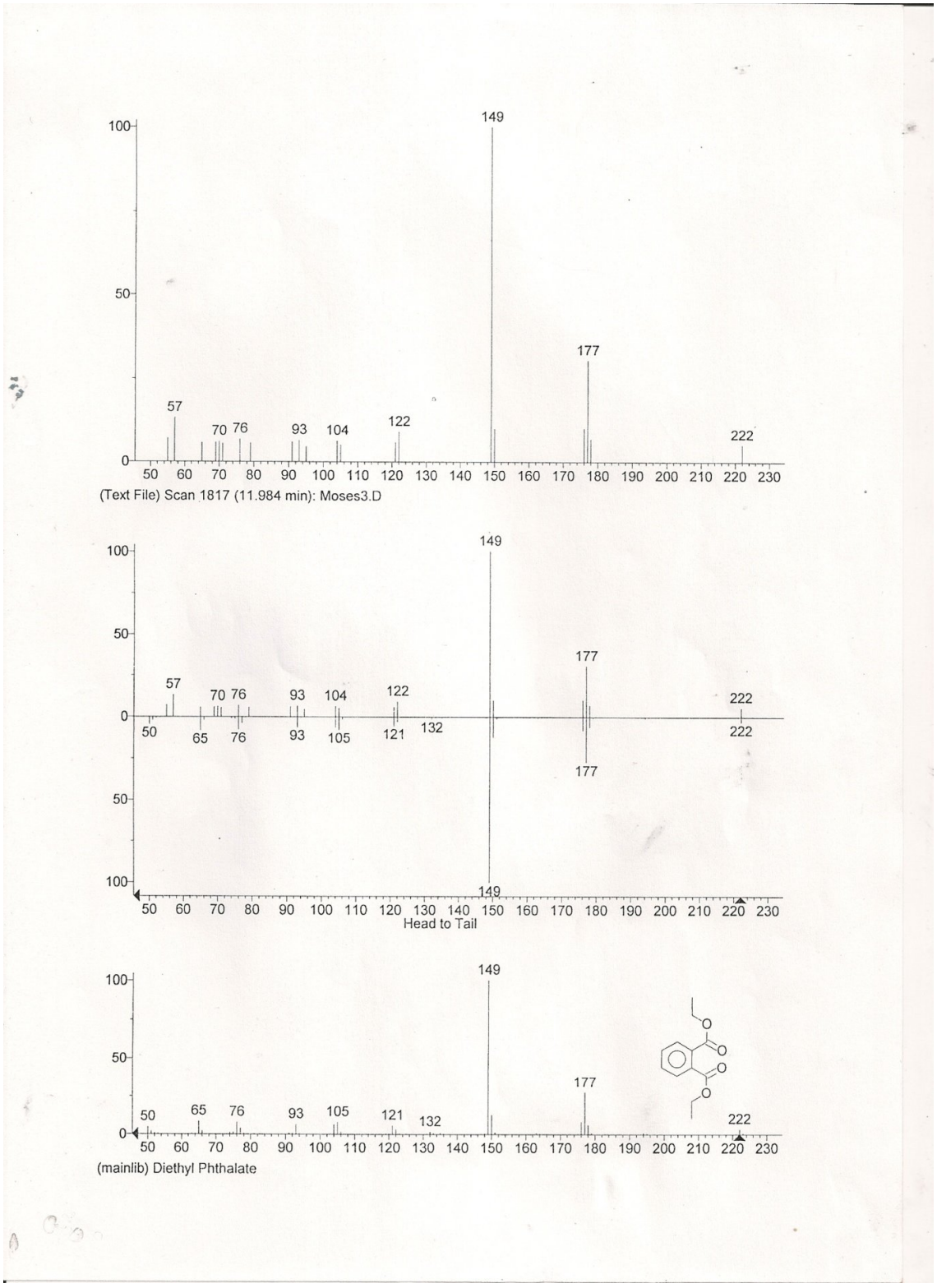
**Appendix 19: GC/MS spectra for sample D2 (dry season)**



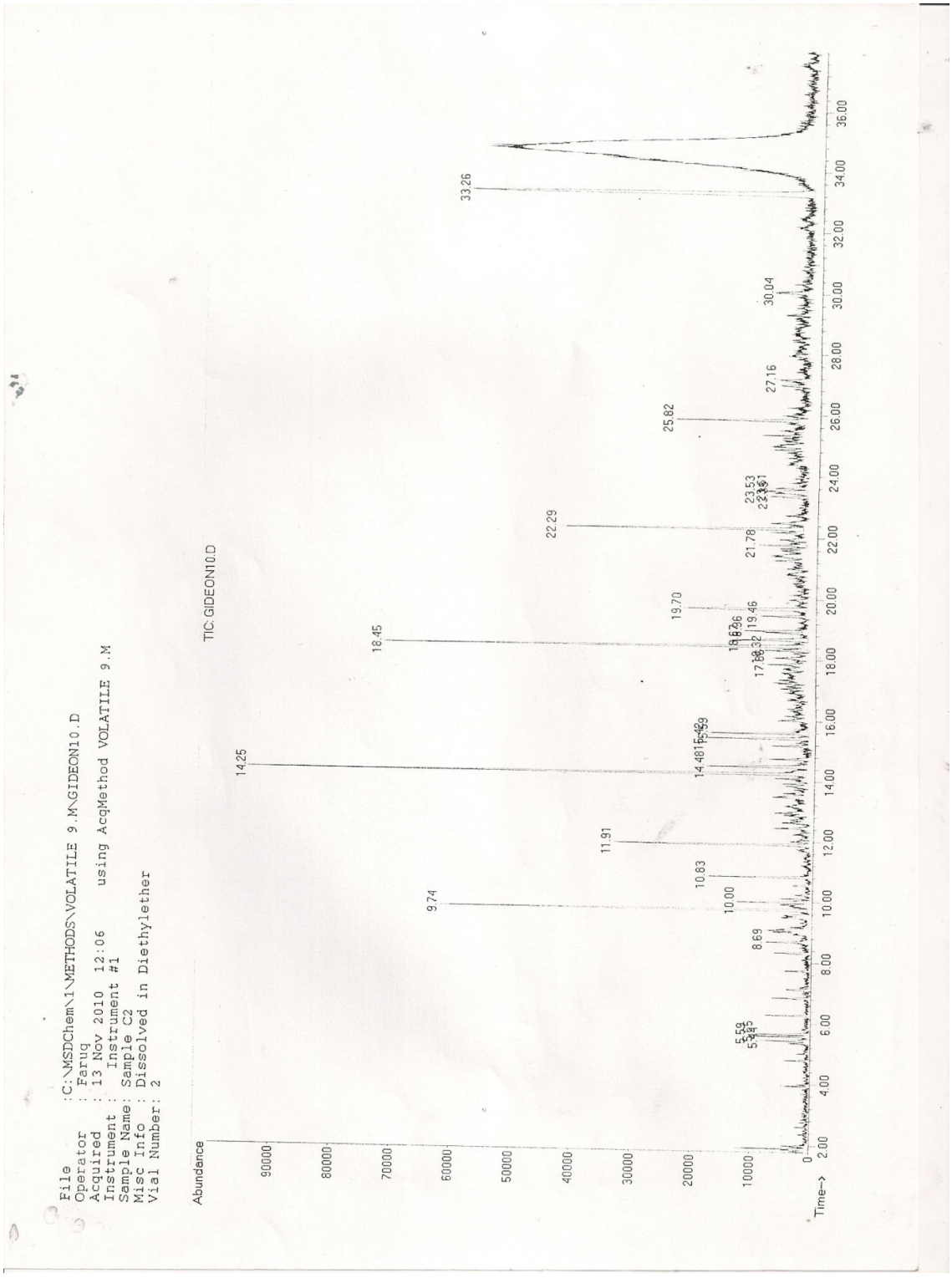
**Appendix 20 GC/MS trace of sample P2 (dry season)**



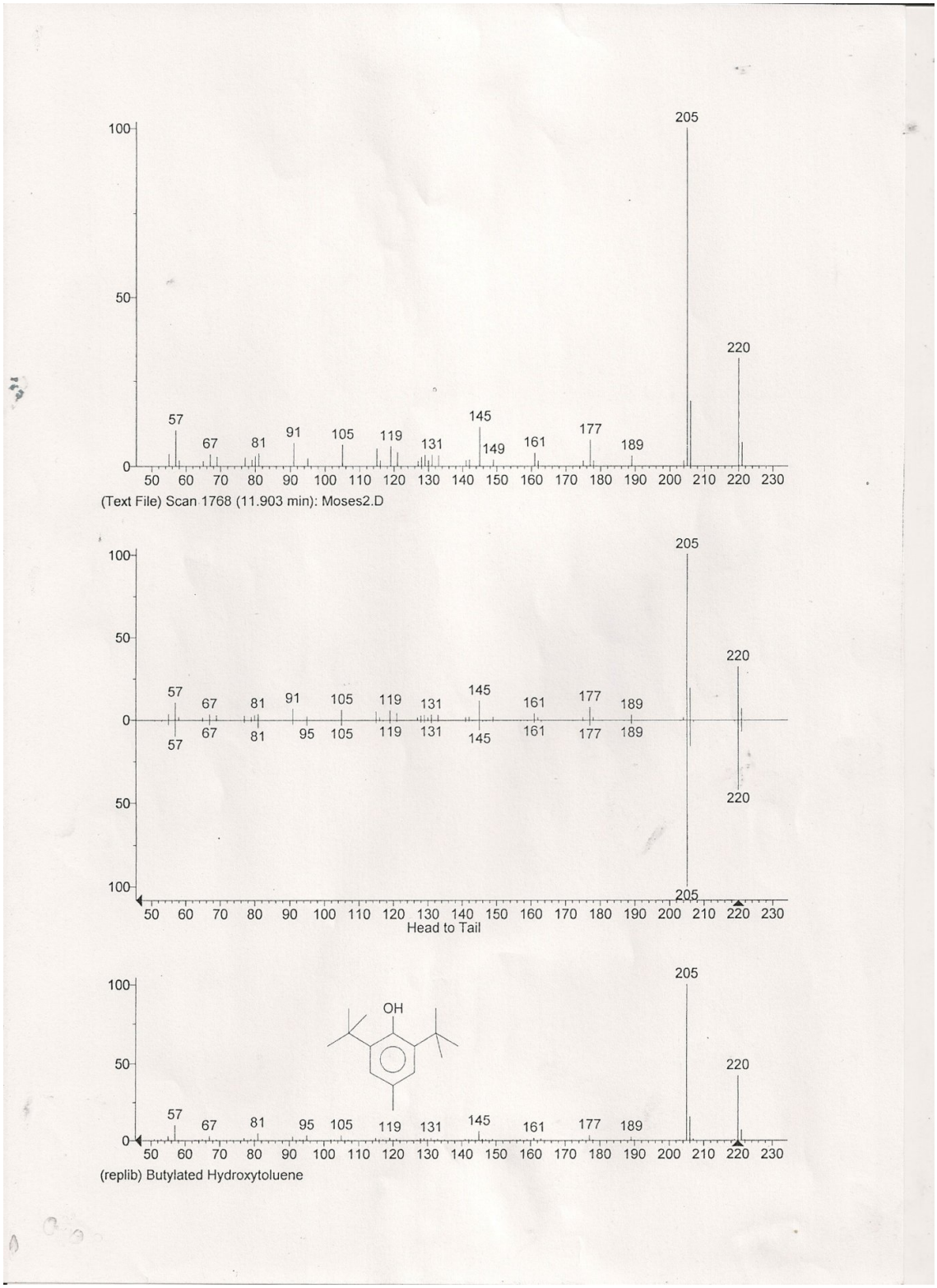
**Appendix 21: GC/MS: spectra for sample P2 (dry season)**



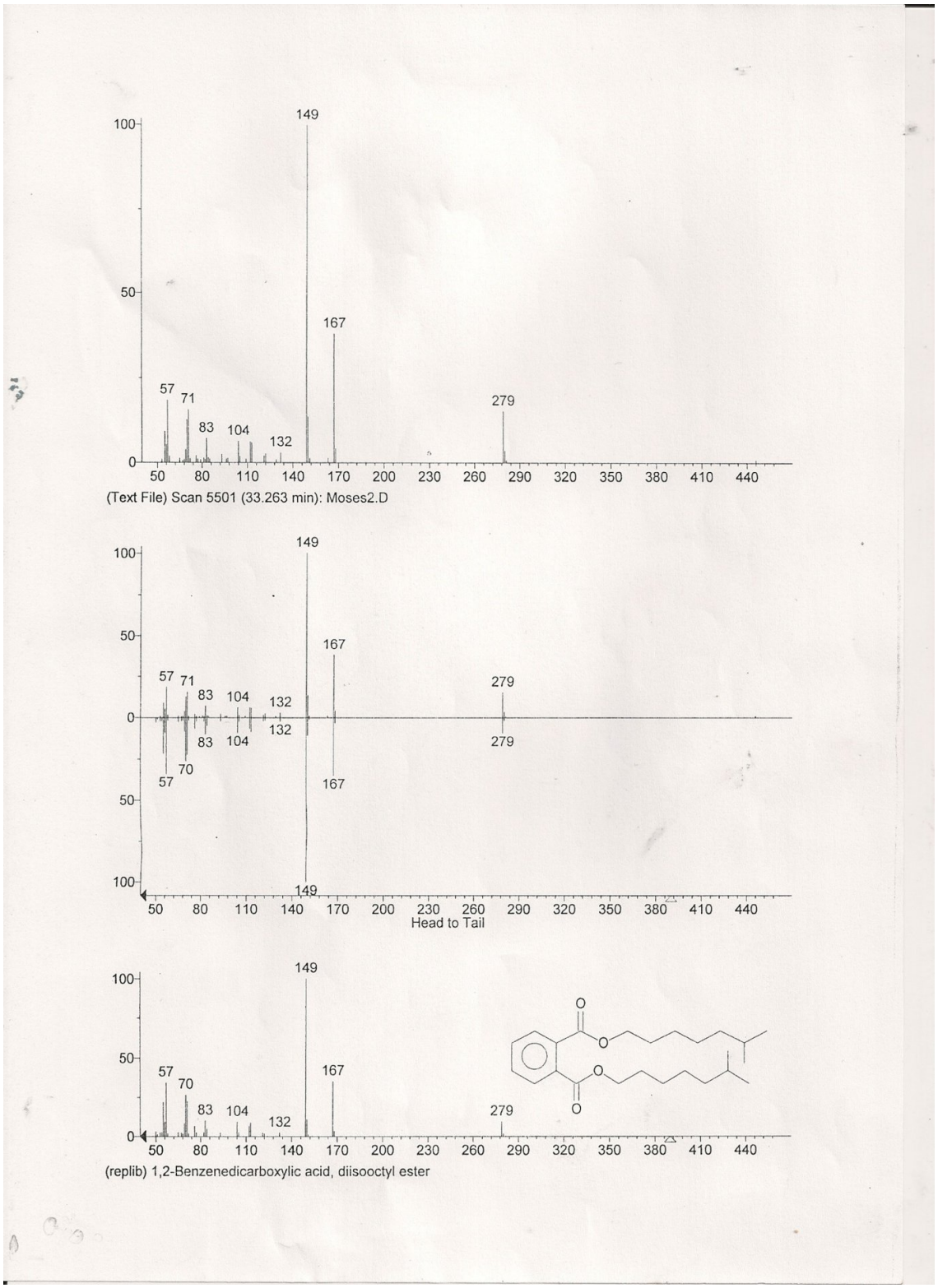
**Appendix 22 GC/MS trace of sample C2 (dry season)**



