BLOOD LEAD LEVELS IN AUTO-MECHANICS, PETROL STATION ATTENDANTS AND FULANI CATTLE REARERS IN ILORIN WEST LOCAL GOVERNMENT AREA OF KWARA STATE, NIGERIA

BY

SIDDIK, SULAIMAN OBA
B.Sc BIOCHEMISTRY (UNIVERSITY OF IBADAN)

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DEPARTMENT OF EPIDEMIOLOGY, MEDICAL STATISTICS AND ENVIRONMENTAL HEALTH
FACULTY OF PUBLIC HEALTH, COLLEGE OF MEDICINE,
UNIVERSITY OF IBADAN, NIGERIA

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CERTIFICATION

I certify that this work was carried out by MR SIDDIK SULAIMAN OBA of the Environmental Health Division, department of Epidemiology, Medical Statistics and Environmenta. Health, Faculty of Public Health, College of Medicine, University of Ibadan.

SUPERVISOR
PROFESSOR M. K. C. SRIDHAR
B.Sc (Andhra),M.Sc(Baroda), Ph.D (IISC) C.Chem,
M.R.S.C.,F.R.S.H., M.C.I.W.E.M.

Department of Epidemiology, Medical Statistics and Environmental Health, Faculty of Public Health, College of Medicine, University of Ibadan.

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Department of Epidemiology, Medical Statistics and Environmental Health, Faculty of Public Health, College of Medicine, University of Ibadan.

ABSTRACT

Lead substances and exhaust from automobiles pose both environmental and health hazard. The occupational handling of leaded petrol, exposure to exhaust as well as the increase in the number of *car- wash centres* discharging their waste water into streams increase the predisposition to lead and associated health hazard. There have not been studies on blood lead levels in auto-mechanics, petrol station attendants and herdsmen in the area. The main objective of the study was to measure the blood lead levels in the three different occupational groups, viz. automobile mechanics, petrol station attendants and Fulani herdsmen in Ilorin West LGA of Kwara State, Nigeria.

The study had descriptive and laboratory components. Purposive sampling was used to select 41 mechanics, 40 petrol attendants and 29 Fulani herdsmen. Semi-structured questionnaire was administered to the 110 respondents. The information collected included demographic characteristics, occupational features and perceived health problems. Food habits of the selected respondents were documented and venous blood samples were collected at two periods in time; during panic buying and normal sale and samples of fodders collected around where cattle grazes were analysed for lead using Atomic Absorption Spectrophotometer Bulk 200. The blood levels of calcium and zinc were also determined. The data were analysed using χ^2, correlation, t- and F- tests.

The mean ages of auto- mechanics, petrol station attendants and Fulani herdsmen were 32.4, 32.7 and 27.5 respectively. Ninety-eight percent of the auto-mobile mechanics and 100% of the petrol station attendants used petrol as solvent for removing grease or as hand wash. Ninety-one percent of auto-mechanics and petrol attendants siphoned it from automobile tank with mouth and rubber hose. Ninety-three percent of auto-mechanics and

87.5% of petrol attendants used plastic containers for carrying petrol. During the panic buying period in 2004, the auto-mechanics, petrol station attendants and herdsmen had mean blood lead (µg/dl) of 20.1 (± 4.2), 14.2 (± 3.2) and 2.2 (± 2.3) respectively and during the normal sale, they had 17.8 (± 4.6), 11.5 (± 3.1) and 1.9 (± 2.1) respectively. The values during both periods were less than the WHO limit of 25 µg/dl. A strong positive correlation existed between blood lead levels in both periods ($r = 0.965$ and $p < 0.05$). Significant relationship was observed between the blood lead levels and occupation in both periods with ($p < 0.05$). In auto- mechanics and petrol station attendants, lead levels positively correlated with length of contact in both periods ($r = 0.255$, $p < 0.05$ and $r = 0.331$, $p < 0.05$) respectively. Significant relationship was observed between fodder and lead ($p<0.05$). Lead levels negatively correlated with the blood calcium and zinc levels in both periods.

The auto-mechanics are more predisposed to environmental lead absorption. Risk of high lead was higher in the auto-mechanics than others. The low blood lead in herdsmen indicated some level of exposure through the food chain because analyses of fodder consumed by cattle during grazing showed lead. There is need for the replacement of leaded petrol with unleaded one or absolute spirit.

Key words: Occupation, Petrol, Blood, Lead.

Word count: 499

DEDICATION

This piece of work is specially dedicated to the almighty god who is the Beginning and the End of all things.

And to all concerned towards the survival of our Environment.

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TABLE OF CONTENTS

CHAPTER THREE

CHAPTER FIVE

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND INFORMATION

In the quest for improved standard of living, man ventured into the homeostatic natural habitat through different areas of scientific knowledge which in the end resulted into myriads of problems very difficult to solve. There was increase in total energy consumption as well as numbers of chemical substances needed. Insatiable quest later resulted in pollution and the introduction of some chemical substances that are poisonous to humans and animals.

As at 1988, about 88.0% of the total world energy consumption was provided by fossil fuels (oil 37.5%, coal 30.0% and natural gas 20.2%) and the combustion of the fuel for different purposes is the predominant source of primary pollutants in developed and industrialized nations as well as developing nations. The primary pollutants when there is complete combustion are CO_2, SO_2, NO_x, and volatile trace metals such as arsenic (As), cadmium (Cd), lead (Pb) and mercury (Hg) (UNEP 1992).

Lead is a bluish grey metal that is malleable and non-corrosive but it is a serious cumulative poison. It is ubiquitous in the environment of industrial and developing nations as a result of its diverse areas of application. The contribution of the natural sources to the environment (about 19,000 tonnes/year) is low compared to that from human activities (Patterson et al, 1991) such as mining, smelting, refining, manufacturing and recycling which account for about 12,600 tonnes of lead per year getting into the air, water and surfaces of the soil (Nriagu, 1989). The annual consumption of lead is over 3 million tonnes (WHO 1993).

Some sectors which are contributors to the increase in lead in the environment include automobile traffic, heavy civil construction sector, manufacturing industries and those involved in combustion of fossil fuel (Onianwa, 1985). Natural water contains up to 5 µg/l of lead. In some cases up to 400 µg/l has been recorded (UNEP/FAO/WHO 1988) as a result of contamination from various sources such as industries, mines, smelter discharge, leaded pipes, erosion and others.

The primary production of lead is about 3.4 million tonnes (3.4×10^2 million kg) per annum while the secondary production of refined lead accounts for 43% of the total production as shown in Fig.1.1 (UNEP 1992). Petrol fraction takes a high proportion of the lead in the form of tetraethyl lead (II) and tetramethyl lead (II). As long as leaded petrol is used, there is need for continual monitoring of lead level of human blood as well as that of the environment.

A litre of petrol (petrol) in Nigeria contains from 0.5 g to 0.7 g of lead (Uche et al, 1991) in the form of tetraethyl lead (II) ($Pb(C_2H_5)_4$) and tetramethyl lead (II) $Pb(CH_3)_4$ used as anti-knocks (WHO,1993) as a way of boosting the Octane Number (ON). Octane number is the quantitative measurement of the performance of a fuel in an internal combustion engine (Uche et al, 1991). n-heptane has ON of zero while 2,2,4 trimethyl pentane has ON of 100.

To prevent lead from depositing inside the engine, two solvents (additives) are added to enhance its volatility. The additives are 1,2, dichloroethane and 1,2 dibromoethane. As such 75% of the lead used in petrol (petrol) ended up in the exhaust gas (Hu, 1998)

FIGURE 1.1: WORLD LEAD PRODUCTION 1960-1989
Source: United Nations Environment Programme (UNEP), 1992

and part of which is inhaled by humans and other animals while the remaining suspended particles settle on exposed objects, plants and water.

Ninety- eight percent (98 %) of car's exhaust is composed of water, oxygen, nitrogen and carbon dioxide. The volume of this mixture produced daily is high. The remaining 2 % nonnally considered as pollutants becomes very significant. Lead generated from tetraethyl lead (TEL) takes a high proportion of the pollutants (Agbo, 1997).

Lead is a highly toxic metal, which has no physiological benefit and technically its ideal blood level should be zero. However, because of its excellent physicochemical properties, the element has been found to be useful in a wide range of occupations that are extremely beneficial to man (Anctor et al, 1999).

Occupational Safety and Health Act of United State of America (OSHA, 1979) stipulated 0.05 mgPb/m^3 as permitted lead level in the work place air and that of blood of workers to be less than 40 mg Pb/100 g whole blood for adult worker and less than 30 mg Pb/ 100 g whole blood for prospective parent (Moshman, 1997).

Replacement of white lead in paint with titanium oxide has contributed greatly to the reduction of lead poisoning through flakes and aerosol spray from leaded paints. In the case of leaded petrol that has not been completely phased out (Fig 1.2), the auto-mechanics and the petrol attendants are more exposed to the lead because of their frequent exposure to automobile exhaust and also through some occupational features and practices.

Since lead in the blood is biologically active, it is used as an indicator of recent exposure and to evaluate the likelihood of health effects (UNEP, 1992). In some studies, lead concentration in air-borne particulates and blood showed similar decreases

Global Opportunities for Reducing the Use of Leaded Gasoline

Figure 2: Countries Using Leaded Gasoline vs. Unleaded, 1998

Source: IOMC 1998.

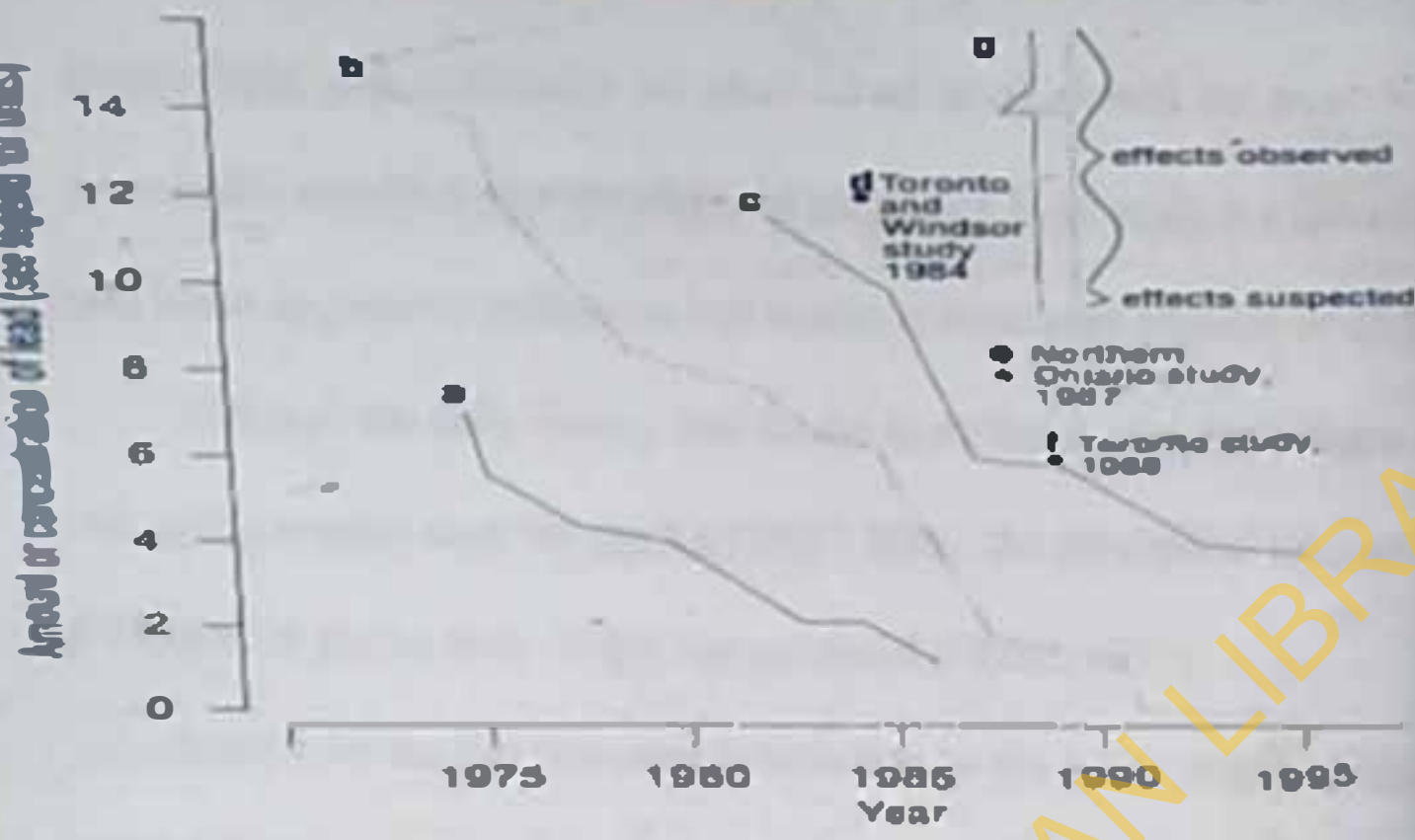
FIGURE 1.2: GLOBAL OPPORTUNITY FOR REDUCING THE USE OF LEADED PETROL

Source: World resources, 2001

associated with reduction of lead in petroleum and a shift to unleaded fuel as shown in Fig. 1.3.

Lead taken in by absorption, ingestion or diffusion will certainly get into the blood and then to various organs of the body where it could be stored for a long period as in osseous tissues of the bone. If it is possible to prevent or control the entry of lead through the dermal, GIT and other minor routes, it is really difficult to totally prevent its entry through the pulmonary route when it is present in the ambient air.

Figure 2.2 Time trends in lead emissions and environmental concentrations in Canada



a — lead concentration in ambient air ($\mu g\ m^{-3} \times 10$)
b — lead emissions from gasoline combustion (10^3 t)
c — lead emissions from all sources (10^3 t)
d — average blood lead levels in children in two southern Ontario urban areas (Toronto and Windsor) in 1984 ($\mu g\ dl^{-1}$)
e — average blood lead levels in children in a northern Ontario urban area in 1987 ($\mu g\ dl^{-1}$)
f — average blood lead levels in children in a southern Ontario urban area in 1987 (Toronto) ($\mu g\ dl^{-1}$)
g — current lowest range of blood lead levels at which deleterious effects have been observed in some population groups ($\mu g\ dl^{-1}$)

Source: (14)

FIGURE 13: TIME TREND IN LEAD EMISSIONS IN AND ENVIRONMENTAL CONCENTRATION IN CANADA

Source: United Nations Environment Programme (UNEP), 1992

Figure 2.2 Time trends in lead emissions and environmental concentrations in Canada

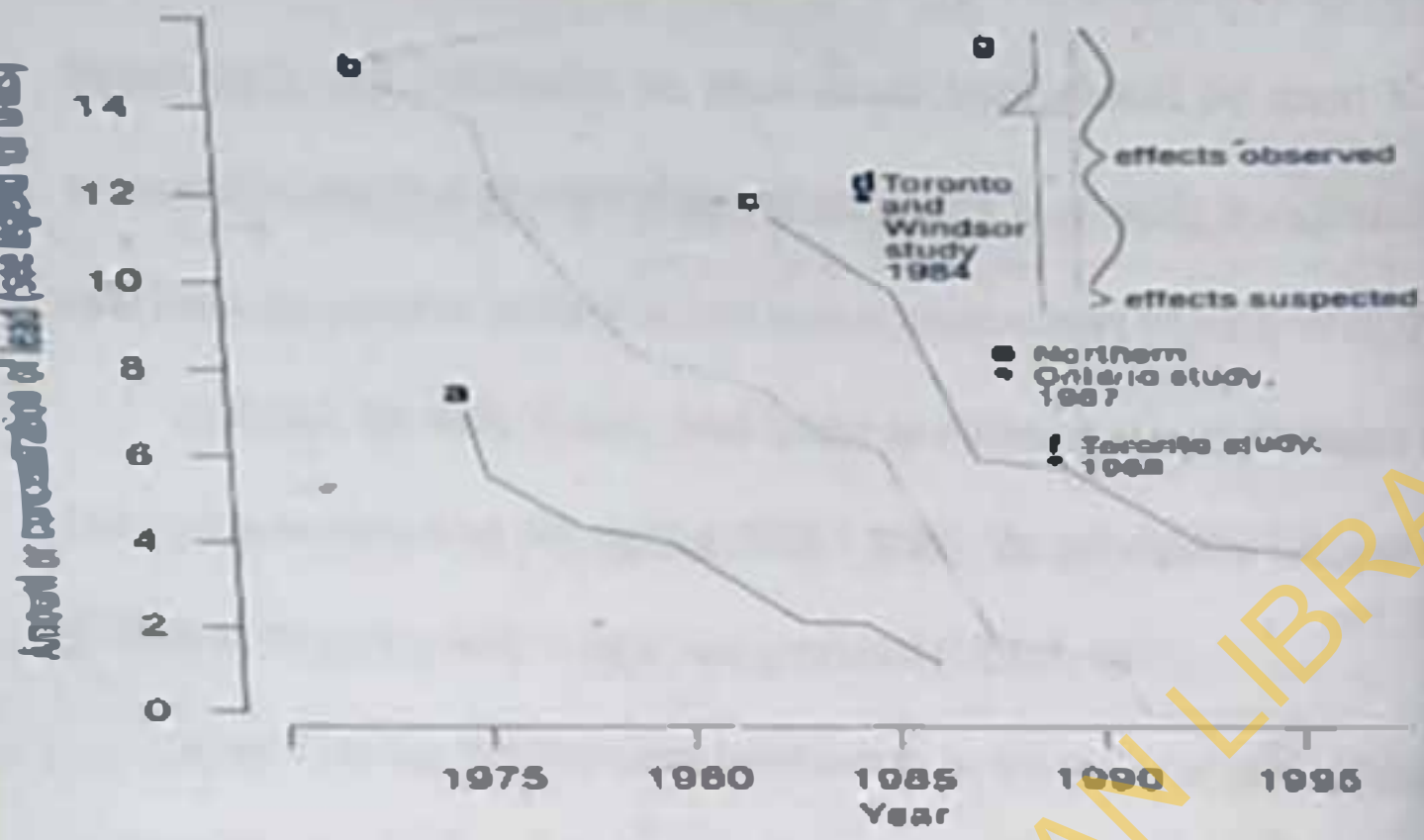


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FIGURE 1.3: TIME TREND IN LEAD EMISSIONS IN AND ENVIRONMENTAL CONCENTRATION IN CANADA

Source: United Nations Environment Programme (UNEP), 1992

1.2 STATEMENT OF THE PROBLEM

Several studies about lead on health have proved that it has no useful function in human body and technically its ideal blood level should be zero. Nevertheless, its unavoidable excellent physico-chemical properties have made it extremely beneficial to man hence its possible infiltration into human covironment (Anctor *et al*, 1999).

Although the daily dietary lead intake in different countries ranges from less than 100 µg/Kg to more than 400 µg/Kg (WHO 1989), the provisional tolerant weekly intake (PTWI) of 25 µg/Kg body weight was proposed (UNEP, 1992).

Apart from the fact that paint is known to be the major source of bioavailable lead in the environment, titanium dioxide is fast replacing it in the developed countries. In developing countries, lead as an additive to petrol fraction is the major source of lead pollution. Every litre of petrol sold in Nigeria, contains between 0.5 g to 0.7 g of Pb in the form of Tetraethyl lead II ($Pb(C_2H_5)_4$ as an antiknock agent and with the estimated daily consumption of 20 million litres therefore, more than 1500 Kg of lead is emitted into the atmosphere daily (Agbo, 1997).

In 1975, the lead that was emitted from petrol combustion in Canada alone was estimated to be 1.45×10^4 tons, though the ambient air only retained about 78 µg /m^3 of lead (UNEP, 1992). The average blood lead level in children in Northern Ontario in 1987 was 8 µg /dl. Records like these are very necessary in Nigeria, considering the leaded petrol still in use and the rise in the number of rickety vehicles on our roads which contribute a lot to the lead emissions into the atmosphere. Issues pertaining to lead poisoning appear to be trivially handled by the government with little or no consideration for the purpose of urban and environmental planning.

The importation of toxic fuel between 1995 and 1998, recorded a number of casualty. The fuel was found to contain a more poisonous lead bromate as an additive. Though lead contamination cuts across diverse environmental media such as water, air, and food, it is absolutely clear that pulmonary route of entry is the most difficult to prevent except by total elimination of the source (that is through substitution or change of process). Presently no socio-economic group, geographical area, racial or ethnic population is spared from lead poisoning (CDC, 1991) which is as a result of long- term low level exposure to lead (IPCS, 1995). The auto-mechanics and the petrol attendants are frequently exposed to lead from vehicular exhaust as well as through some occupational practices. The Fulani herdsmen were also exposed to lead (through mobility and other exposure sources) despite the fact that the occupation was not lead related and their life style less urban.

The effects of lead poisoning include fatigue, headache, irritability, abdominal pains, respiratory disorders like asthma, encephalopathy with sensory and cognitive disorders and neuro-psychological effects, and also more chronic manifestation such as hypertension (Lindgren et al, 1999) and increasing percentage of spermatozoa with abnormal morphology occurring in male adults (Hu, 2001). Spontaneous abortion in pregnant women, kidney damage, impaired bones, and cardiovascular diseases can also occur (Goyer, 1993)

The neuro-psychological effects may even account for uncoordinated behaviour manifesting from those that are continuously exposed to lead within the occupational setting.

1.3 RESEARCH QUESTIONS

(1) Will the length or period of contact have effect on the blood lead level?

(2) Will the level of education of the vulnerable group has effect on the handling of leaded petrol as well as the blood lead level?

(3) Will the nature of occupation significantly determine the lead level of the blood of the individual?

(4) Will there be any relationship between lead and zinc in the blood?

(5) Will there be any relationship between lead and calcium in the blood?

1.4 RESEARCH HYPOTHESES

The null-hypotheses for the research are as follows:

(1) The length of contact with leaded petrol is not a significant exposure factor to the blood level of lead

(2) The level of education of the professional is not a significant factor to the blood level of lead.

(3) The nature of the occupation is not a significant contributor to the blood lead level.

(4) There is no relationship between lead and zinc level of the blood

(5) There is no relationship between lead and calcium level of the blood.

1.5 JUSTIFICATION FOR THE STUDY

The study location, Ilorin West Local Government Area is a fast developing commercial centre but the inhabitants have little or no knowledge/awareness about lead poisoning. Apart from government employees (a small percentage of the population), auto-mechanics, petrol attendants and commercial vehicle drivers constitute a larger percentage of private employees which are predominantly male.

The Local Government Area is experiencing a fast growing number of petrol stations as well as unwholesome attitude of buying fuel in plastic containers at the slightest shortfall in supply. These containers are used for water or storing food items later when normal supply is restored.