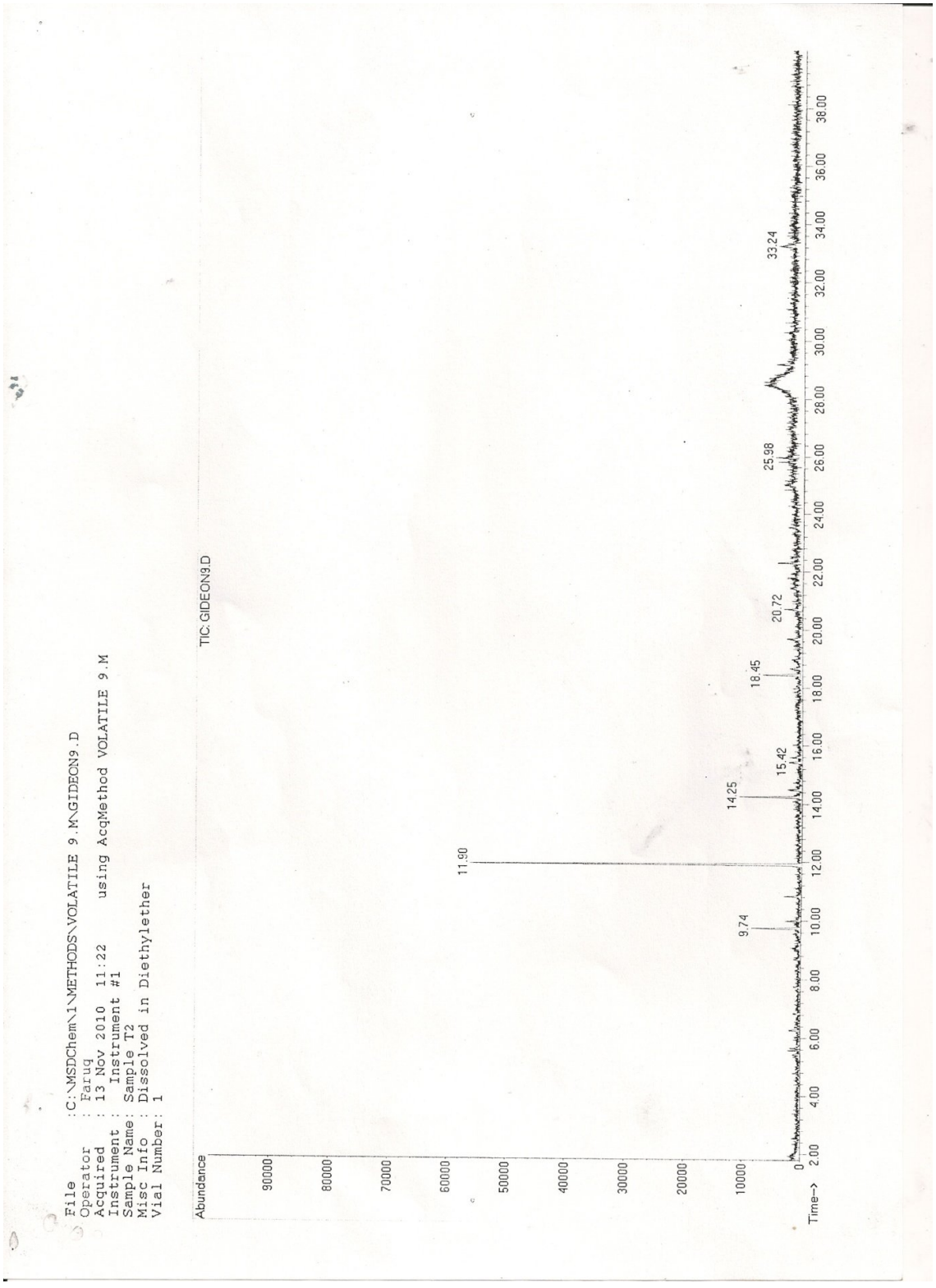
**Appendix 23: GC/MS: spectra for sample C2 (dry season)**



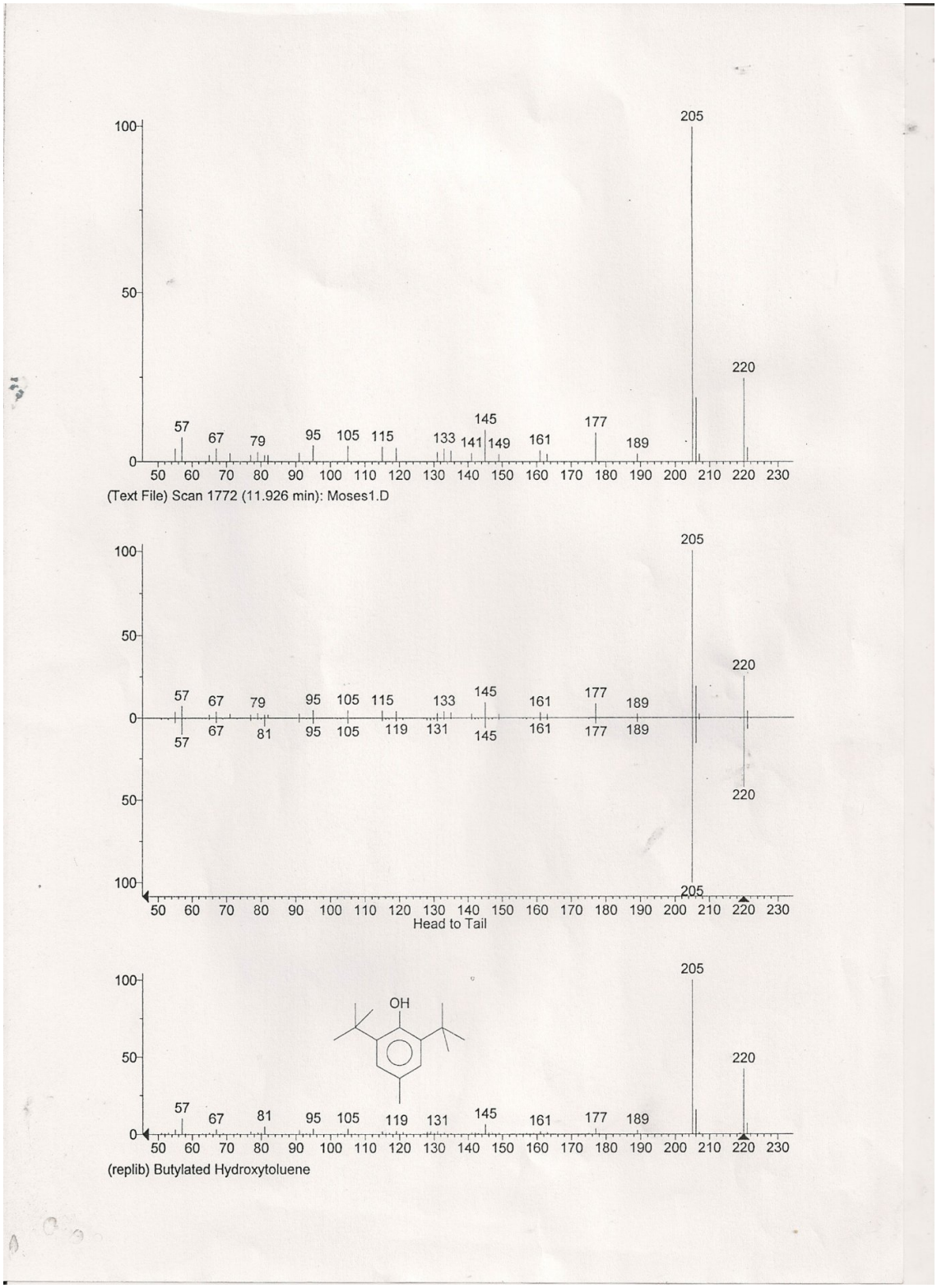
**Appendix 24: GC/MS: spectra for sample C2 (dry season)**



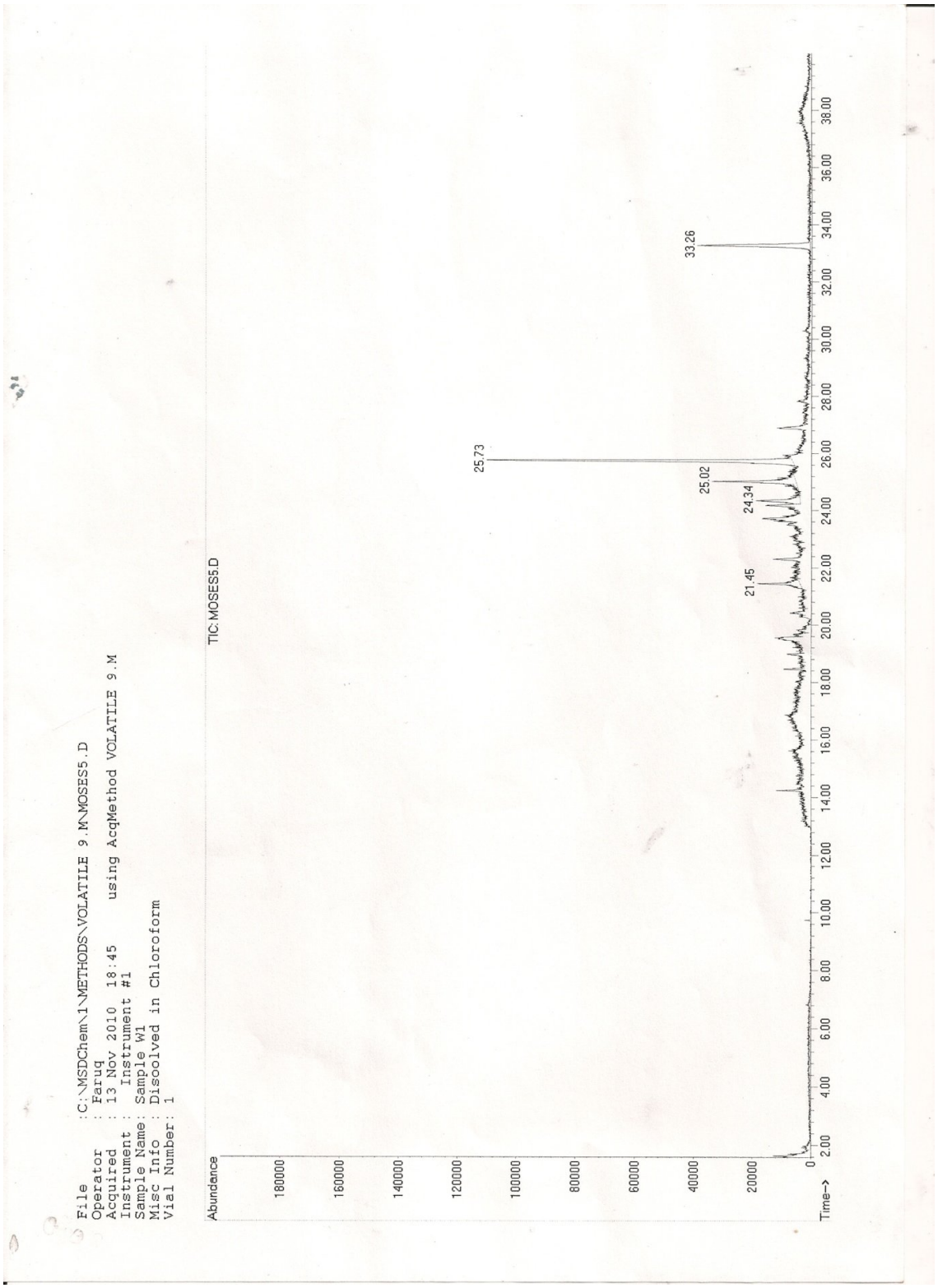
**Appendix 25 GC/MS trace of sample T2 (dry season)**