Some adverse occupational features among the auto-mechanics and petrol attendants that can result in ingestion of lead need to be studied. It is a common habit among auto-mechanics to apply petrol on fresh wound instead of anti septic like iodine tincture. An old habit of drinking radiator water as a therapy for a form of phobia among the auto-mechanics is still in practice.

There is an increase in the number of rickety commercial vehicles in Ilorin (West) Local Government Area which discharge thick smoky exhaust and apart from reducing visibility, increases the lead contents of the atmosphere. The development is also bringing faster encroachment to the suburbs where the herdsmen are and who at present are better comparative groups for the study, considering their present attitudes towards the use of motor cars and urban living.

There is proliferation of car wash centres in and around the area. This results in constant discharge of the waste- water into the streams which are consumed by cattle and the herdsmen as well as farmers in the suburbs. Cattle mostly depend on the grasses growing alongside of the streams during dry season.

Although there is an improvement in refuse disposal in the area, occasional burning of refuse containing old tyres and tubes occurs since there are no standard incinerators for refuse. In this case, thick smoke of contaminants is discharged into the atmosphere thus adding to the lead content of the atmosphere.

According to United States Centers for Disease Control (CDC 1985), lead's toxic effect can occur at very low concentration levels in the blood. For children, it occurs at lead levels of 10 µg/dl of blood and for adults, at 25 µg/dl of blood (CDC 1985).

The government of Nigeria has not fully implemented the Agenda 21 of 1992 Earth Summit with the United Nations Conference on Environment (UNCED) held in Rio De Janeiro, Brazil towards a 'commitment to reduce lead exposure'. Also the fulfillment of the promise by the government to finally remove leaded petrol from circulation by the year 2005 as published on Monday, March 1, 2004 (Punch, 2004) has not been ascertained.

Conclusively, the study will enable us to ascertain any disparity between blood lead levels of those occupationally related and those unrelated to petrol. It will also be useful to the government in effecting measures toward reducing lead in petrol as well as the blood lead level of petrol and non- petrol related workers.

1.6 OBJECTIVES

Broad objective: The broad objective of the study is to measure the blood lead levels (relative to calcium and zinc levels) among selected occupational groups in Ilorin West Local Government Area and to ascertain the factors predisposing them to bioaccumulation and associated perceived health effects.

Specific objectives:

1. To determine the concentration of lead, calcium and zinc in blood of selected occupational groups- Auto-mechanics, Petrol attendants and Fulani herdsmen in Ilorin West Local Government Area of Kwara State.
2. To compare the lead levels of the various groups to their life style and behaviour.

3. To determine the relationship between blood lead and zinc and blood lead and calcium.
4. To determine the health knowledge of the respondents on lead poisoning and the occupational features exposing them to lead.
5. To ascertain whether the herdsmen also experienced the health cooditions similar to auto-mechanics and petrol attendants and also compare their food intake style or habit.

1.7 SCOPE OF SIUDY

The research is limited to only the blood samples of three occupational groups, the auto-mechanics, petrol attendants and herdsmen and their food intake habits.

1.8 LIMITATIONS OF THE STUDY

1. The study will not involve gender because of the absence of females in the group of the auto-mechanics.
2. The present level of lead in the petrol will not be determined since it is not constant in the product marketed in the country.

CHAPTER TWO

LITERATURE REVIEW

2.1 NATURAL OCCURRENCE OF LEAD

Lead does not occur free in nature, it occurs naturally as Galena (PbS), Cerussite ($PbCO_3$), Gelesite ($PbSO_4$), Crocoisite and Morphite all of which are products of erosion of igneous, metamorphic and sedimentary rocks (Waldron & Stofen, 1974).

It occurs naturally in water as soluble salts of lead traceable to leachates from soil and leaded pipes, industrial effluent, mines, and smelter discharge. Lead has been known for a very long time as it was used by the Romans for constructing lead pipes (Holderness & Lambert, 1979).

2.2 PHYSICAL AND CHEMICAL PROPERTIES OF LEAD

Although lead is a metalloid, it exhibits all the physical properties of metals in terms of malleability, ductility, tensile strength, lustreness and conductivity as shown in Table 2.1. Lead is a moderately reactive metal. It reacts with air, moist air, water, acids, alkalis, potassium tetraoxodichromate (VI) and potassium iodide as shown in Table 2.2.

2.3 USES OF LEAD AND ITS COMPOUNDS

Lead has wide areas of application as a metal, alloy, or compound. As a metal, it is used in making pipes for water and gas; roofing sheets, lead shots for bullets, hydrometer and so on. As an alloy it is used for making type metal, solder, pewter, battery plates and casings, ceramics and as compounds). It is used in petrol (as tetraethyl lead II), paint (as white lead ($PbCO_3Pb(OH)_2$), as printers ink. It is an important shield against dangerous X-ray and radioactive radiations.

Table 2.1: Physical Properties of Lead

Properties	Description
Appearance	Greyish – white solid with lustre
Isotope	Four(208, 206, 207and 204 in order of abundance)
Relative density	11.3
Malleability	Very malleable
Hardness	Not hard, soft enough to be cut with a knife
Ductility	Not ductile enough to be drawn into wires
Tensile strength	Fair
Melting point	327°C
Conductivity	A very good conductor of heat and electricity
Flame colour	Light blue
Absorbance line	216.8nλ.

Source: Holderness & Lambert, 1979 (modified)

Table 2.2: Chemical Properties of Lead

Properties	Description
Oxidation state	+2 or +4
With moist air	Forms a thin white coating of lead II hydroxide and lead II trioxocarbonate (IV)
Heated in air at 450°C	Forms dilead (II) lead (IV) oxide, Pb_3O_4
With water	No reaction with either hot or cold water
With acids	Attacked by oxidizing acids
With sodium hydroxide	Reacts to form a white precipitate of lead (II) hydroxide which dissolves in excess of the alkali to form a plumbate
With $K_2Cr_2O_4$	Yellow precipitate of $Pb_2Cr_2O_4$
With KI	Yellow precipitate of PbI_2

Source: Holderness & Lambert, 1979 (modified)

Sources of lead exposure are mainly lead-based paint, petrol, solder, smelter while the pathways of exposures are air, food, water, dust and soil. Lead compounds are useful in many areas. The common ones are shown in Table 2.3. Their molecular formulae, melting and boiling points and solubilities in water, acid, alkali and/or ethanol are indicated.

Table 2.3: Physical and Chemical Properties of Lead and Selected Compounds

Name	Relative atomic	M. Pt. (°C)	B. Pt (°C)	Solubility in Coldwater (g/l)	Soluble in
Lead	207.19	327.502	1740	Insoluble	HNO_3: hot conc. H_2SO_4, hot water, alcohol
Lead salts:					
Acetate	325.28	280		443	
Carbonate	267.20	315 decomposes		0.0011	Acid, alkali, decomposes in hot water, alcohol
Chlorate	374.09	230 decomposes		Very soluble	
Chloride	278.10	501	950	919	NH_4 salts: slightly soluble in HCl, NH_3 and hot water
Nitrate	331.20	470 decomposes		376.5	Alcohol, alkali, NH_3, hot water(1270 g/l)
Ortho-phosphate	811.51	1014		0.00014	Alkali, HNO_3
Oxalate	295.21	300 decomposes		0.00016	HNO_3, dil. HCl, acetic acid
Dioxide	239.19	290 decomposes			
Monoxide	223.19	888		0.017	Dil. HNO_3, acetic acid, NH_4
Sulphate	303.25	1170		0.0425	salts, conc. H_2SO_4
Sulphide	239.25	1114		0.00086	Acid

Source: Weast, 1985

2.4 SOURCES OF LEAD

(a) Lead in Paint

The primary uses of paint are decoration and protection against corrosion. Paint is the major source of bioavailable lead in the environment (WHO, 1989). Leaded paints are used for both interior and exterior decoration of both residential and commercial buildings as well as toys, furniture and even cosmetics (nail enamels) all of which causes unavoidable contact with lead (OEHHA, 1996). Lead-based paint remains the most common source of high dose of lead exposure for pre-school children. Throughout 1940s lead-based paint containing up to 50% lead was widely used but the use of interior lead-based paint declined in 1950s and until 1978 when paint containing more than 0.06% of lead by weight was banned for both interior and exterior residential surfaces, toys and furniture (USA Committee on Environmental Hazards/ Committee on Accident and Poison Prevention (CEH/ CAPP, 1987). Despite this, lead-based paint available for industrial, military and marine usage occasionally ends up in homes. Nevertheless, lead paints are still used on steel structures of bridges and expressways (Landrigan *et al*, 1981).

The risk of lead poisoning is related to the presence of lead-based paint and the condition of such paint (EPA, 1986). The risk being greater when the lead paint or the underlying surfaces are in deteriorating condition and when lead paint is located in accessible areas (EPA, 1986). Lead paint on the interior or exterior part of windows is easily abraded into dust by repeated opening and closing of the windows (Farfel & Chisolm, 1990) there by increasing the accessibility to lead. Renovation, remodeling or deleading of homes not properly carried out often results in childhood poisoning (Marino,

1990; Landrigan *et al*, 1982). In some countries the allowable amount of lead in paint ranges from 0.7-1.2 mg/cm^2 of wall using x -ray fluorescence analyzer (XRF) or a standard of 0.5% lead by weight. The regulatory limit is based mostly on practical and not health consideration.

(b) Lead in the Petrol

The primary reason for adding lead into petrol is to reform the fraction and prevent engine knock during combustion. A litre of petrol contains from 0.5 to 0.7g of lead in the form of tetraethyl lead (II) (Pb $(C_2H_5)_4$) (Uche, 1991) and 75% of it ends up in the exhaust gas (Hu, 2001). Major sources of lead in ambient air are estimated to emit approximately 180 tons per year in California (OEHHA, 1996, EPA, 1977). Apart from aircraft fuel combustion that emits 149 tons/year, stationary fuel combustion also contributes a large amount of lead into the ambient air and dust (Annest et al, 1983). There is correlation between the reduction in amount of lead added to petrol and reduction in children blood lead level. There is also a correlation between leaded petrol sales and umbilical cord blood lead level (Rabinowitz & Needleman, 1983).

(c) Lead in Water

Lead in drinking water is a result of distribution system where lead -lined cisterns or leaded water pipes are used for its storage and distribution respectively. The contamination can occur at five different points such as at the (a) connectors, that is, goose necks or pigtails (b) leaded service lines (c) leaded solder joint (d) leaded water fountain or coolers (e) leaded brass faucets and fixtures (CDR, 1991). The extent of lead contamination of water is affected by many factors such as (a) its corrosiveness in terms of its pH, alkalinity, and mineral content (b) age of lead soldered joints with new

ones being more risky (c) quantity and surface area of leaded material (d) standing time and temperature of water in contact with leaded surfaces (ATSDR, 1988).

Water with a low pH, low concentrations of Ca^{2+} or Mg^{2+} that is, soft water, or with an elevated organic content is known to be more corrosive and dissolves heavy metals such as cadmium, and/ or lead easily from pipes containing them (NAS, 1979). Soft water can dissolve up to 500 µg/l compared to hard water of about 30 µg/l (Davies & Everhart 1973).

Suspended lead in air may finally settle on standing water (OEHHA, 1996) thus contributing to its lead content. Waste water from mining, smelting, refining, manufacturing and recycling could get into body of water and empty its lead content (Patterson et al, 1991). Solid wastes such as lead-based glassware, lead glazed pottery and so on are often dislodged into standing water body thus contributing to its lead level (Patterson et al, 1991).

Although the recommended level of lead in drinking water is 15 ppb, one can be more exposed after taking plants that have absorbed lead (OEHHA, 1996). Lead in drinking water is absorbed more by the body than that in food with adult absorbing 35%-50% and children more than 60% of the lead they drink (ATSDR, 1988).

(d) Lead in Air and Dust

Air can be categorized into indoor and outdoor types. The indoor air lead concentrations are typically lower than that of the outdoors air (OEHHA, 1996). Most of the lead in the indoor air of non-occupational environments is usually from infiltration of lead particles from outdoor air and the ratio of indoor to outdoor lead concentration ranges from 0.3:1 to 1:1 (OEHHA, 1996).

Large amount of lead particles can be released during remodeling of indoor house paint, removal of lead-based paint, re-entrained contaminated dust as well as particles from agricultural activities. The average ambient air lead coocentration is between 0.02 and 0.12 $\mu g/m^3$ in some cities, but the approved standard is 1.5 $\mu g/m^3$ (OEHHA, 1996). Atmospheric lead level depends on geographical location with highest concentration near smelters. The level ranges from 0.000076 $\mu g/m^3$ in remote areas to 10 $\mu g/m^3$ near smelter (Elias, 1985). Lead particles greater than 2 µm in diameter are transported over a long distance and results in contamination of remote areas such as arctic circle (Settle & Patterson, 1980). Their removal is influenced by atmospheric conditions and their size (Nielsen, 1984).

Apart from the stationary point as a source of air lead, other important sources are area source fuel combustion, aircraft combustion contributing up to 149 tons/ year in California alone (OEHHA, 1996), autobody refinishing, cement manufacturing, incinceration, battery manufacturing, paperboard mill, sand and gravel facilities, foundries, steel mills, secondary lead recycling facilities, re-entrained and inorganic lead may contribute 390 tons/year to the atmosphere (OEHHA, 1996). It is necessary to state that air-borne lead contributes a small proportion to lead burden but those deposited on objects are responsible for high concentration of lead in dust that children ingest (Charney, 1982). The dust contributes 7 to 10% of the baseline lead in adult but 44% in 3 years old children (Elias, 1985).

(c) Lead in the Soil

Soil is the natural residence of lead as ores (Waldron & Stofen, 1974). The contribution of this natural source to the environment is low compared to that from human activities (Patterson et al, 1991). Since lead does not dissipate, biodegrade, or decay, the lead deposited in soil or dust becomes a long- term source of lead exposure to children. Despite the ban of lead emission from petrol in some countries, about 4-5 million tons of lead used in petrol remains in dust and soil. (ATSDR, 1988).

Soil contributes a greater proportion of lead to the background burden and to the young children than to adult and older children because of their increased hand to mouth activities (Charney, 1982). The topsoil in the immediate environment can be a major source of lead that has deposited and accumulated for many years from suspended lead in the ambient air. Because the organic component of the soil immobilizes lead, it remains in the upper 2-5 cm of undisturbed soil (EPA, 1986). Naturally, the soil contains lead and the typical lead background concentration is approximately 15 milligram per kilogram (or 15 ppm). However, soils near emission sites may have concentration of 100 fold higher or more (OEHHA, 1996). Soil lead level within 25 m of road ways are 30-2,000 ppm higher than natural level, with some road side soil having concentration of as high as 10,000 ppm. Those adjacent to houses painted with lead paint have lead level of above 10,000 ppm, and those adjacent to smelter have as high as 60,000 ppm (EPA 1986). There is a high correlation between average blood lead levels and the amount of lead in indoor dust, topsoil and paints in the immediate environment (Rabinowitz *et al*, 1984) and the effect is high with children living near high level sources (Landrigan *et al*, 1976) For every 1,000 ppm increase in soil or dust lead level, there is a general rise of 3-7 µg/dl

children blood lead level (EPA, 1986. Bornschein *et al*, 1986, ATSDR, 1988). Particle size and the chemical form of lead may affect the bioavailability of lead in the soil and dust; access to soil, behaviour pattern and presence of ground cover (Barltop & Meek, 1979, IPSC, 1989)

(f) Lead in Food

Lead in food comes from several sources apart from lead solder. Soil on which the plant is grown; air and rain; food processing; contact with lead solder or ceramic wares used to store the food and contact with lead dust in the home are some of the sources (CDC, 1991). Food from agricultural crops grown in heavily travelled roads or near industrial sources of lead or their effluents must contain a high level of lead (OEHHA, 1996).

Canned food can also absorb leachate from lead soldered can (Mahaffey, 1983). Food contaminated with lead also occurs in handling during processing and packaging. This makes milk and infant formulated food have significant amount of lead (FAO, 1986 a & b). Breast milk contain one-tenth (1/10) of maternal blood lead concentration (Moore, 1983).

The use of sewage sludge from high way run-off (that has been contaminated with lead) as fertilizer increases the lead in foodstuff and animal fodder (Kinder, 1997). pH, phosphorus content, buffer capacity and amount of organic content of the soil as well as the type of plant determine the quantity of lead transferred to the plant (CDC,1991). Unusually high lead contamination of food may be due to (a) a long time storage in lead soldered cans (b) acidic food stored in lead glazed ceramic container (c) processing of

food with lead contaminated water (CDC. 1991). Provisional tolerable weekly intake (PTWI) of 25µg Pb/Kg body weight was set in 1993 (FAO/WHO 1993).

(g) Lead in local Cosmetics and Medicines

Other sources of lead contamination are local medicines such as greta and azarcon (which contains lead (II) chromate with lead (II) oxide) used in Mexico to treat diarrhea and GIT disorder called 'empacho' (has more than 70% of lead). Cosmetics such as surma or kohl (used in India/Pakistan) as astringent on umbilical cord stump or tiro used for eye decoration or treatment of conjunctivitis contains a high level of lead (Aslam et al, 1979; Fernando et al, 1981; Sharma et al, 1990; CDC, 1991). There is also an Hindu folk medicine for treating diabetes, which contains 8 mgPb/g (Pontifax & Garg, 1985). Bukhoor, which is a mixture of lead metal and lead sulphide, is burnt as incense and believed to wade- off evil spirits (Shaltout et al, 1981). Lead poisoning due to various compounds of lead used as ingredients in traditional medicines/cosmetics has been recorded among children. (Fernando et al, 1981; Sharma et al, 1970; Mitchell-Hegg et al, 1990).

(h) Lead in local Alcoholic Beverages

Lead finds its way into alcoholic drinks through various routes such as in preparation, repair of casts, kegs for storage and conveyance, tap line or pesticide such as lead (II) arsenate used to treat soil where grapes are grown. Though alcoholic beverages have been observed not to be significant contributors of lead intake (IPCS, 1995; Sherlock et al, 1986 & 1991), a chronic high level of lead was associated with individuals that are chronic consumers of locally produced wines and spirits (Anctor et al, 1999) as a result of old leaded pipes used in distillation.

(i) Lead in Tobacco

Filter –tipped cigarettes produced between 1960 and 1980 had lead content of about 2.4 µg/g of which approximately 5% may be inhaled while the remainder occurs in the cigarettes and side-stream smoke (Mussolo- Rauhamaa et al, 1986).

2.5 Etiology of Lead Toxicity

Having itemized various sources of lead, many of them still constitute the etiology of its toxicity. Through hand to mouth, swallowing or motor activities in the young ones, many non-food items are swallowed e.g. Pica, paint flakes, lead containing dust and garden soil (WHO, 1989; Bourdreef, 1986). Waterfowls, ducks that often ingest spent lead gunshots and discarded fishing weight, contribute to the lead toxicity when they are also consumed (USEPA, 1991).

Though lead in air, food and water are at lower level than those in paint, soil and dust, an average of 2 year old child may receive 44% of his daily intake from dust, 40% from food, 14.8% from water and beverages and 1% from inhaled air (Elias, 1985).

Improper packaging and handling of foods during processing and with the use of lead soldered cans increase the chances of lead toxicity in infant and children who depend on canned milk and infant foods (FAO, 1986 b).

Most of lead particles emitted into air are less than 10 µm in size. The size makes them constitute a health risk because they are respirable and can bypass the body's natural defence mechanism and are also capable of long residence in the lung. Those particles in the dust that are more than 10 µm in size and which are not respirable are ingested when deposited on food and water (OEHHA, 1996).

The common habits of eating without prior thorough washing of hand by professionals of lead related jobs coupled with the attitude of sucking petrol from containers usually result in the ingestion of significant amount of lead. Some dyes or creams for treating greying hair contain lead salts as the active ingredient such as lead acetate, which can be absorbed through the skin or ingested orally with food. Some cyclinder also contains lead particles that are easily absorbed through lachrymal ducts (CDC, 1991).

Tmditional method of distilling with leaded pipes, conveyance of water through lead pipes (Holderness & Lambert, 1990) pave way for lead ingestion. Ceramic dishes or bowls contain significant amount of lead that could dissolve in acidic drinks such as vinegar and be ingested.

Exhaust from automobiles as well as stationary engines using leaded petrol (fuel) directly contribute immensely to the level of lead in air (Chamey, 1982) and indirectly to the blood lead level (Needleman, 1983).

Alloys of lead such as soldering flux, battery plates produce particles that can attach to clothes or waste materials and be brought home (Maizlish et al; 1990 CDR Wonder; 1991). Table 4 below shows some occupations or operations, which may present lead hazards for workers.

There are many occupations that expose the workers to lead toxicity through continuous exposure to lead emitted from the work place. Some hobbies also expose people to lead hazard. Accidental ingestion of lead also occurs through foods, medicines and containers used for preparing and serving them. Table 2.4 shows the list of some of the workers at risk; the hobbies and the substances that can cause lead exposure.

Table 2.4: Occupations, Operations or Substances, which may present Lead Hazards

Occupational	Hobbies	Substance Use
Construction workers Lead Miners /Smelters Steel welders Bridge reconstruction workers Firing range instructors and cleaners Painters / paint Sprayer Remodelers and refinishers Foundry workers Scrap metal recyclers Auto repairers (radiator inclusive) Cable splicers Storage battery manufacturers: pasting, assembling, welding of battery connector Ship breaking	Casting bullets or fishing sinkers Home remodeling Target shooting at firing ranges Lead soldering Auto repair Stained glass making Glazed pottery making Mixing (by hand) of lead stabilizers into polyvinyl chloride. Mixing (by hand) of crystal glass mass	Some folk remedies Some Health Foods Moonshine whiskey Ceramic ware

Sourced but modified: Hemberg,1973 and N.Y. State Dept. of Health, 2001

2.6 Toxico-Kinetic Routes of Lead into the Body

The three identified routes of lead into the body are

a. Gastrointestinal tract

b. Respiratory tract

c. Dermal (percutaneous) route (CDC, 1991).

(a) Gastro Intestinal tract (GIT)

A significant amount of lead is ingested through the GIT along with food and non-food items such as Pica, locally distilled alcohol, some local drugs and hair treatment creams.. The lead particles in air that are more than 10 μm in size are usually deposited on the upper part of respiratory tract and finally enter the GIT (OEHHA, 1996). The daily dietary lead intake in different countries ranges from less than 100μg to more than 400 μg (FAO / WHO, 1989).