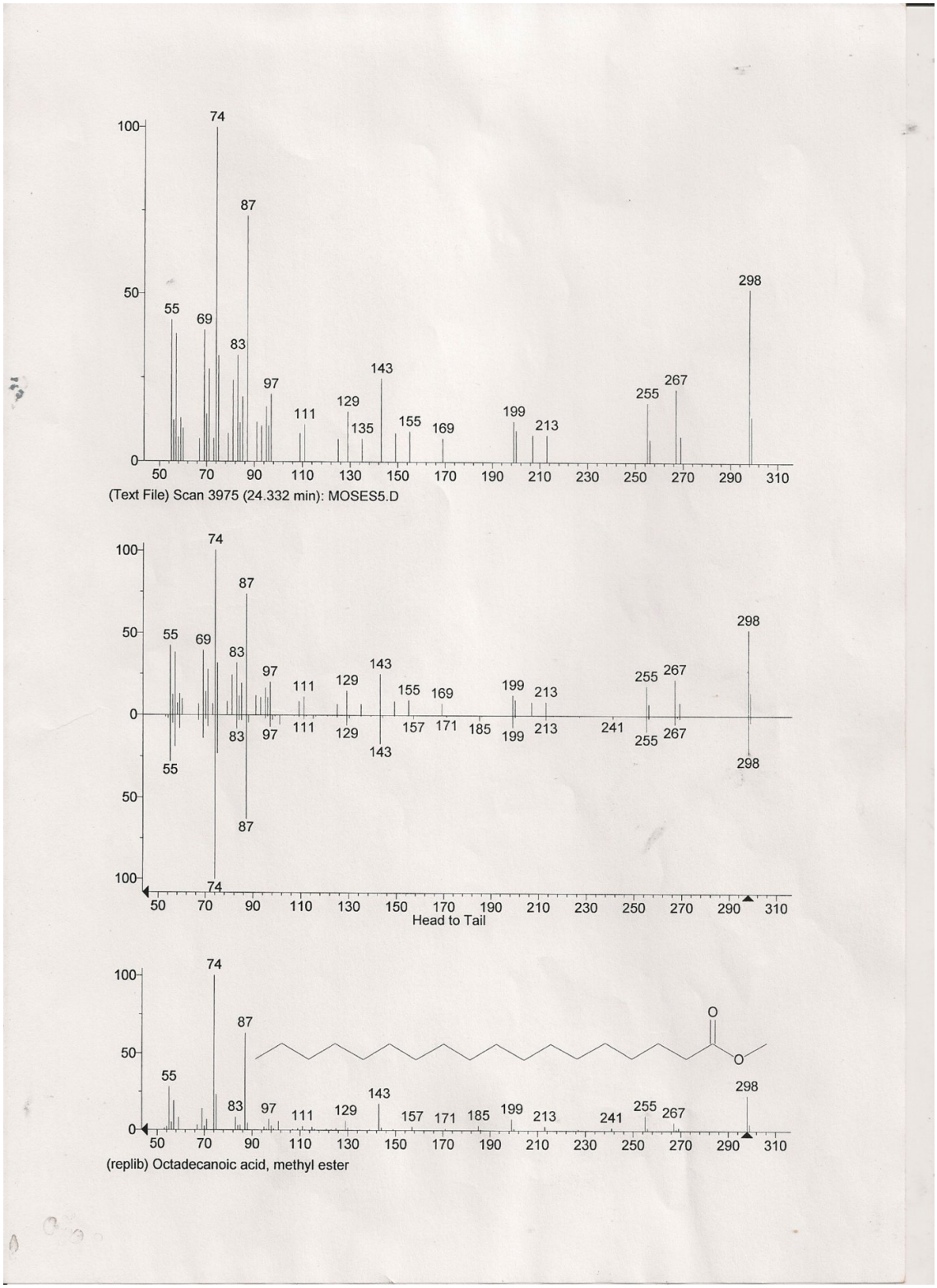
**Appendix 26: GC/MS: spectra for sample T2 (dry season)**



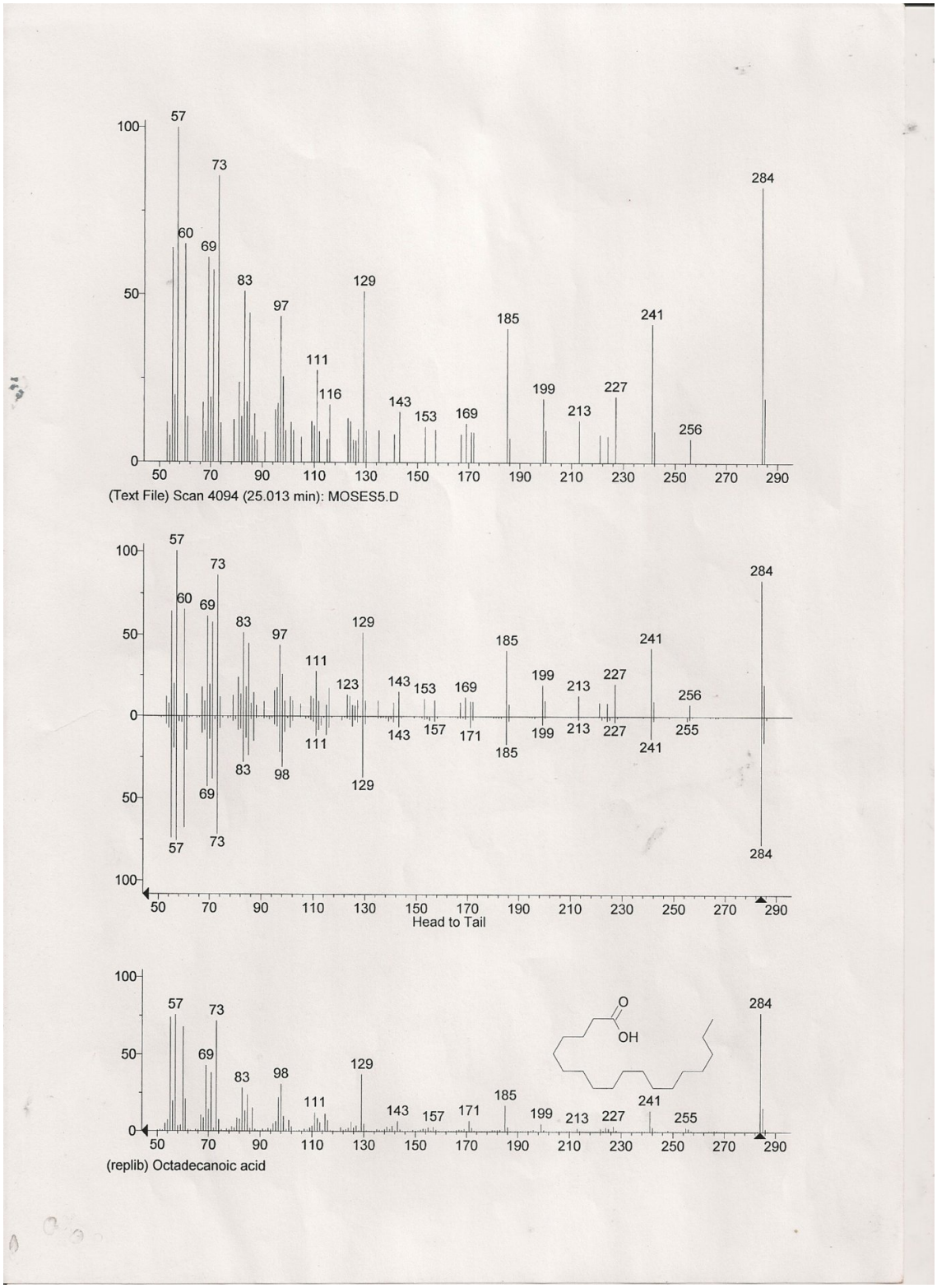
## Appendix 27 GC/MS trace of sample A1 (wet season)



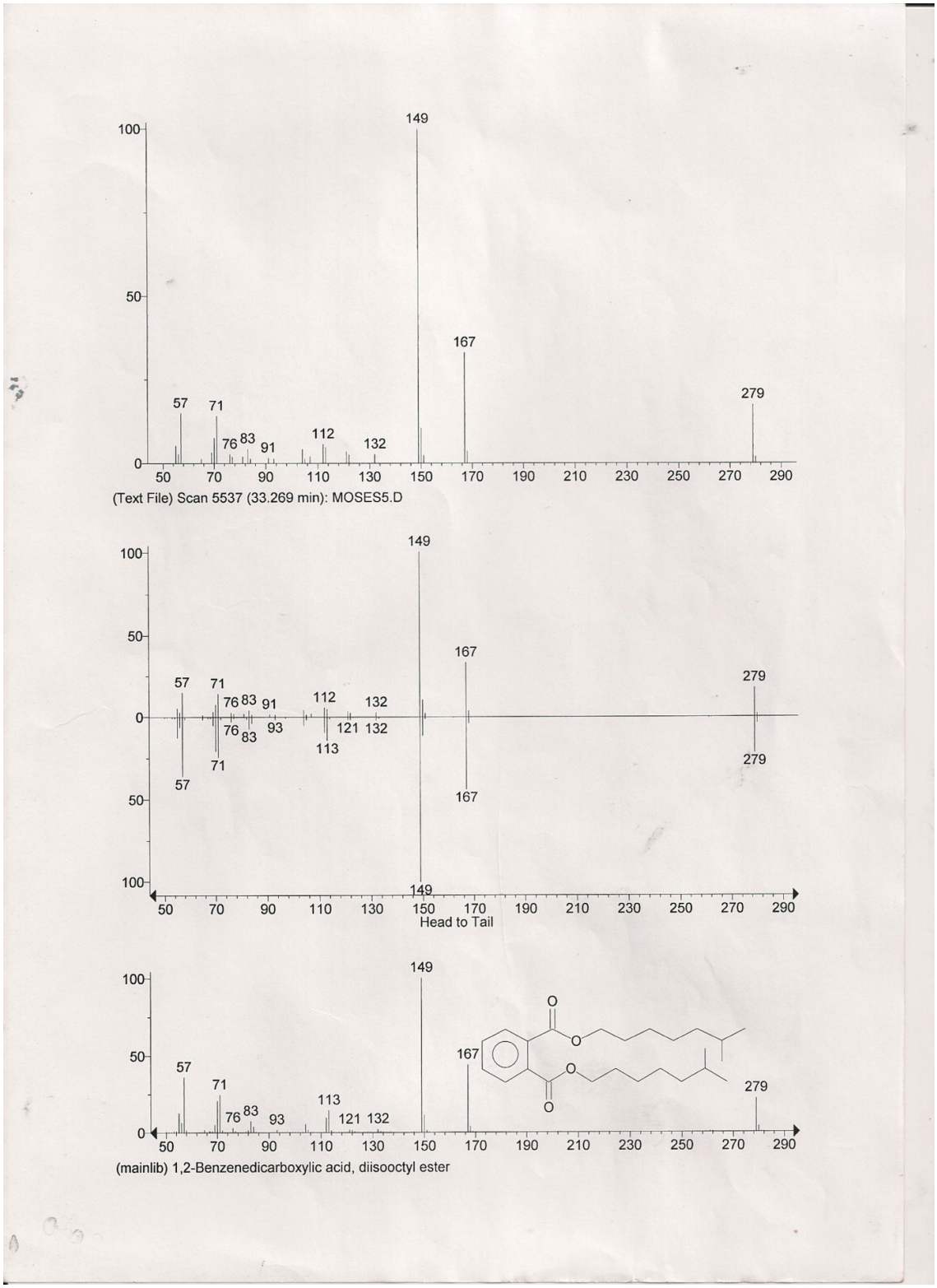
**Appendix 28: GC/MS: spectra for sample A1 (wet season)**



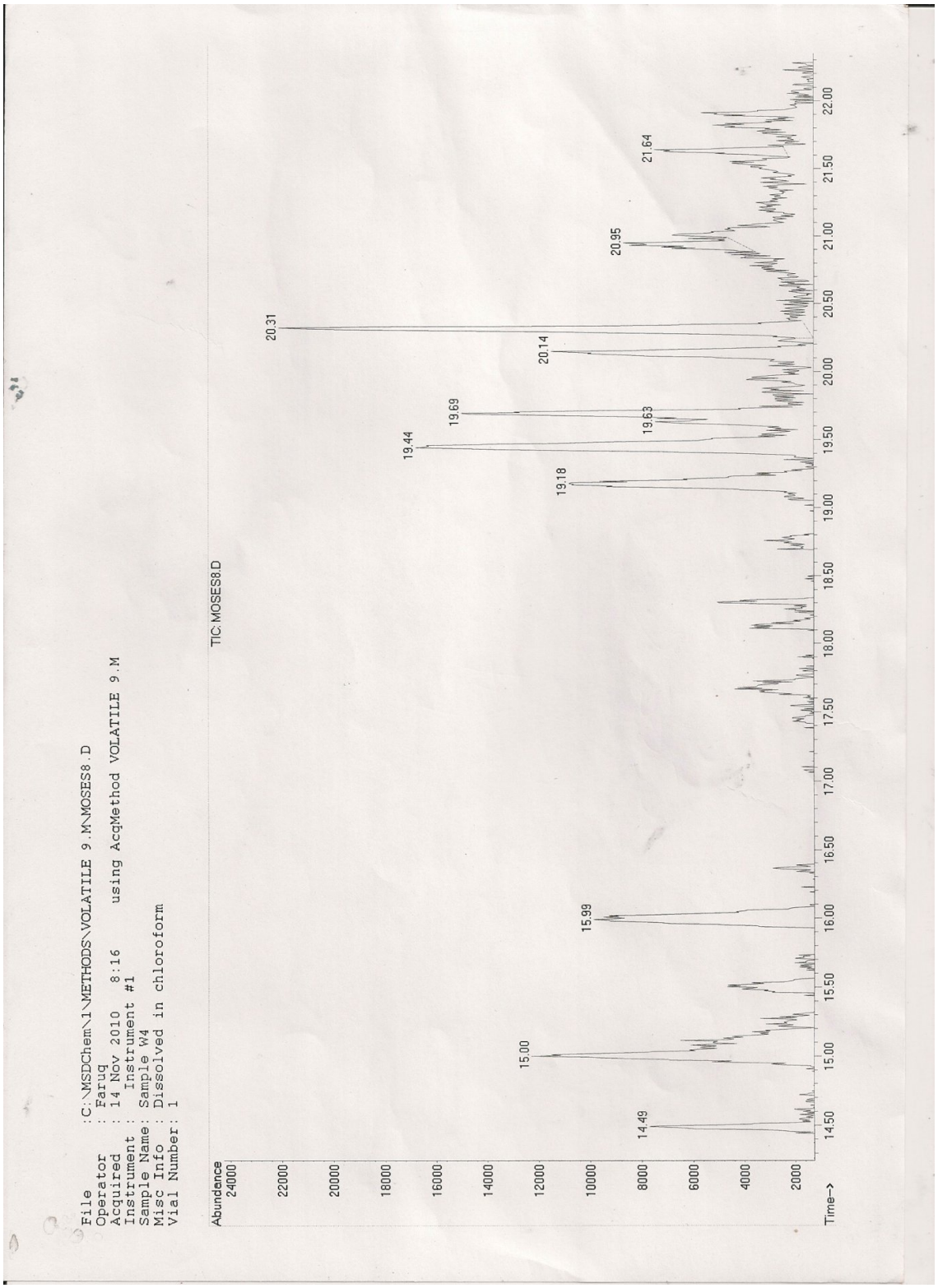
**Appendix 29: GC/MS: spectra for sample A1 (wet season)**