For adults only a range of 1 to 10% is absorbed and children may absorb up to 50%. The absorption is influenced by:

i. Nutritional deficiency such as a low level of calcium, iron, zinc, vitamin D (WHO 1989, WHO, 1995).

ii. Presence of fat and ascorbic acid decrease the absorption (Lavender 1977).

iii. The efficacy of absorption of lead from a drink depends upon whether the drink is taken before food (high lead uptake) with or after food (low lead uptake) (Sherlock, 1991).

(b) Respiratory Tract Route

Although solubility of lead salts differ greatly according to the nature and its oxidation state, its chemical forms are not considered factors for respiratory absorption (USEPA, 1986; WHO, 1987).

Its absorption from the air sacs (alveoli) into the blood stream involves two steps namely:

i. Deposition of the air – borne lead particles in the respiratory tract.

ii. Clearance from the tract into the circulation (WHO, 1995).

Large particles of lead deposit faster at the upper respiratory tract and finally enter the gastro-intestinal tract (GIT) (USEPA, 1986; WHO, 1995). The clearance is direct for particulates that are less than 10 µm in size because of their ability to by-pass natural defence mechanism (OEHHA, 1966). However, respiratory system is capable of absorbing up to 10 – 15% of deposited lead.

(c) Dermal Route

Generally, the skin is mainly permeable to organic particles (WHO, 1995) and for this reason, organic form of lead such as tetraethyl lead (TEL) can enter through the skin. Lead particles incorporated in oil may also penetrate the skin but the effect may be negligible (Hamilton et al, 1972).

(d) Transplacental Route/Breast Feeding

Transplacental route of transporting lead is important in that lead in fetal tissue is detectable by the twelfth week of gestation (Barltrop, 1972). Placenta can account for 57.4% of the level of lead transferred to the foetus. Also the umbilical cord blood lead level correlates with maternal lead level (Moore, 1983). Breast milk contains about one-tenth of the maternal blood lead concentration (Moore, 1983).

2.7 Absorption, Distribution, Retention and Excretion of Lead

(a) Absorption of Lead

Though lead is toxic and commonly found in nature, it gets into the system mainly by ingestion and inhalation (Fleming *et al.* 1997). The absorption of lead is a function of:

(a) The amount of lead available to the portals(routes) of entry

(b) The physico-chemical state of the metal

(c) Age, nutritional level, physiological state and possibly genetic factors (WHO, 1995).

Absorption of any air-borne particles (lead inclusive) through respiratory tract is determined by

i. The size of the particle

ii. Distribution level of the particle and

iii. Ventilation rate of the individual

In children, the main route of lead is gastrointestinal tract. The absorption is about 40% to 50% of intake. In adult, the absorption is between 5 to 10% of dietary lead intake and it varies with sources, that is, water, food and so on. Decrease intake of essential minerals such as iron, zinc and calcium as well as poor nutritional status increases its absorption (Rosen, 1985). Milk may promote the gastro-intestinal tract (GIT) absorption of lead when leaded cans are used as its containers (Stephen & Waldron, 1975).

(b) Distribution of Lead

For either orally or inhaled dose of lead, distribution into various organs and systems generally depends on:

i. The rate of blood delivery

ii. The affinity of a particular tissue for lead

iii. The type and size of the organ (or tissue) and

iv. The accessibility of such organ to lead (Rabinowitz et al, 1976; Rabinowitz et al, 1977).

This makes the distribution not uniform. Blood lead concentration is a reflection of balance between uptake and excretion as well as the equilibrium of exchange to and from

soft and hard tissues. The blood and some components of soft issue contain 10% of the body lead and of which 9.0% to 99% is associated with the red blood cell (USEPA, 1977).

The mean half-life of lead in the accessible portion is about 36 days while that of other tissue is about 40 days. The lead in the bone and teeth has half-life of about 10,000 days thus forming the largest and accessible depot (Rabinowitz et al, 1976; Rabinowitz, 1991). Even the bones and teeth do not store equal amount of lead and also the distribution in tissues differ between young and adult because lead accumulates more in immature brain than adult brain as well as other organs even when they are exposed to equal amount of lead. In young animals, tissue lead level rises faster than blood lead level (Mahaffey, 1983).

(c) Retention and Excretion

In infant, when the intake of lead is less than 4 µg/kg/day, fecal excretion exceeds intake but when the intake is more than 5 µg/kg/day, net absorption is 42% of intake and the retention is about 32% of intake (Ziegler et al, 1978) while retention rate of particulates by adult ranges from 20 to 60% (USEPA 1986; WHO, 1987).

Infants and children not only absorb lead more efficiently but also excrete it more rapidly than adult do (Rabinowitz *et al.* 1976). About 76% of lead excretion is primarily through the kidney, 16% via the gastrointestional tract and 8% through sweat, bile, hair and nails (WHO, 1977). As a result of the affinity of lead for osseous tissues of the bone, its return from them to the blood is slow. Moreover, the longer the period of exposure to lead, the slower the removal from the body (Hammond, 1982).

(d) Factors affecting Lead Retention in the Body

The retention of lead in the body is not different between male and female but it is proportional to dose up to 400 µg. It is not related to iron absorption capacity or the size of body iron storage or ingestion of 10 fold molar excesses of iron. Retention is lowered with increased fat content of food, ingestion of ascorbic acid and markedly with ethylene diamine tetra acetic acid (EDTA). It is not affected by administration of lactose (Lavender, 1977). It is decreased by calcium intake of up to 1500 mg per day, 10 fold molar excesses of zinc and high cobalt intake. The deficiencies of calcium, zinc, iron, and copper (to a lesser extent) increase absorption, retention as well as toxicity of lead (Lavender, 1977).

2.8 Kinetics of Lead in the Blood and Body Fluids

Lead in its oxidation state of +2 (Pb^{2+}) is aided in its functions by lead binding proteins (PbBPs), which are numerous, and of generally low molecular weights. They are rich in dicarboxylic amino acids such as aspartic and glutamic acids. At binded state, it has very low dissociation constant of the order of 10^{-8} for lead. This appears to influence the intracellular bioavailability of lead in target organs such as brain, kidney etc (Mosden et al, 2000).

Another form of kinetics takes the form of filtering – effect of placenta tissue on lead which makes the placenta account for 57.4% of the lead transferred to the foetus using a dynamic modus (Nashashibi et al, 1999; Ziegler, 1978).

The kinetics of lead is modified in human by polymorphism in δ - amino levunilic acid dehydratase enzyme (Hu et al, 2001).

2.9 Lead binding at Cellular Level

Lead exhibits its toxicity by several mechanisms in different targets of attack.

(a) Red Blood Cell

It has several targets of attacks in the process of haem synthesis. It inhibits amino levulinic acid dehydratase (ALAD) which catalyses the synthesis of 5-aminolevulinic acid. It binds and inhibits caprooxidase involved in the synthesis of protoporphyrin from coproporphirinogen III. It binds and inhibits ferrochelatase involved in heam synthesis from protoporphyrin III (Masden, 2000).

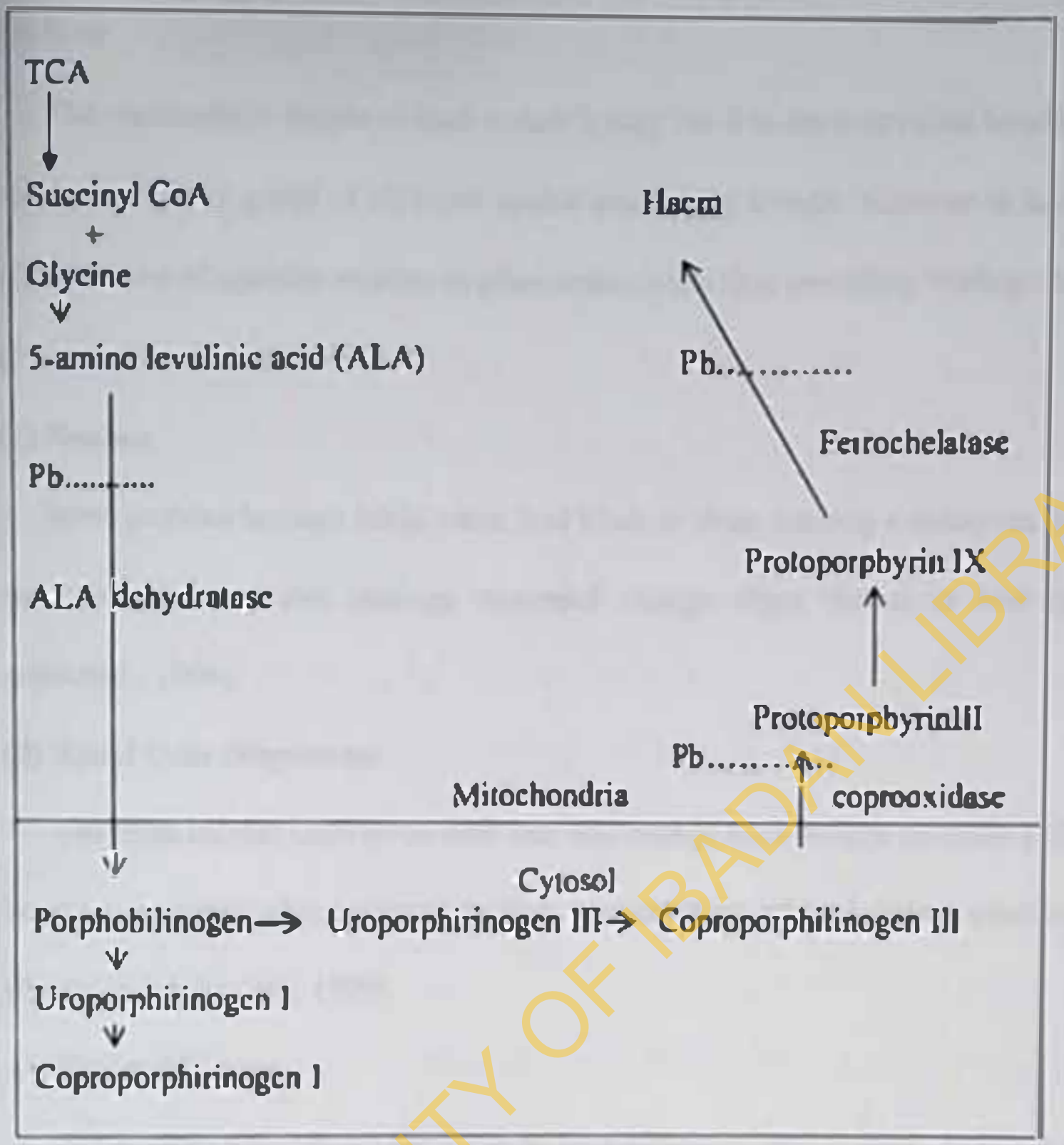

FIGURE 2.1: THE EFFECT OF LEAD ON HAEM SYNTHESIS

Source: Burtis and Ashwood , 1996

(b) Hair

The electrophilic nature of lead makes it easy for it to form covalent bonding with the sulphydryl (-SH) group of Cysteine amino acid in the keratin. Keratins in hair contain a high fraction of cysteine relative to other amino acids thus providing binding sites for lead. (Burtis and Ashwood , 1996)

(c) Neuron

Some proteins become labile when lead binds to them, causing a change in their tertiary structure. Neurons also undergo structural change when binded to lead (Burtis and Ashwood , 1996).

(d) Renal Cells (Nephrons)

The renal tubular cells binds with lead and change their tertiary structure sufficiently to become antigenic when exposed to high concentration of lead during clearance process (Burtis and Ashwood , 1996).