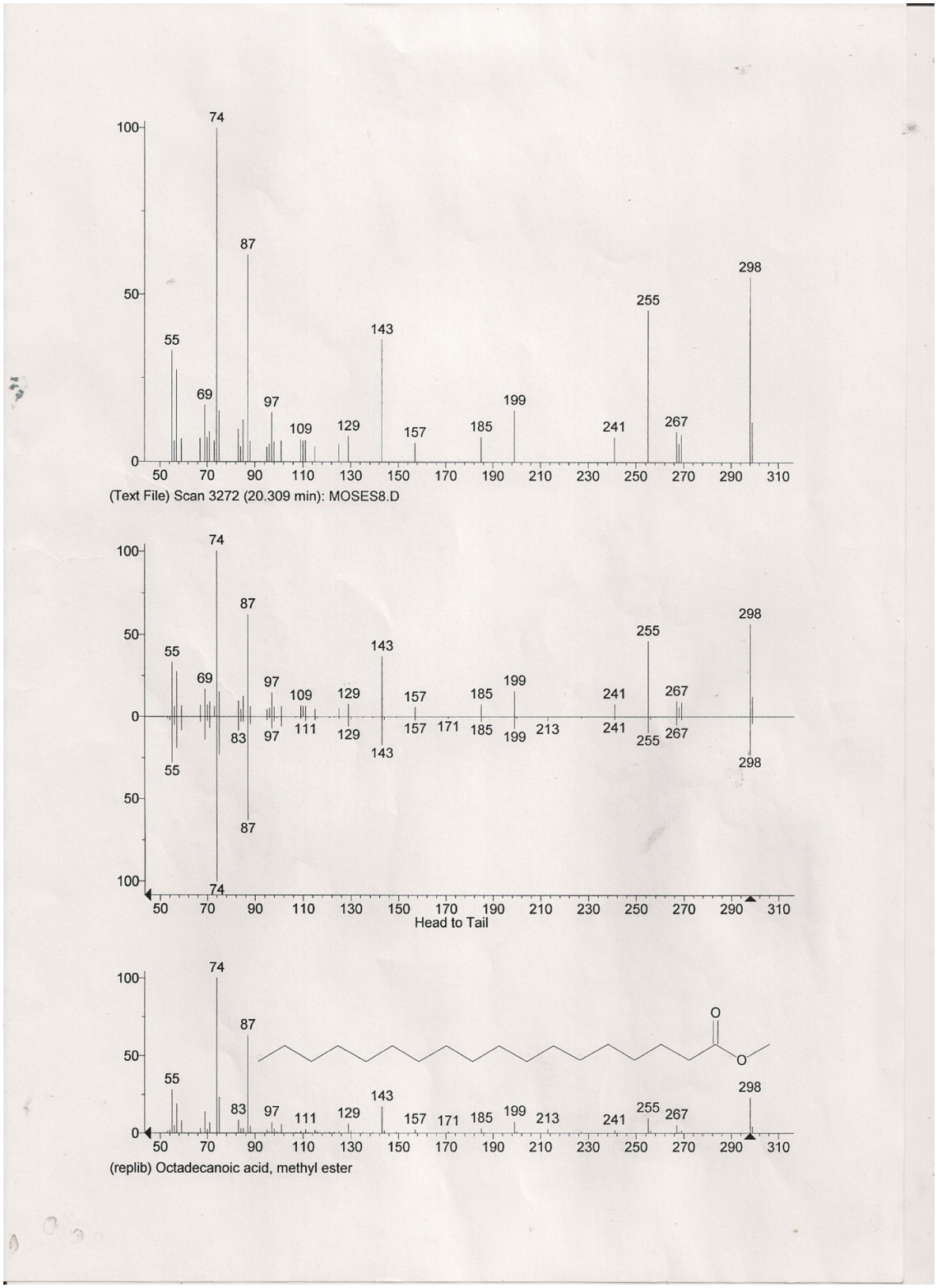
**Appendix 30: GC/MS: spectra for sample A1 (wet season)**



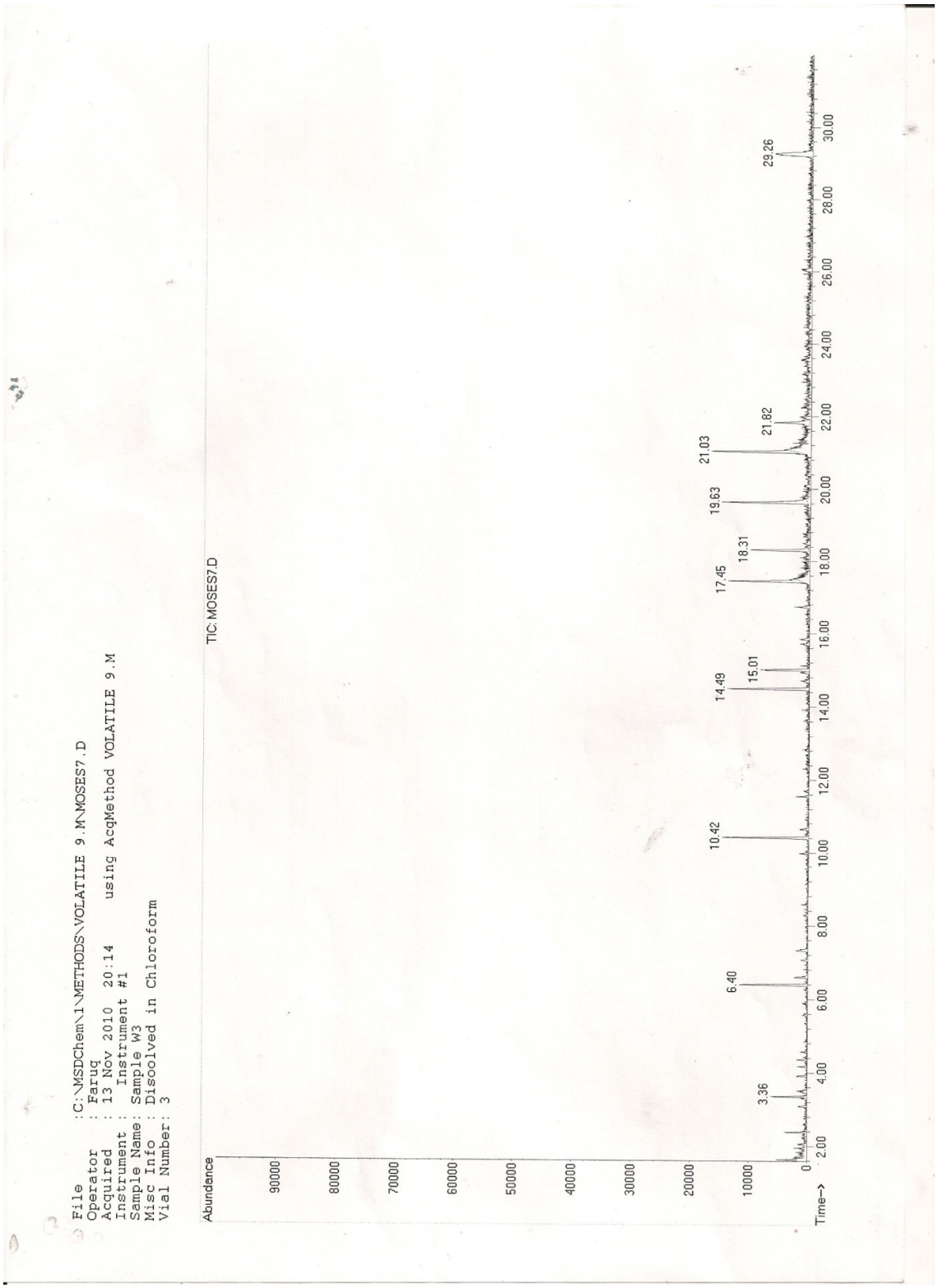
**Appendix 31 GC/MS trace of sample A2 (dry season)**



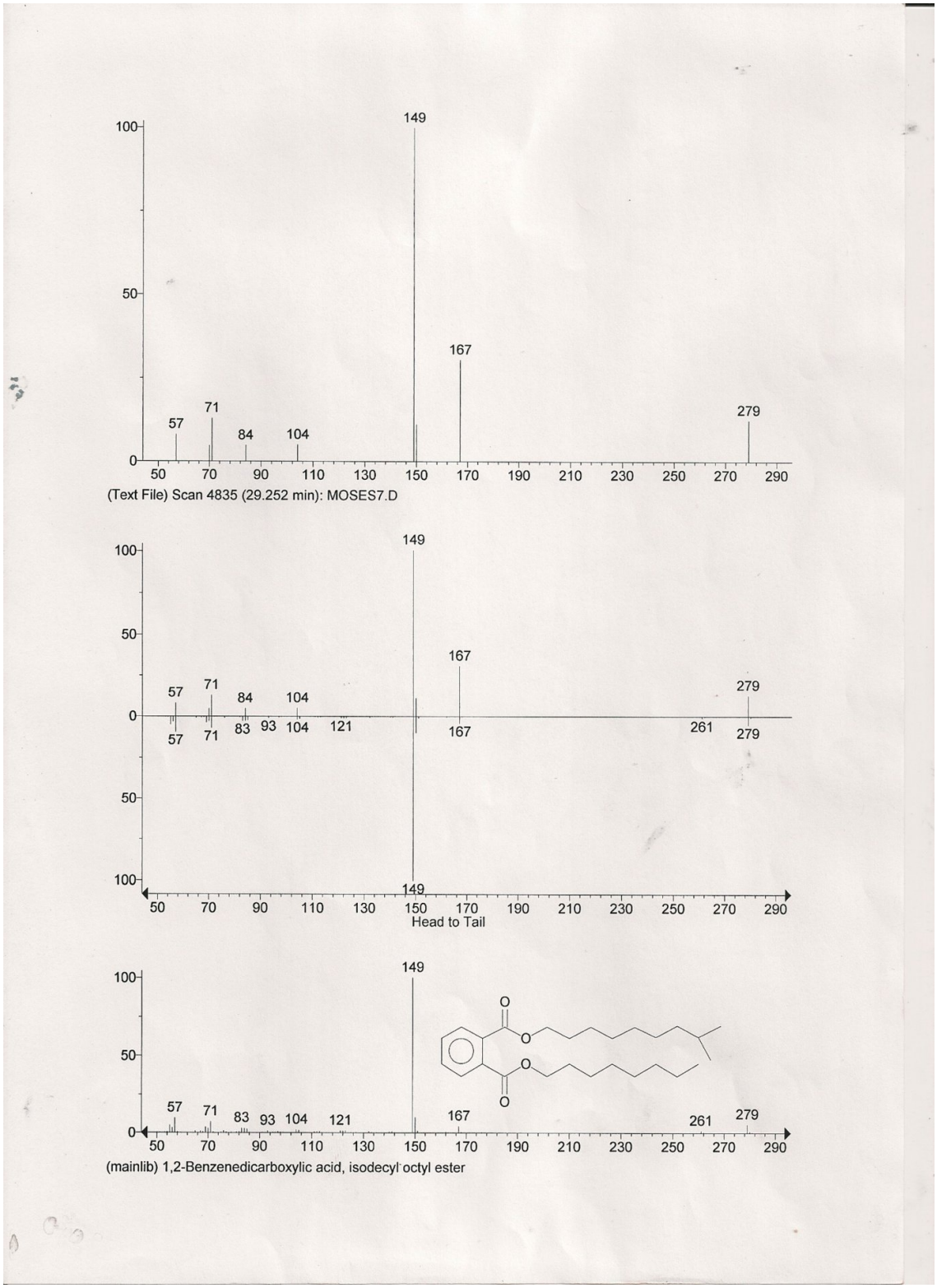
**Appendix 32: GC/MS: spectra for sample A2 (dry season)**