(e) Skeletal Tissues

The skeletal tissue is the site for long-term storage of lead (UNEP, 1992). A significant fraction of absorbed lead is rapidly incorporated into bone because of its high affinity for osseous tissues (Hammond, 1982). Lead is known to exhibit some similar properties as calcium due to its divalent nature.

2.10 Effects of Lead on Humans Health

Generally, the effects of lead can either be acute or chronic (Binders *et al*, 1991; Mahaffey, 1977).

(a) Effect of Lead on Metabolic Processes

The ability of lead to bind with biologically important molecules and interfere with their functions through a number of mechanisms is the basis for its toxicity. It competes favourably with essential cations such as calcium ion for binding site on calcium dependent enzymes thus inhibiting their activities.

At subcellular level, mitochondria appears to be the main target where it selectively accumulates in it causing structural damage and impairing cellular energetic and other functions (Bricrley, 1977; Holtzman *et al*, 1978). At 10 µg/dl, it interferes with δ-amino levunilic acid dehydratase in the synthesis of haem, a prosthetic group for haemoglobin, myoglobin, cytochrome p450 and cytochromes (Hemberg & Nikkanem, 1970). This causes the accumulation of δ-amino levunilic acid (δ-ALA), which in turn causes toxic effect on neural tissues thus affecting the activities of neurotransmitter γ-amino butyric acid (GABA) (Silbergeld & Lamon, 1980).

The reduction in haem synthesis adversely affect a haem requiring tryptophan pyrollase activity thereby forcing the tryptophan metabolism through the second pathway resulting in a high blood and brain levels of neurotransmitter serotonin (Litmnn & Correia, 1983).

In children, it inhibits red cell pyrimidine– 5– nucleotides at a blood lead concentration of 10 to 15 µg/dl (Angle et al, 1982). At blood level of 10 to 15 µg/dl, it inhibits hydroxylation of 25-hydroxyl vitamin – D needed to produce active form of vitamin – D also (Mahaffey *et al*, 1982).

(b) Effect of Lead on Heamopoietic System

Lead is a cumulative poison producing a continuum of effects primarily on hacmopoietic system (Rosen, 1985, Moore & Goldberg, 1985). In pediatric group, excessive exposure causes microcytic, hypochromic and mild haemolytic anaemia (Silbergeld & Lamon, 1980). There is increase in the blood concentration of protoporphyrins and δ-ALA before the development of overt anaemia at 40 µg/dl (WHO, 1977). Similarly increase occurs in adults at blood lead level of 16.07 µg/dl in female and 24.38 µg/dl in male (Chalevelakis *et al*, 1995).

(c) Effect of Lead on Nervous System

In children, it causes chain of effects from slowed nerve conduction at 30 µg/dl (Landrigan et al, 1976), to behavioral changes such as general decline in mood resulting in anger, confusion, depression, fatigue and tension (David et al, 1972; Landrigan et al, 1975; Landrigan et al, 1995; Winncke et al, 1983). Decrement in cognitive ability occurs at between 30 to 60 µg/dl blood lead level and even at a lower level of 10 to 20 µg, the intelligent test score of a child is decreased by 2 points (Davis & Svensgaard, 1987; Mushak *et al*, 1989).

Dentine lead levels above 20 ppm were associated with a seven fold risk of not graduating from high school, a six-fold risk of having a reading disability, deficit in vocabulary, problems with attention and fine motor coordination, greater absenteeism and lower class ranking (Needleman et al, 1979; Lyngbye et al, 1990).

Even as low as 10 µg/dl it results in deceased hearing acuity (Schwartz & Otto, 1987). Mental retardation is conspicuous at 80 µg/dl and acute encephalopathy and death occurs at

80 to 100 µg/dl (Needleman et al, 1979; Needleman & Landrigan, 1981). In adult encephalopathy and other effects developed at slightly higher blood lead levels.

The effects on central nervous system (CNS) are mostly morbidity and mortality (Mahaffey, 1977). The sequels include seizure, cerebral palsy and optic atrophy. A near source exposure to lead at annual average ambient concentration of 0.24 µg/m^3 could cause four-fold increase in neuro-developmental effect. It has negative effect on postural stability in exposed workers (Dick *et al.* 1999; Bhattacharya et al, 1988).

(d) Effect of Lead on Excretory System

The excretory pathway is affected by the lead toxicity on kidney, which impairs its multiple functions. The early toxicity results in proximal renal tubular dysfunction shown by increased urinary excretion of glucose, amino acids and phosphate which occurs at a high level of 150 µg/dl blood lead concentration in children (NAS, 1972). Chronic lead nephropathy is shown in both children and adults by intense interstitial fibrous and tubular atrophy and dilation after a prolong exposure to high level of lead (Mahaffey, 1977).

(e) Effect of Lead on Growth and Reproduction

The reproductive outcomes of high blood lead level during pregnancy are abortion and stillbirth. During pregnancy and lactation periods, the cumulative lead flux from maternal skeleton into the blood ranges between 0.9 to 10 µg/day (Gulson et al, 1999).

Maternal and cord blood levels of 10 – 15 µg/dl appear to be associated with reduced birth weight, reduced gestational age (preterm delivery inclusive,), neonatal head circumference (Shwarz *et al*, 1986. Bornschein *et al*, 1986; Shukla *et al*, 1989,). It is also a statistically significant predictor of height, weight and chest circumference of children with lead in the

blood. There is strong relationship between blood lead and height down to 4 µg/dl (Schwarz et al, 1986).

In male with high blood lead level, it causes an increase in the percentage of spermatozoans with abnormal morphology, decrease in spermatozoan concentration and total sperm count and alteration of male endocrine function (Hu, 1998). In female, increase in lead release from bone is associated with both perimenopausal period and Osteoporosis (Symanski et al, 1995).

(f) Effect of Lead on Cardiovascular System

There is a correlation between lead in blood and increase in blood pressure and related cardiovascular conditions in adults with increase in both systolic and diastolic pressure even as low as 4µg/dl for middle aged adults and stretched over a wide range cutting across women, different races and age groups (Houston & Johnson. 1999; Hu et al, 1996).

A near source exposure to lead at the annual average ambient concentration of 0.24 µg/m^3 could cause increase in blood pressure (OEHHA, 1996) and decrease in oxygen absorption (Kinder, 1997). An increase in blood lead level from 10 to 20 µg/dl in adult will cause an increase in systolic blood pressure from 1 to 3 mm Hg (OEHHA, 1996).

(g) Lead as a Carcinogen

Lead can cause gene mutation and cell transformation in mammalian cell in culture by interfering with DNA synthesis. It can induce kidney tumor in rodents. Extrapolation of data from animal to man and from ingestation to inhalation gave a range of unit cancer risk from 1.2×10^{-3} to 6.5×10^{-5} µg/m^3 for a life time exposure to 1 µg/m^3 of lead (OEHHA, 1996). The effect of lead on various physiological processes of the body is summarized in Table 2.5.

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Table 2.5: Effect of Lead on Various Physiological Processes

Neurological Effects	Gastro intestinal Effects	Reproducive Effects	Haem Synthesis	Renal Effects	Others
Peripheral neuropathy Fatigue / Irritability Impaired concentration Hearing loss Wrist / Foot drop Seizures Encephalopa-thy	Nausea Dyspepsia Constipation Colic Lead line on gingival tissue	Miscarriages/ Stillbirths Reduced sperm Abnormal sperm	Anemia Erythrocyte protoporphyrin elevation	Chronic nephropathy with proximal tubular damage Hypertension	Arthralgia Myalgia

Source: Rempel, 1993.

2.11 Signs and Symptoms and Treatment of Lead Toxicity

(a) Signs and Symptoms

Although there is lack of specificity of symptoms of lead toxicity, it was described as a silent hazard and with non-specific symptoms (Got, 1993) and symptoms of lead toxicity may include anorexia, abdominal pains, malaise, vomiting, irritability, loss of memory and apathy (Louria, 1985). Early symptoms may include headache, sleep disturbance, fatigue, aching muscles and bones (myalgia and arthralgia) (Zeilhius, 1983). Table 2.6 shows some of them.

(b) Treatment of Lead Toxicity

The immediate action to be taken is removing the patient from the source of lead and which may be the only action required. In high lead level with clinical symptoms and biochemical evidences of an appreciable degree of poisoning, chelation therapy may be the best option. It is the mainstay in the treatment of heavy metal toxicity (Waldron, 1966) whether acute and chronic. Ca-EDTA is the common chelating agent. The chelate is excreted in the urine. New chelating agents include (a) 3- dimmercapto propane sulphate (DMPS), (b) dimmer captosuccinic acid (DMSA). Both of them are derivatives of 2,3dimercapto propanol (BAL). Penicillamines are also used especially in children with blood lead less than 35 µg/dl because they less rebound than DMPS and DMSA (Goyer et al, 1995; Schwartz et al, 1997).

Table 2.6: Signs and Symptoms of Lead Toxicity

Fatigue	Weight loss
Irritability	Dizziness
Poor concentration	Arthralgia
Wrist or foot drop	Myalgia
Vague abdominal pain	Hyperkalaemia
Gingulal lead line (Burtonus line)	Nausea and vomiting
Mycrocytic hypochronic anemia	Anorexia
Gout (hyperuricaemia)	Sleep disturbance
Interstitial nephritis	Memory loss
Anemia	Mental retardation /dysfunction
Dulling sensation	Personality change
More rapid aging	Metallic taste

Source: Zeilhius, 1983; Louria, 1985.

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Interstitial nephritis	Memory loss
Anemia	Mental retardation /dysfunction
Dulling sensation	Personality change
More rapid aging	Metallic taste

Source: Zeilhius, 1983; Louria, 1985.

2.12 ZINC

Zinc is a crystalline bluish- white metal, which does not occur free in nature. It occurs in various forms as ores. The properties of zinc are shown in Table 2.7.

(a) Sources of Zinc

The sources of zinc are natural and anthropogenic of which the latter contributes largely to the environmental level of the metal in air, water and food.

Natural Sources of Zinc

Natural environmental concentration of zinc in fresh water ranges from less than 0.1 to 1.5 µg/l, sea water contains 0.002 to 0.1 µg/l, soil contains 10 to 300 mg/Kg dry wt, sediments contain up to 100 mg/Kg dry wt and air contain up to 300 ng/m^3 (EHC, 2001).

Anthropogenic Sources

Sources from various human activities cause elevation in zinc level such that near source water contains up to 4mg/l, soil about 35 g/Kg dry wt, estuarine water, 15 mg/l and air up to 8 µg/m^3 (EHC, 2001).

Food Sources

Zinc is present in red/white meat and shellfish but very low in embryo part of grains e.g. wheat. Phytic acid combines with zinc to form an insoluble complex, which reduces its bionvailability in food. Other inhibitors of zinc are polyphenols and high level of calcium intake (King & Lean, 1999).

2.13 Recommended Dietary Intake

The recommended dietary intake of zinc are 5.6-10 mg/day for infants/ children aged 2 months to 11 years, 12.3 to13.0 mg/day for children between 12-19 years, 10-15 mg/day for male above 10 years, 12 mg/day for female above 10 years, 8.8 to14.4 mg/day for adult between 20-50 years. 15 mg/day for pregnancy and lactation between 0-6 months is 19 mg/day and 16 mg/day between 7-20 months. Drinking water to supply less than 0.2 mg/l (King & Lean, 1999)

2.14 Compounds of Zinc

There are many compounds of zinc that have many areas of applications. Some are found natural while others are synthesized. Table 2.7 summarizes the compounds and their chemical formulae.