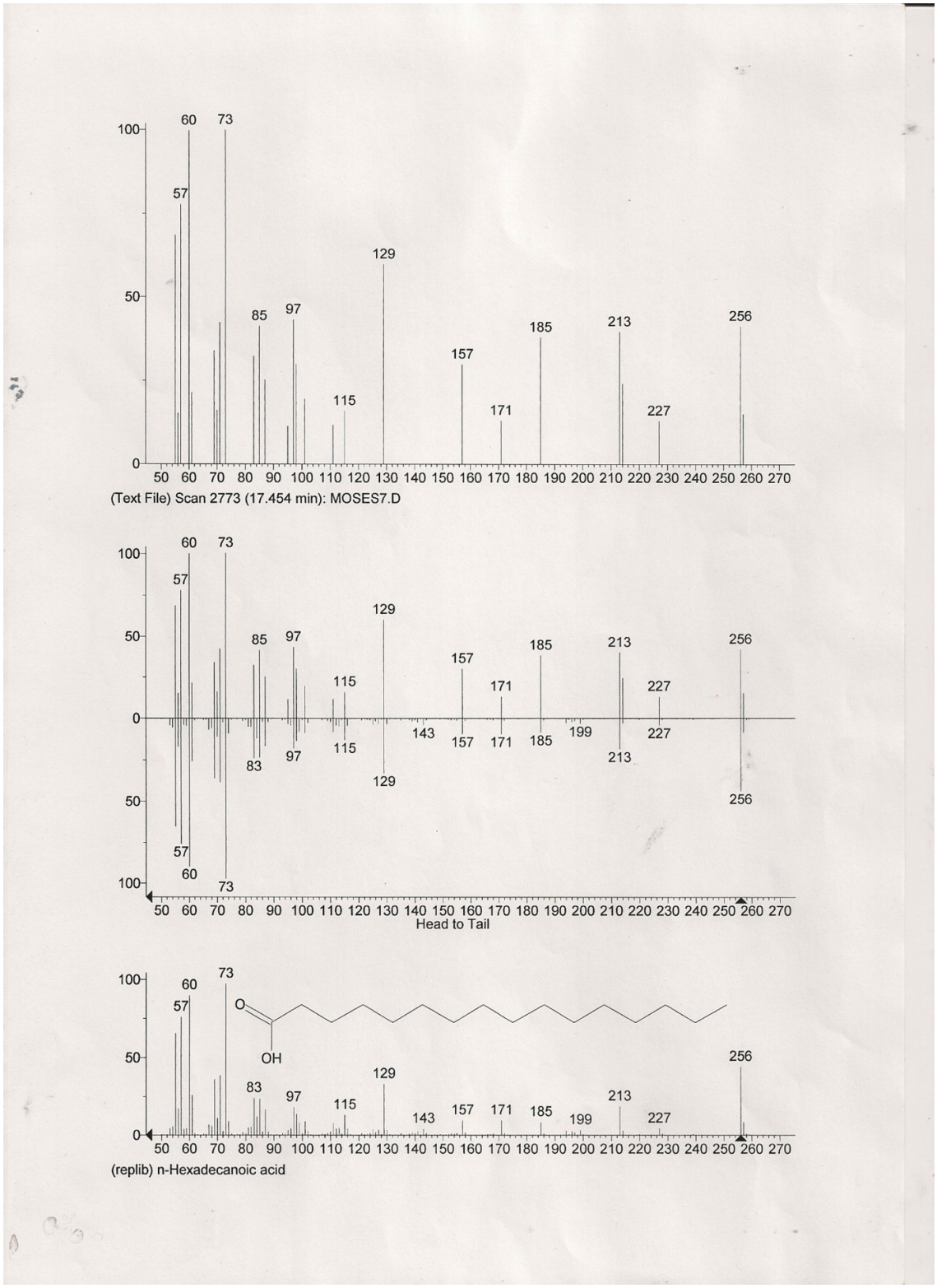
**Appendix 33 GC/MS trace of sample D3 (wet season)**



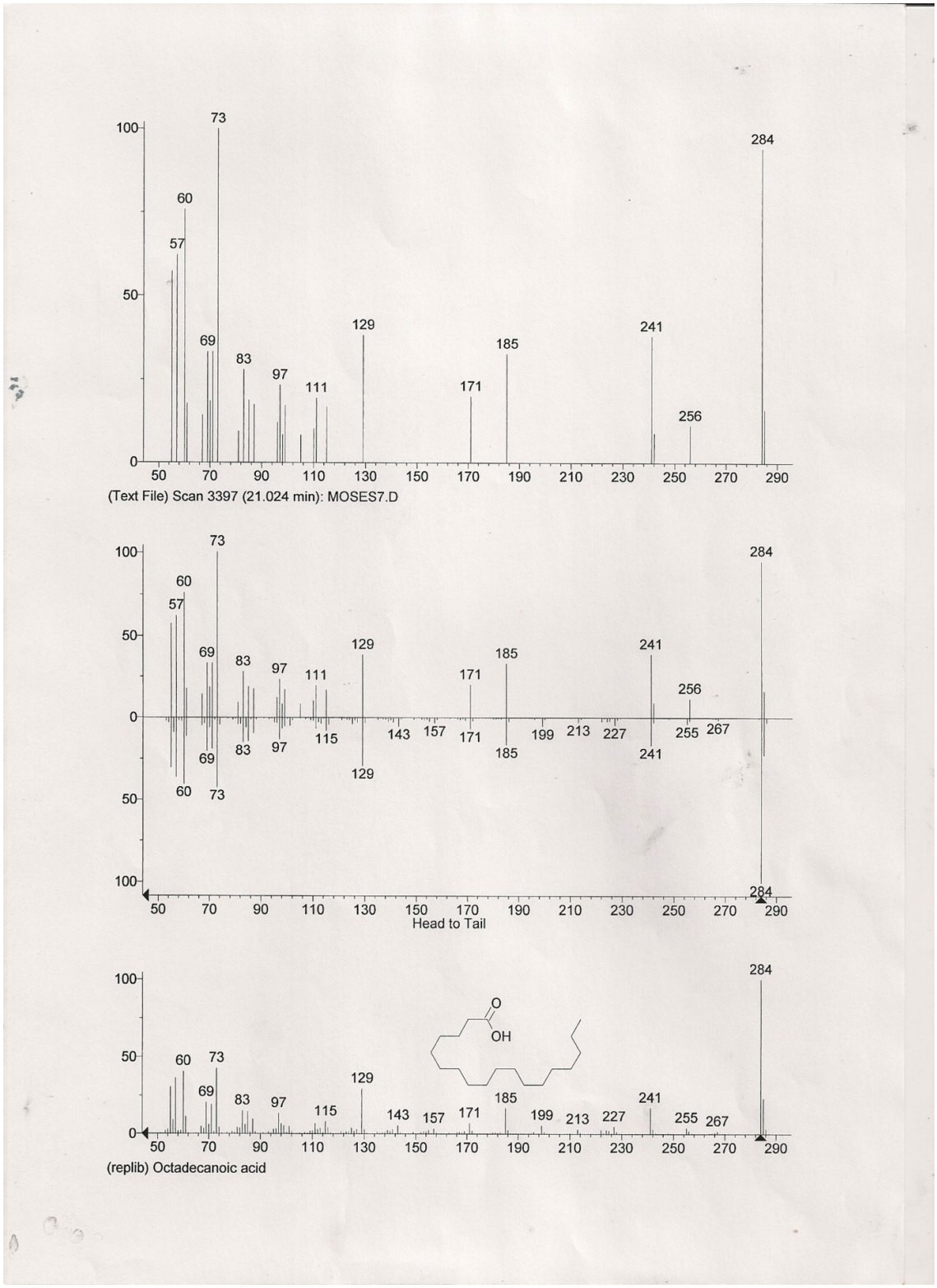
**Appendix 34: GC/MS: spectra for sample D3 (wet season)**



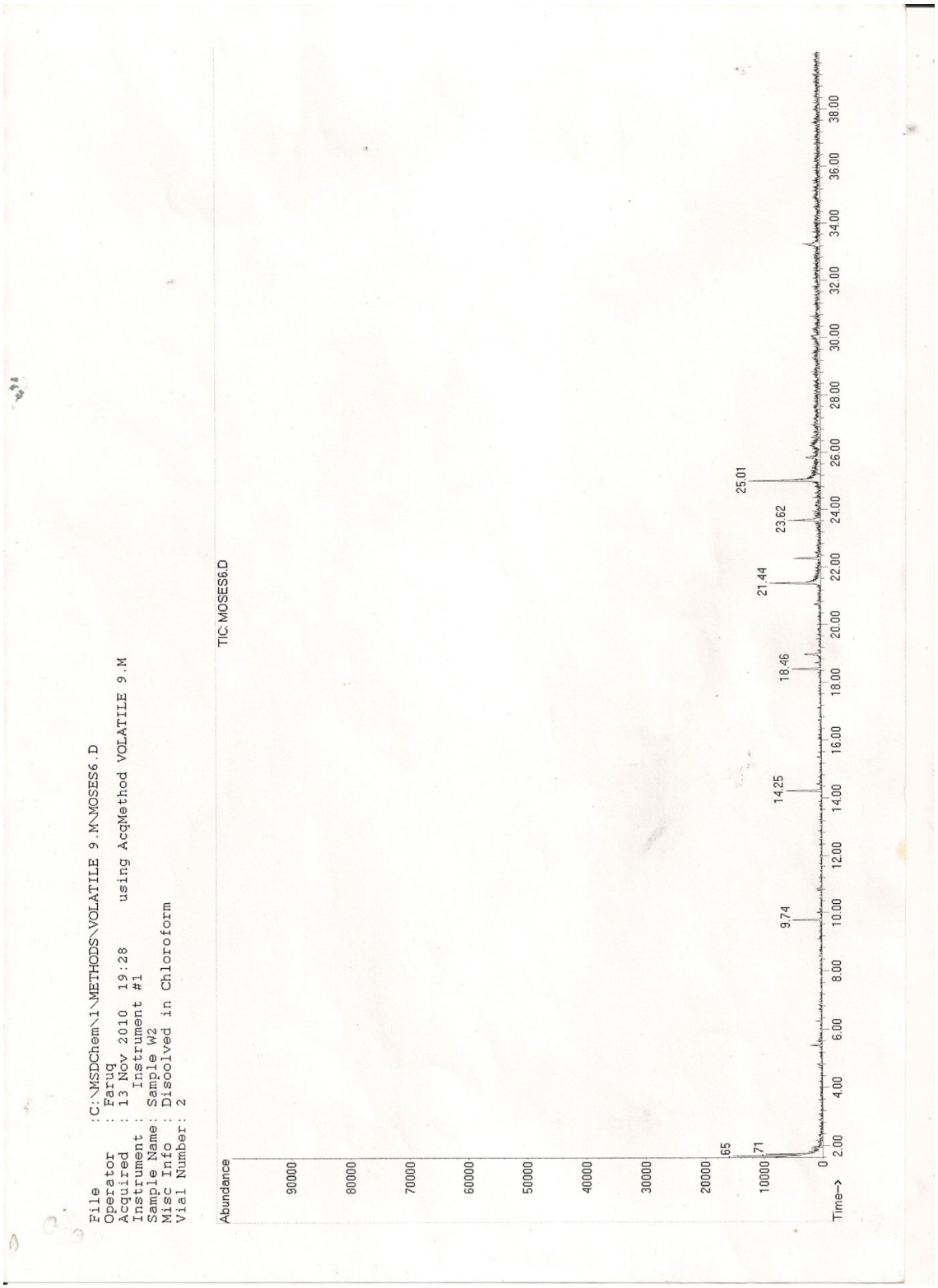
**Appendix 35: GC/MS: spectra for sample D3 (wet season)**



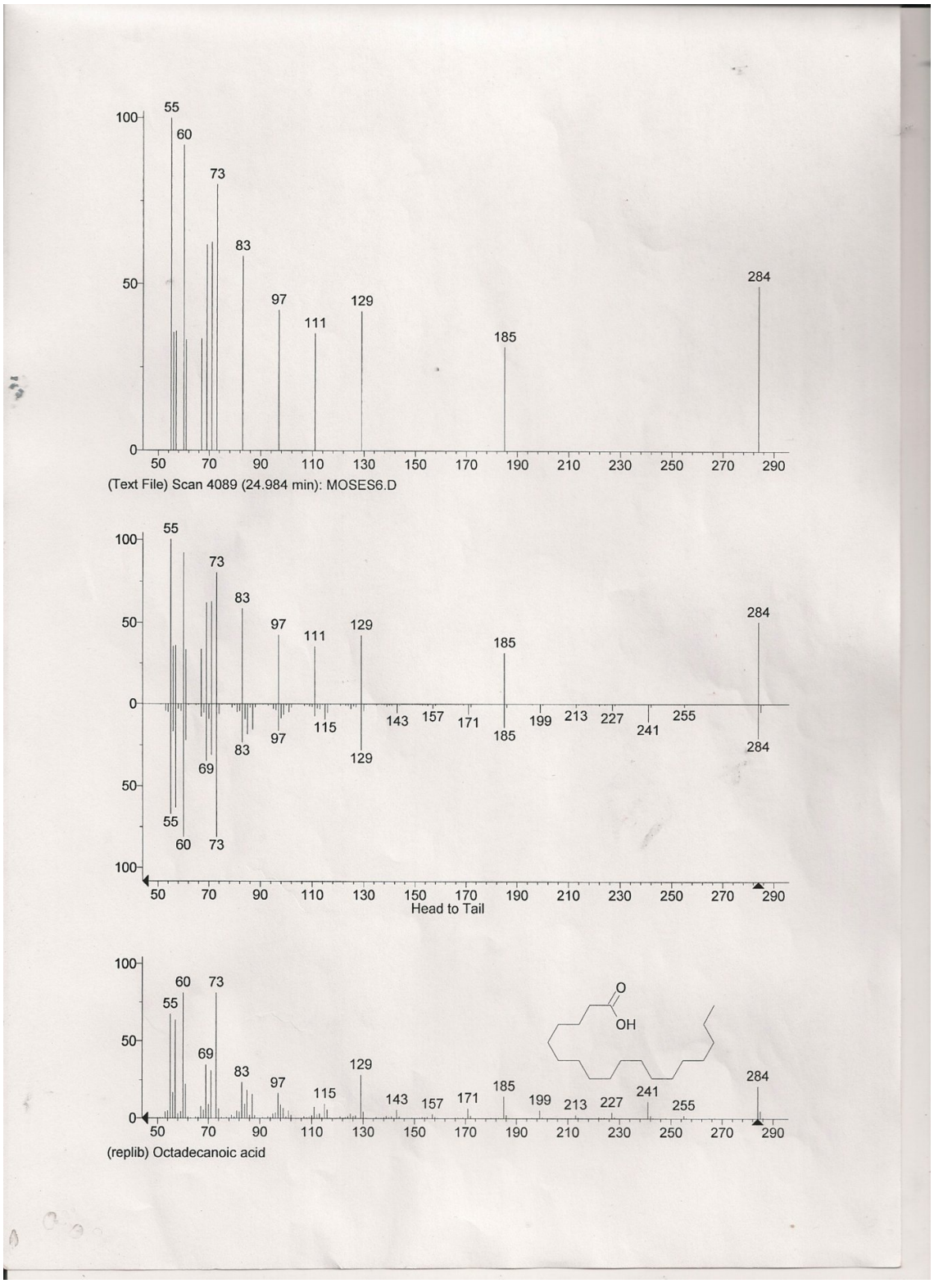
**Appendix 36: GC/MS: spectra for sample D3 (wet season)**



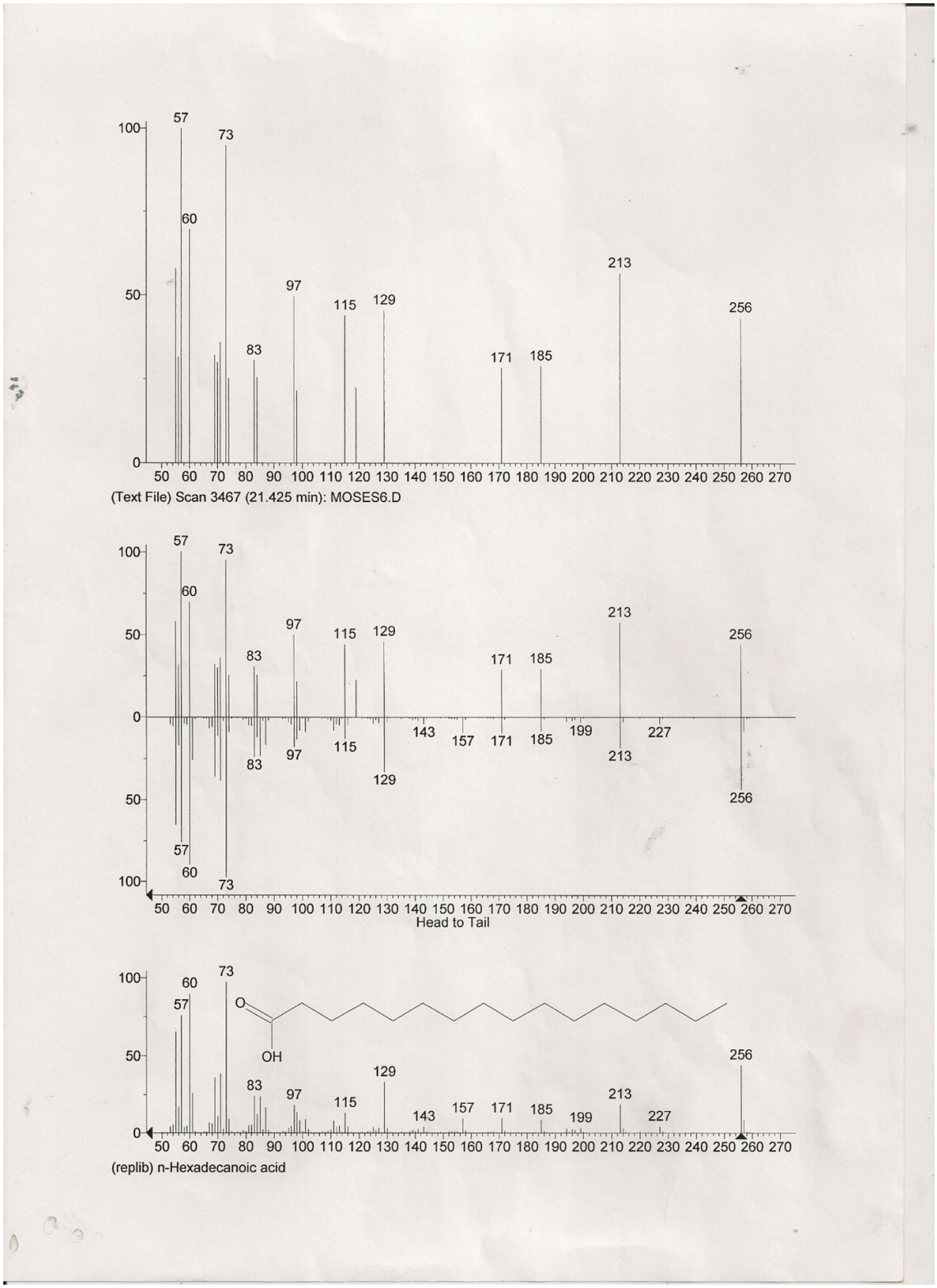
**Appendix: 37 GC/MS trace of sample D4 (wet season)**



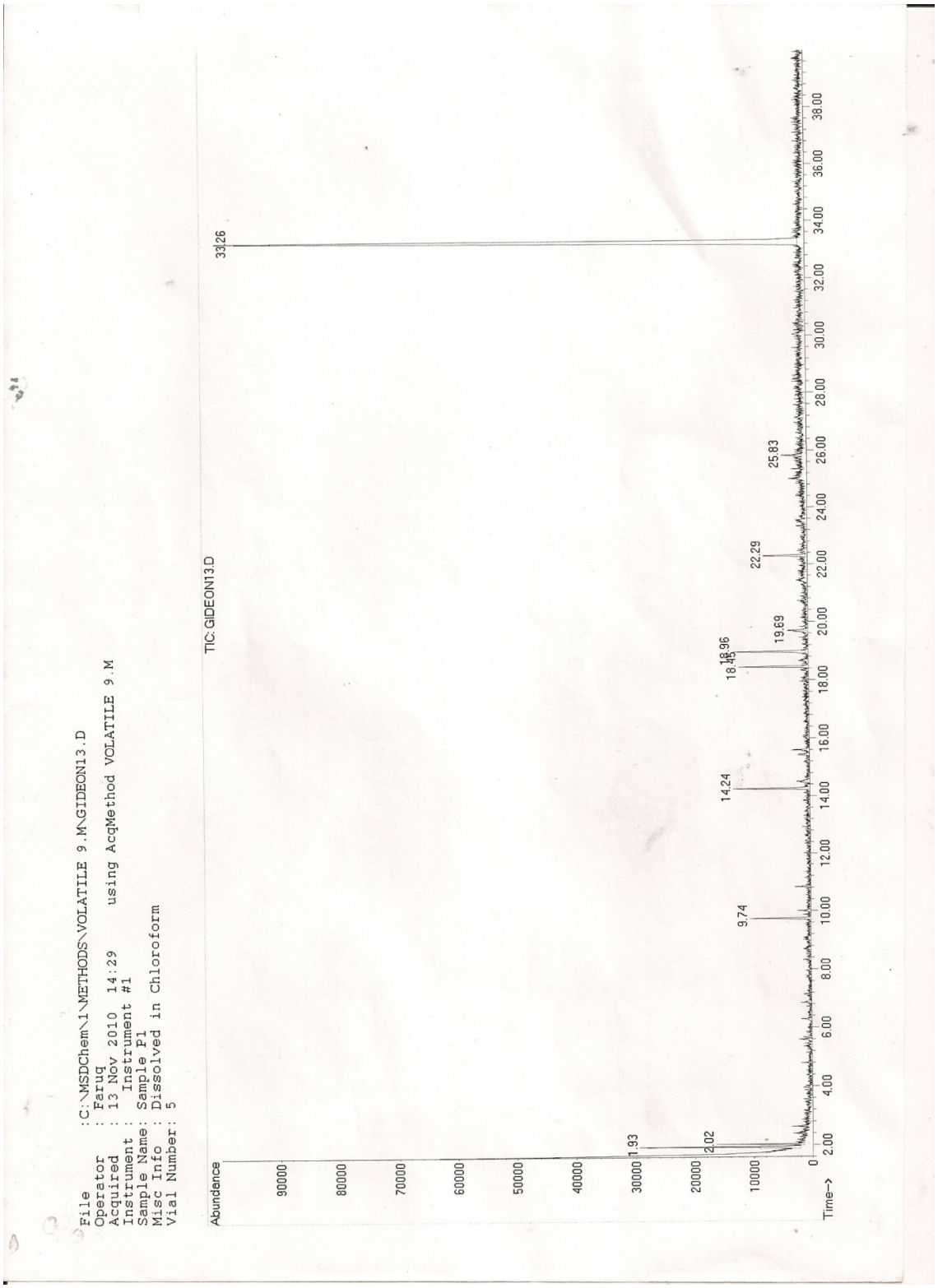
**Appendix 38: GC/MS: spectra for sample D4 (wet season)**



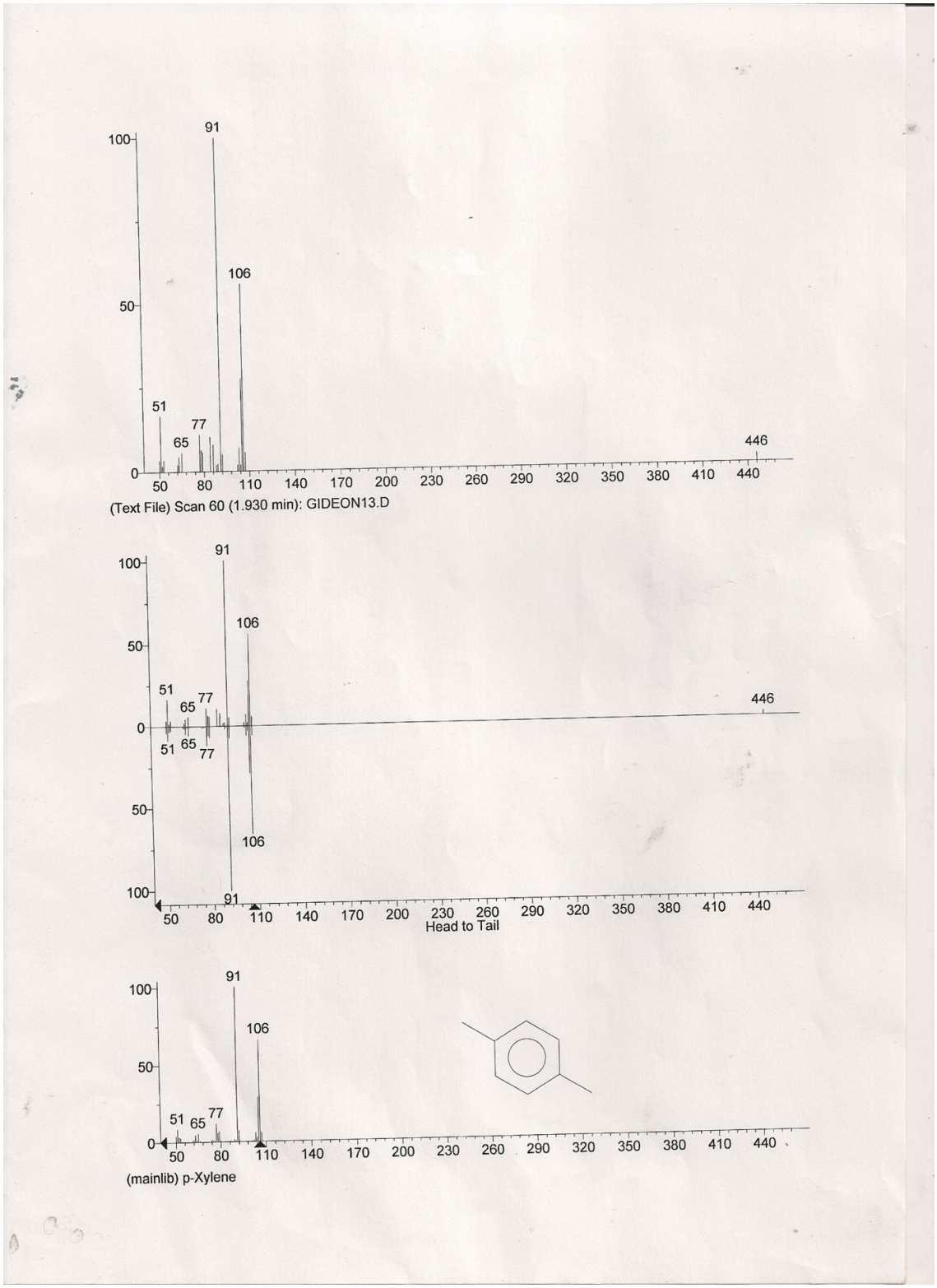
**Appendix 39: GC/MS: spectra for sample D4 (wet season)**