Table 2.7: Chemical Names, Synonyms and Formulae of some Zinc Compounds

Chemical name	Formula	Synonyms
Zinc arsenite	$Zn(AsO_2)_2$	Zinc meta-arsenite, ZMA
Zinc bromide	$ZnBr_2$	-
Zinc carbonate	$ZnCO_3$	-
Zinc chloride	$ZnCl_2$	Butter of zinc
Zinc cyanide	$Zn(CN)_2$	-
Zinc fluoride	ZnF_2	-
Zinc hexafluorosilicate	$ZnSiF_6.6H_2O$	Zinc silicofluoride; zinc fluosilicate
Zinc iodide	ZnI_2	-
Zinc nitrate	$Zn(NO_3)_2$	-
Zinc oxide	ZnO	Chinese white; zinc white; flowers of zinc; philosopher's wool
Zinc permanganate	$Zn(MnO4)_2.6H_2O$	-
Zinc peroxide	ZnO_2	Zinc dioxide; zinc superoxide; ZPO

Source: Environmental Health Criteria (EHC), 2001

2.15 PROPERTIES OF ZINC

(a) Physical properties

As a metal, zinc exhibits all the physical properties of metal such as malleability, tensile strength, metallic luster as well as conductivity. Table 2.8 summarizes these properties.

(b) Chemical Properties of Zinc

Zinc is a transition metal but differs from the other members because

i. Its has only one oxidation state of +2

ii. Its ions are not coloured and

iii. It lacks direct catalytic function.

iv. It is moderately reactive as it will combine with oxygen (in air), water, many non-metals, acids and alkalis (Ababio, 2004).

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Table 2.8: **Physical Properties of Zinc**

Physical Property	Description
State	Solid
Appearance	Bluish-white, can be polished
Density (g/cm^3)	7.1
Malleability	Malleable between 100-150 ^0C
Tensile strength	High
Melting point	419^0C
Conduction of heat and electricity	Good
Absorbance	214nm

Source: Holdcmess and Lambert, 1979

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Source: Holderness and Lambert, 1979

2.16 ZINC IN THE BLOOD

Zinc has been shown to prevent inhibitory effect of lead on the red blood cell enzyme d- amino levulinic acid dehydratase (ALAD) presumably by inducing more synthesis of enzyme for which zinc is an essential component (Clayton & Clayton, 1982). There is rise in red cell zinc protoporphyrin level in lead worker even at low lead levels (Clayton & Clayton, 1982).

2.17 USES OF ZINC

The various uses of zinc can be categorized into catalytic and non-catalytic uses.

(a) Non-Catalytic Uses

Zinc is seldom used alone except as a coating (using hot-dipping or electrogalvanizing), as aging inhibitor or activator and stabilizer for plastics (ATSDR, 2007). It is used to make alloys such as brass, bronze, die-casting alloys, foundry alloys and supper plastic zinc.

(b) Catalytic Uses

Zinc is required for the activities of more than 300 enzymes covering all the six classes of enzymes. Its binding sites are made up of the sulphur in cysteine, the nitrogen in histidine and the oxygen in aspartate or glutamate or a combination. (McCall et al, 2000). The important classes of zinc enzymes are

i. DNA and RNA polymerases

ii. Alkaline phosphatases

iii. Peptidases

iv. Carbonic dehydrases

v. Alcohol dehydrogenases (ADH).

Table 2.9 shows the important amino acids used as the active sites of the enzymes and the functions of zinc enzymes. The active sites of many of the enzymes features a tetrahedrally coordinated zinc centre that is attached to the protein backbone by three amino residues denoted by letters X, Y and Z and the fourth site being water. (Kumura, 1993).

Table 2.9 Coordination Motifs in Representative Mononuclear 5 (XYZ) $Zn^{2}(OH)_2$ Zinc Enzymes and their Functions

X	Y	Z	Enzyme	Function
His	His	His	Carbonic anhydrase	Hydration of water
His	His	Glu	Carboxy peptidase	Exo peptidase
His	His	Glu	Thermolysin	Endo peptidase
His	His	Glu	Neutral protease	Endo peptidase
His	His	Asp	Protease from streptomyces,caespitomyces	Endo peptidase
His	His	Cys	Bacteriophage I7 lysozyme	Cleavage of the amide bond between L-acetyl muramate moieties in polysaccharides
His	His	Cys	Farnesylprotein transferase	Transfer of a farnesyl isoprenoid to a cysteine residue
His	Cys	Cys	Alcohol dehydrogenase	Oxidation of alcohols to aldehydes and ketones
Cys	Cys	Cys	5-aminolevulinate dehydratase	Synthesis of porphobilinogen from 5-aminolevulinic acid

Source: Parkin et al, 2000

2.18 PROPERTIES OF ZINC THAT ACCOUNT FOR ITS ROLE IN ENZYMES

Some properties enable zinc to take part in enzyme activities e.g. redox properties, geometrical orientation in space, ligand binding and exchange enhances its coenzyme activities. It also enables it to compete viciously with lead thereby reduces or inhibits its binding in the body. These properties are stated and described in the Table 2.10.

2.19 ROLE OF ZINC AT MOLECULAR LEVEL

Zinc is important in various functions such as its antioxidant property, protein synthesis, wound healing, development of reproductive organs, prostrate functions, male hormone activity. It governs muscular contraction, blood stability and body alkaline balance. It also aids normal tissue functions, digestion and metabolism of photosynthesis (Wood & Steed, 2004).

Table 2.10: Properties that Enhance Zinc Role in Enzymes

Properties	Description
Oxidation-Reduction properties	The divalent zinc is exceptionally stable With respect to reduction-oxidation and So it does not participate in redox reaction, In contrast to Mn, Fe and Cu.
Coordination Geometries	d^{10} Configuration of zinc complexes are not subjected to ligand field stabilization effects and so coordination number and geometry is only dictated by ligand size and charge. In enzymes, zinc shows a strong preference for tetrahedral coordination, which enhances both the Lewis acidity of Zn center and the Bronsted acidity of a coordinated water molecule. Only Cu is a better Lewis acid.
Ligand binding	Zinc is an element of borderline hardness so that nitrogen, oxygen and sulfur ligand Can all be accommodated in contrast to Mg and Ca, which favours binding to oxygen. Therefore zinc binds strongly to proteins.
Ligand exchange	The flexibility in coordination geometry makes ligand exchange more facile than For Ni or Mg and enhances the ability of Zinc to effect a catalytic cycle.
Ligand nucleophilicity	Anion such as OH^-, OR^- and SR^- retain nucleophilic character when coordinated to Zn. Only Mn^{2+}, Fe^{3+} and Cu^{2+} are better in this regards.

Source: Williams, 1989

2.20 ZINC DEFICIENCY

Zinc deficiency results in retardation and cessation of growth, impaired wound healing, and defects leading to reproductive failure, acrodermatitis entropathica (with loss of hair), inflammation of small intestine, anorexia nervosa and bulimia nervosa (Bryce-Smith, 1989)

2.21 EXCRETION OF ZINC

Most ingested zinc is eliminated in the faeces, about 5 mg/day to 10 mg/day, which comprises of unabsorbed zinc and endogenous zinc from bile, pancreatic fluid and intestinal mucosa cells. A considerable amount is excreted into the small intestine through pancreatic biliary secretion. (Davies, 1980; Matseshe et al, 1980; Johnsons & Evans, 1982). Human pancreatic secretions contain zinc level of 0.5-5 µg/ml (Hambridge et al, 1986). It is also excreted through sweat from a healthy human up to 0.50 mg/l in a man and about 1.25 mg/l in a healthy woman (Hohnadel et al, 1973).

CALCIUM

2.22 NATURAL OCCURRENCE

Calcium does not occur free in nature but in combined forms such as limestone, chalk, marble, calcite and aragonite all with a formula $CaCO_3$. It also occurs as dolomite ($CaCO_3.MgCO_3$), anhydrite ($CaSO_4$), gypsum ($CaSO_4.2H_2O$), fluorspar, calcium fluoride (CaF_2) and calcium phosphate $Ca_3(PO_4)_2$ (Holderness & Lambert, 1979).

2.23 PROPERTIES OF CALCIUM

Calcium is a grey metal which exhibits metallic properties such as high conductivity, lusterness, malleability, ductility, moderately high melting point and a high boiling point as shown in Table 2.11. It is a very reactive metal, which accounts for why it does not occur free in nature. It reacts with oxygen, cold water and acid (such as HCl) to form calcium oxide, calcium hydroxide and calcium salt of the acid (i.e. $CaCl_2$) respectively.

2.24 FUNCTIONS OF CALCIUM IN THE BODY

a. Skeleton formation: An average man's body contains approximately 1.5 Kg of calcium of which 99% makes up the principal structure of bones and skull mainly as calcium phosphate.

b. Component of blood: calcium role in various metabolisms requires a steady maintenance of about 100 mg/l of blood plasma, a process controlled by parathyroid glands.

c. Blood clotting: calcium is one of the several substances in blood clotting to prevent haemorrhage from a wound.

Table 2.11: Physical Properties of Calcium

Physical Property	Calcium
State	Solid
Appearance	Silvery-shining metal which rapidly tarnishes in air to form oxide
Density (g/cm^3)	1.55
Malleability/ductility	Malleable and ductile
Tensile strength	Fair tensile strength
Melting point	850°C
Conduction of heat and electricity	Good conductor
Absorbance	422nm

Source: Holderness and Lambert, 1979 (modified)

d. Muscular contraction: it controls muscular contraction through nerve signal transmission. A drop in calcium level results in tetany.

e. Enzyme activation: it plays an important part in the activation of enzyme such as trypsin from a precursor trypsinogen, and gastric enzyme rennin involves in digestion of milk.

2.25 SOURCES OF CALCIUM

There are two main sources namely the food sources and the non-food sources.

(a) Dietary Sources

The main sources of calcium are milk and milk products such as cheese, dried or condensed milk. Other good sources are fish like sardines, white bait and salmon in the form of calcium phosphate. Table 2.12 shows the calcium level of some food.

(b) The Non- Food Sources

The non-food sources are drinking water, which may contain various amount of calcium depending on its source. Rain water is known to be free of calcium and all minerals. Well water particularly in limestone areas contributes significant amounts of calcium to the diet. Drinking water contributes calcium partly through drinking and partly through precipitation of calcium on food when they are boiled in water. The average daily contribution of calcium reaches 74 mg per head. Intentionally added calcium compounds such as baking powder are often applied for culinary rather than dietary reason. Purified chalk is added to bread flour for regulatory reason (Pike, 1979).

Table 2.12: The Calcium Contents of Certain Food

Food	mg per 100g
Good sources:	
Onion dried	2540
Dried skim milk	1277
White bait	800
Cheese (Hard cheddar)	810
Corn flour with bran	354
Condensed milk	344
Soybean white	331
Fresh milk	120
Canned salmon	66
Baking powder	1130
Moderate sources:	
Cassava ,dried, pounded	69
Eggs	56
Peanut, shelled, dried	38
Gari fermented, dried	31
Yam flour	21
Taro flour	21
Millet	13
Butter	15
Meal	10
Sorghum (whole) red	7
Poor sources:	
Oat meal	55
Sweet Potato	27
Brown flour	24
White flour	15
Irish Potato	8
Rice	4
Corn flour without bran	3
Sugar	0
Cooking fat	0

Source: Pike, 1979 and Isbatou et al, 2001

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Eggs	56
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Gari fermented, dried	31
Yam flour	21
Taro flour	21
Millet	13
Butter	15
Meat	10
Sorghum (whole) red	7
Poor sources:	
Oat meal	55
Sweat Potato	27
Brown flour	24
White flour	15
Irish Potato	8
Rice	4
Corn flour without bran	3
Sugar	0
Cooking fat	0

Source: Pike, 1979 and Isbatou et al, 2001

2.26 CALCIUM ABSORPTION

Substances facilitating calcium absorption into the body are vitamin D and protein while those inhibiting its absorptions are phytic acid, oxalic acid, and fat (Pike, 1979) due to complex formation with calcium.