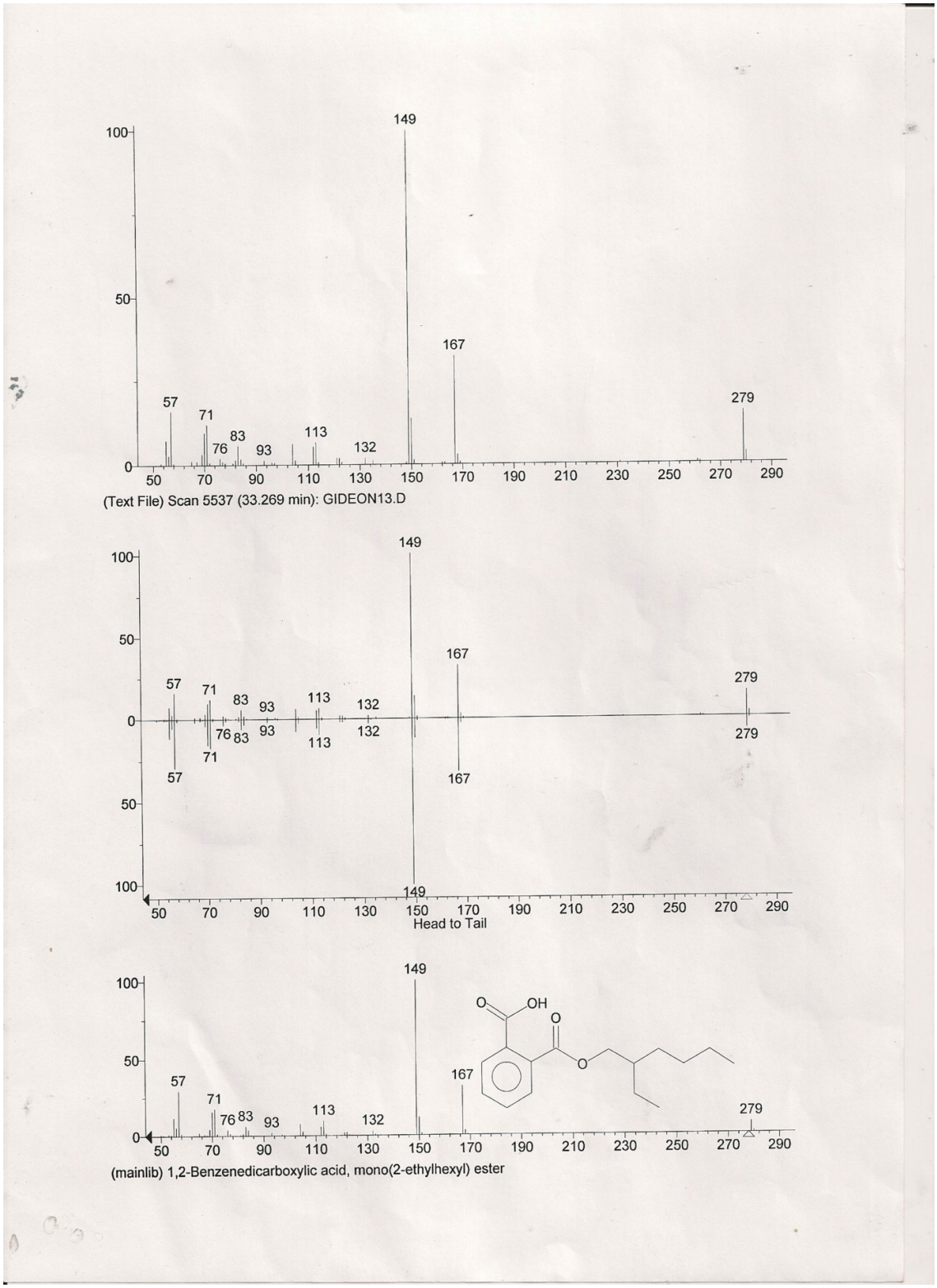
**Appendix 40 GC/MS trace of sample P1**



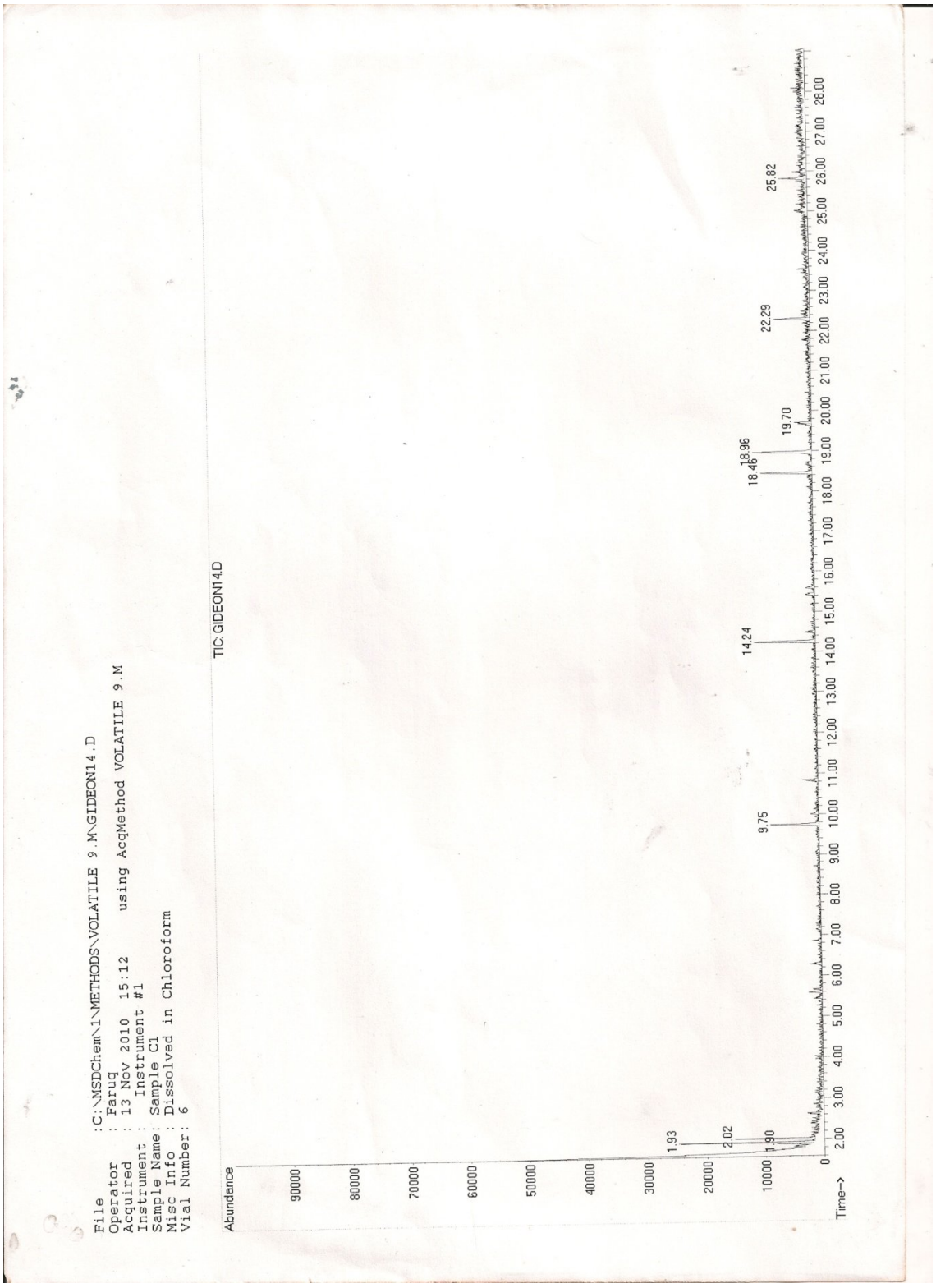
**Appendix 41: GC/MS: spectra for sample P1**



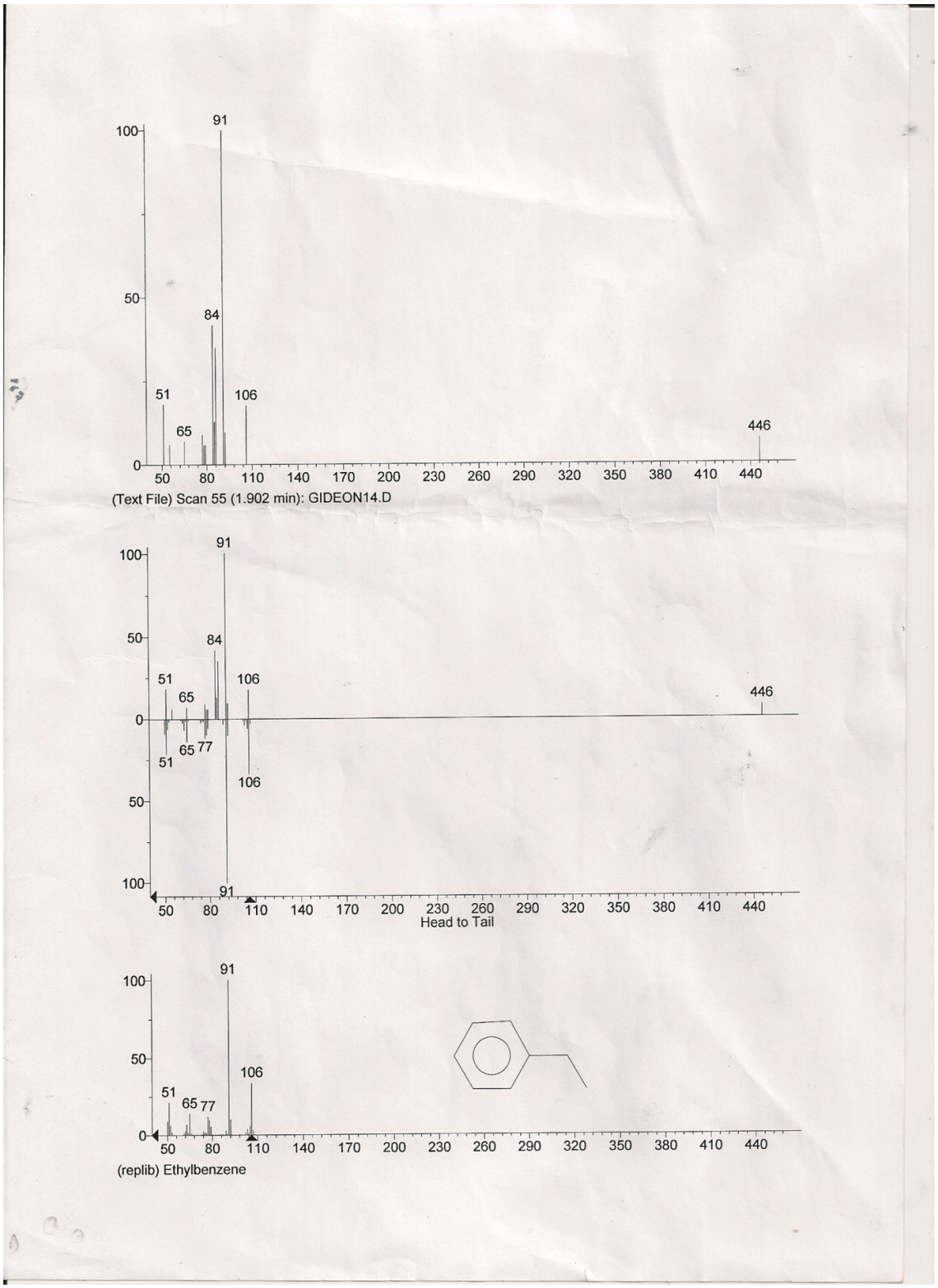
**Appendix 42: GC/MS: spectra for sample P1**



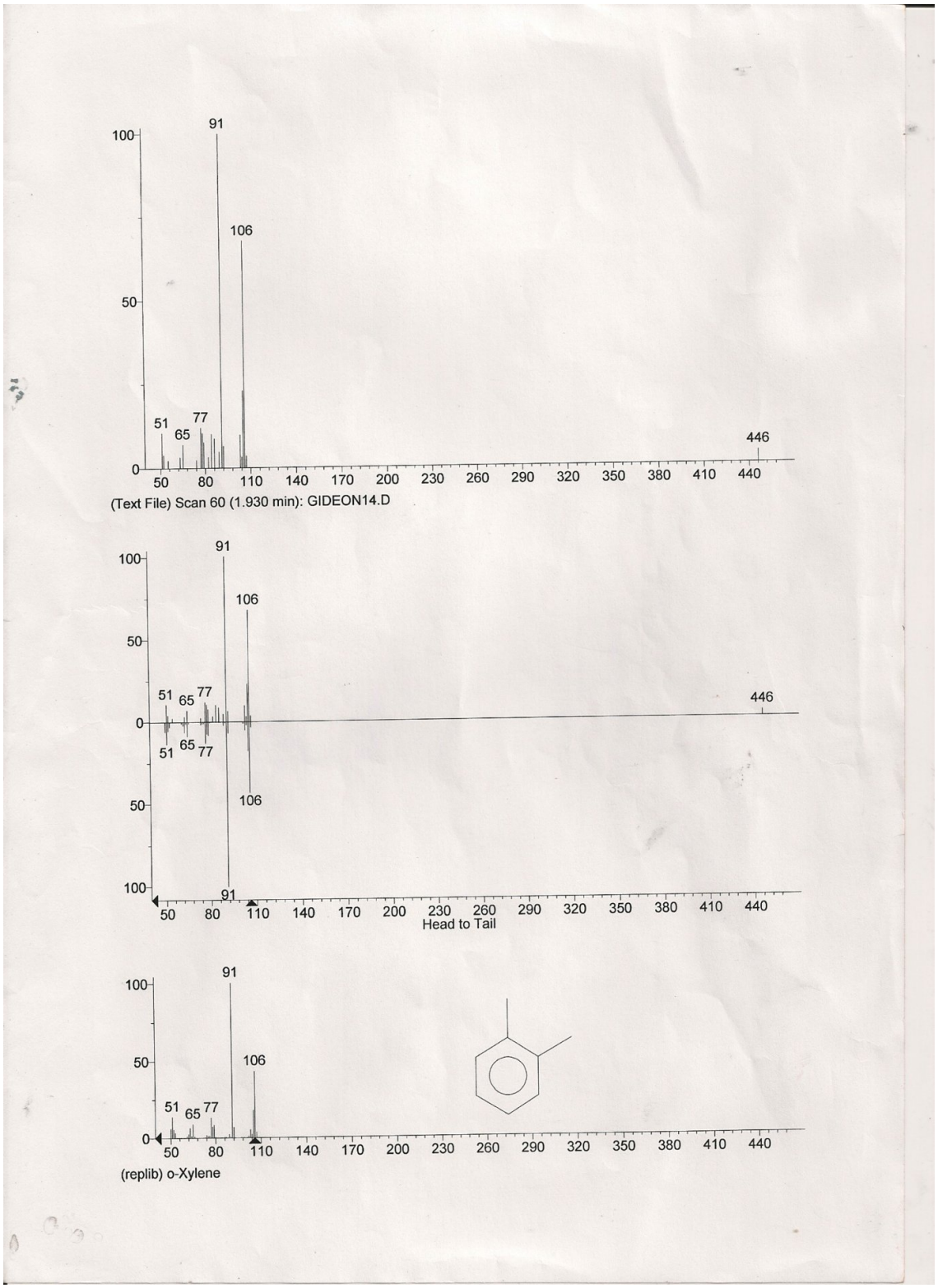
**Appendix: 43 GC/MS trace of sample C1 (wet season)**



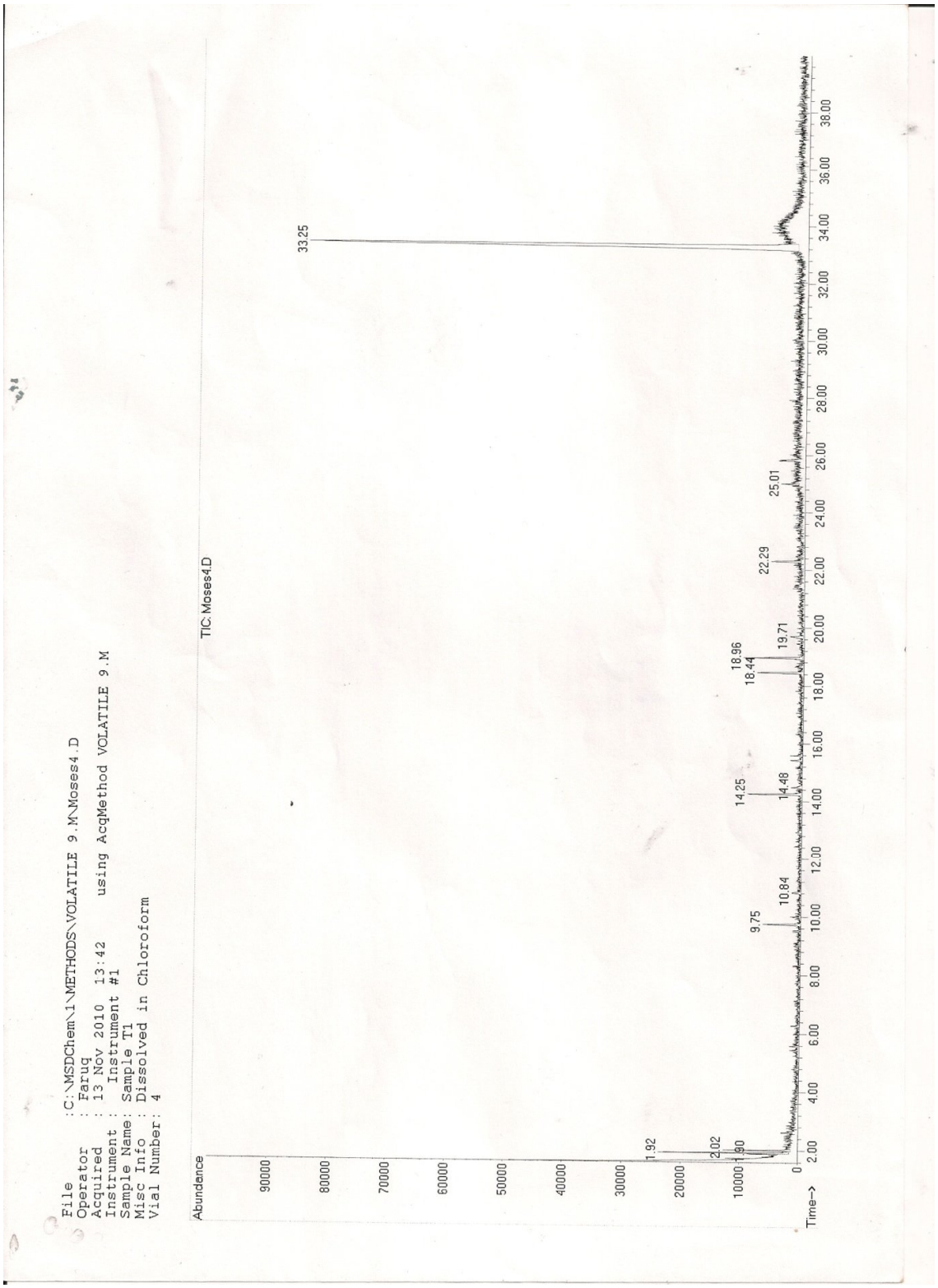
**Appendix 44: GC/MS: spectra for sample C1 (wet season)**



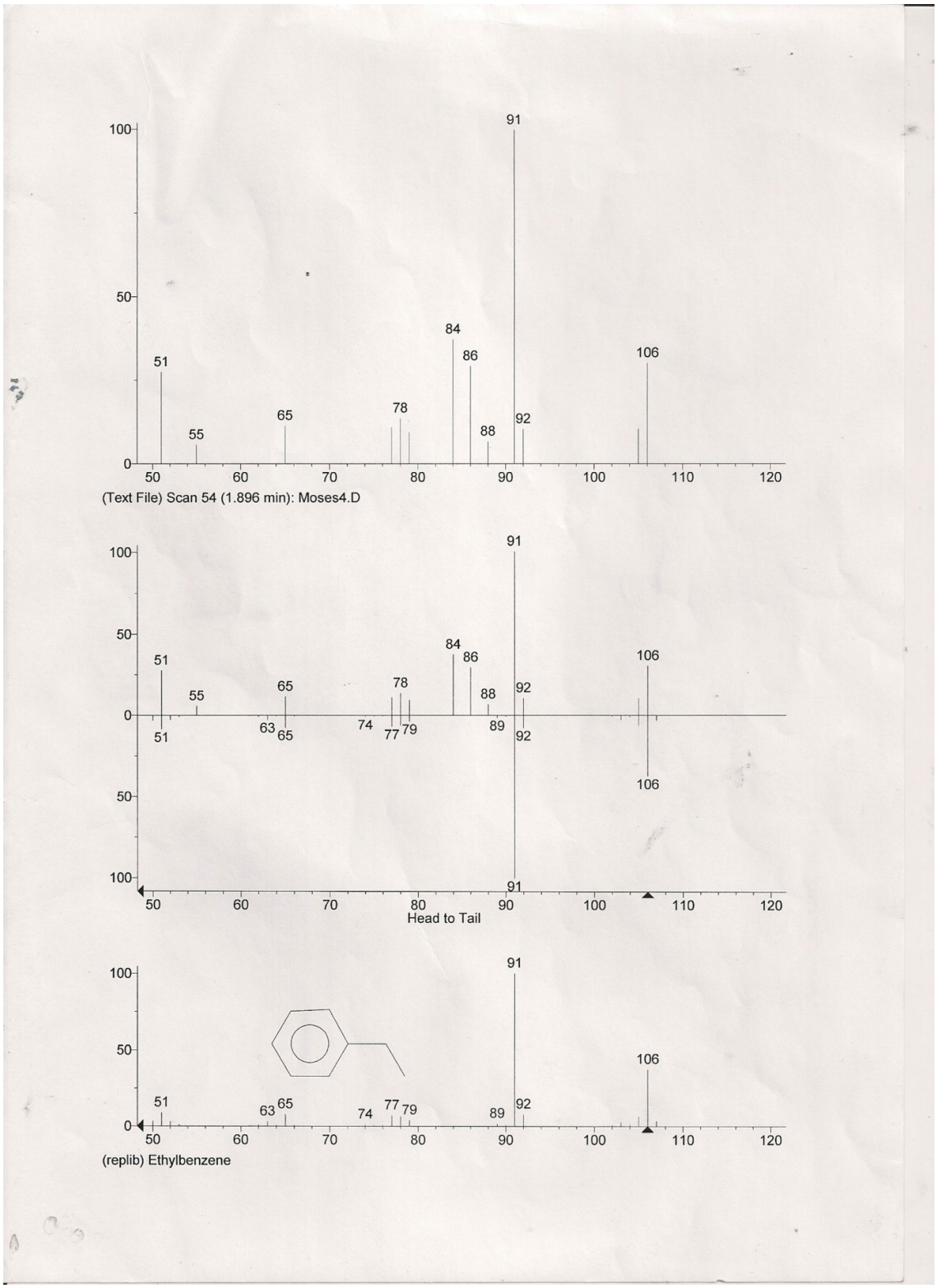
**Appendix 45: GC/MS: spectra for sample C1 (wet season)**



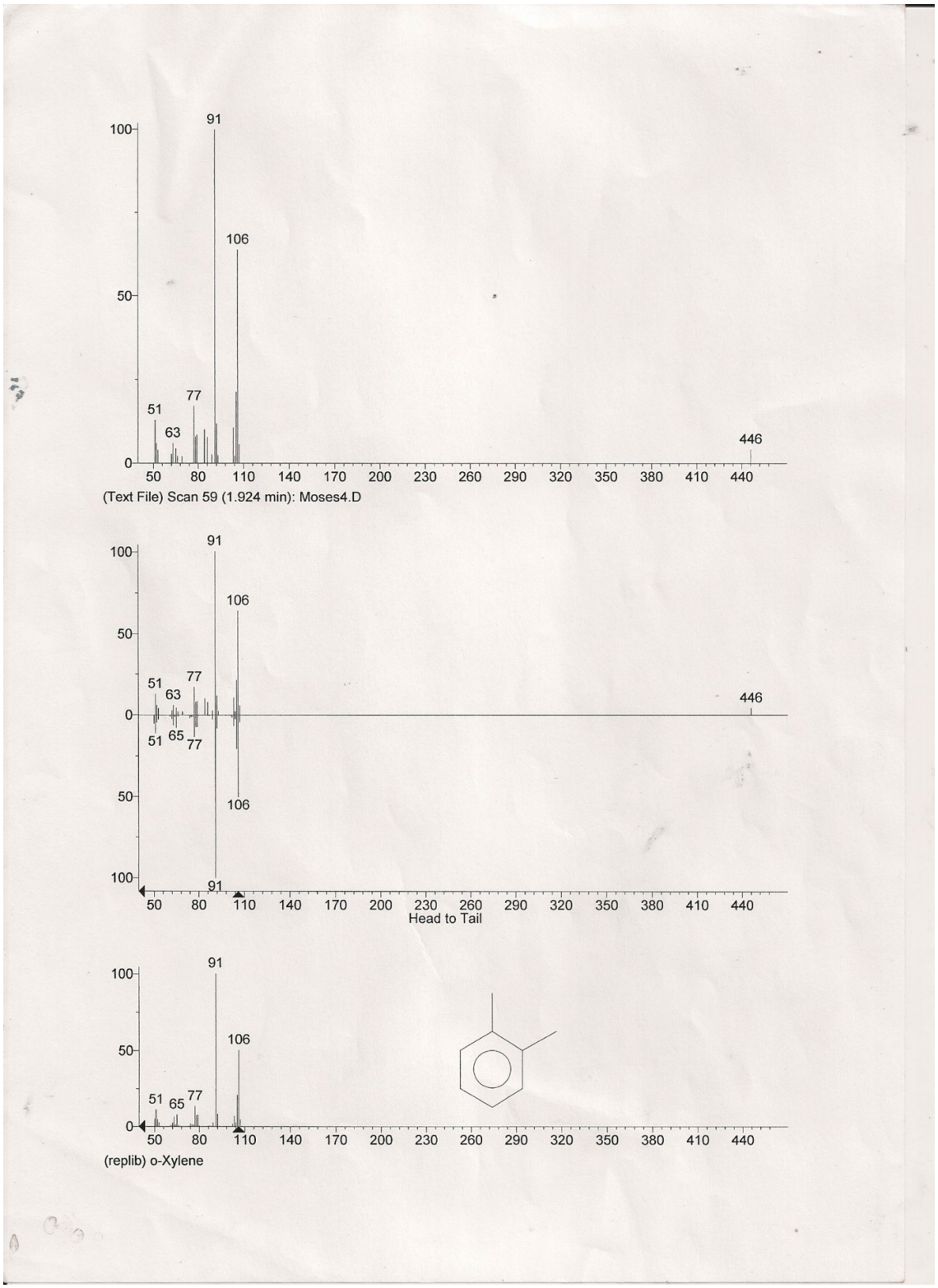
**Appendix: 46 GC/MS trace of sample T1**



**Appendix: 47 GC/MS spectra of sample T1**



**Appendix: 48 GC/MS spectra of sample T1**



**Appendix: 49 GC/MS spectra of sample T1**