2.27 CALCIUM REQUIREMENT OF DIFFERENT PEOPLE

Calcium is primarily required for bones and teeth formation. Growing children required relatively more calcium in their diet than adults. Nursing mothers who are providing calcium rich breast milk also need adequate supply of calcium in their food. Inadequate calcium supply causes rickets in children and osteomalacia in adult. Their treatment requires large doses of calcium up to 1200 mg per day followed by regular supply of diet rich in calcium (Pike, 1979). The dietary requirement of calcium by different people varies according to age and the body morphology. This is shown in Table 2.13.

Table 2.13: Calcium Requirements of Different People

People	mg/day
Infants (0-1 year old)	600
Children:	
1-9 years	500
9-15 years	700
15-18 years	600
Normal adult (men and women)	500
Women in the last 3 months of pregnancy and when breastfeeding their babies	1200

Source: Pike, 1979

CHAPTER THREE

MATERIALS AND METHODS

3.1 DESCRIPTION OF THE STUDY AREA

Kwara State is one of the 36 states of the Federal Republic of Nigeria and is located in the middle belt zone of the country. Geographically, Kwara State is between Longitudes 2^0 and 7^0E and Latitudes 3^0 and 10^0N. It is bounded on the North by Niger State, on the South by Oyo State, on the West by the Republic of Benin and Eastern side by Kogi and Ekiti states. The area of about 32,500 Km^2 and a population of over 1.5 million people made of four ethnic groups viz, Yoruba, Nupe, Fulani and Baruba. The vegetation of the state is mainly guinea savannah and rain forest. It enjoys both wet and dry seasons and has a maximum temperature of 30-35^{0}C and annual rainfall of 1000-1500 mm. The arable soil supports farming and rearing of livestock. Agriculture is thus the main stay of the economy of the state. Kwara State has 16 Local Government Areas and Ilorin West Local Government Area is one of them and part of it makes the state capital, Ilorin. Ilorin Local Government Area has a population of about 44,000 people. On the North- West is Moro LGA; on the South and South-West is Asa LGA and on the East and South-East is Ilorin East LGA.

Ilorin West Local Government Area is the study area. As part of the state capital, urban migration has caused some deforestation with soil more open to erosion. The area does not enjoy any mass transportation system. so the only means of transportation is in vehicles. With the ailing economy in the last few years, second- hand vehicles with old engines are imported into the area. The servicing, repairing and washing of the vehicles have impacts on the environment and the health of the people.

Although some environmental sanitation measures have been put in place by the state government, the areas of vehicular exhaust and increased car wash centres have not been considered. Most car wash centres are sited near streams which receive their wastewater. The streams are used for rice farming and other human and animals needs. They also sustain grasses for animal grazing.

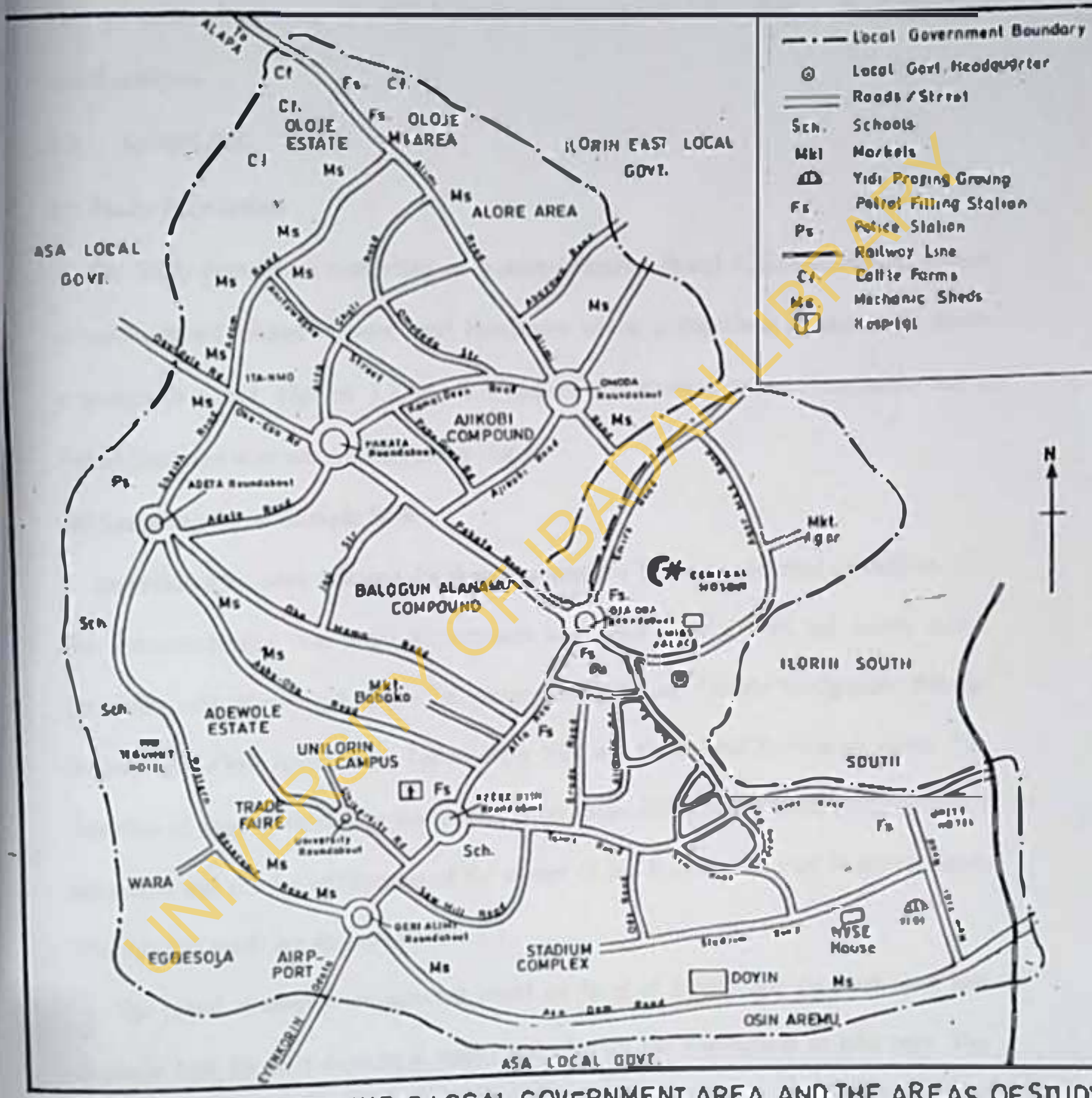

Fig 3.1 MAP OF ILORIN WEST LOCAL GOVERNMENT AREA AND THE AREAS OF STUDY

Source: Ilorin West L.G.A. Town Survey Dept.

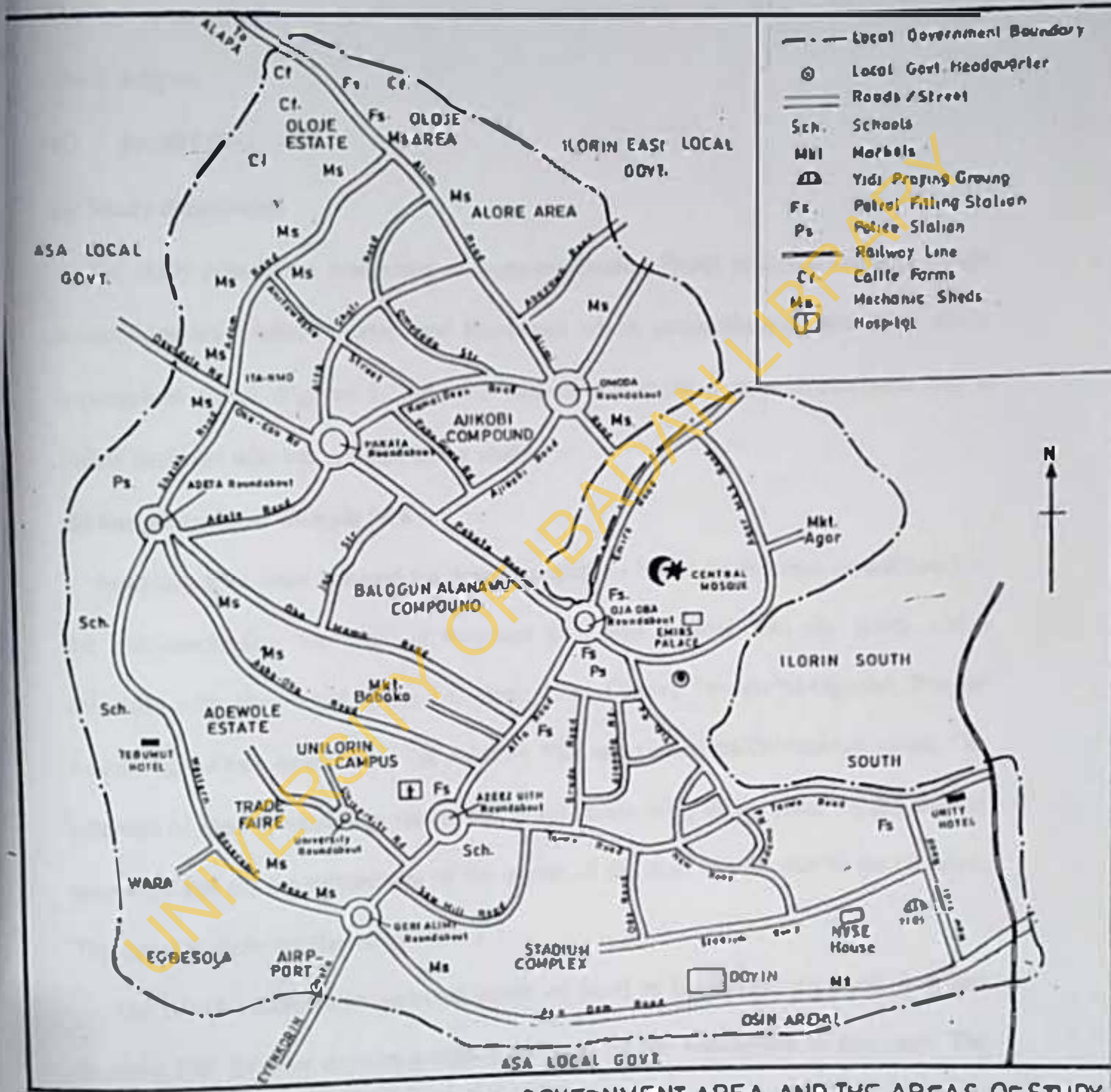

Fig.3.1 MAP OF ILORIN WEST LOCAL GOVERNMENT AREA AND THE AREAS OF STUDY

Source: Ilorin West L.G.A. Town Survey Dept.

3.2 STUDY DESIGN

The study was descriptive in design. It involved both survey and laboratory methods. The survey involved semi-structured questionnaires and the laboratory methods involved blood analysis.

3.3 SAMPLING

(a) Study Population

The study population comprised of Auto-mechanics, Petrol station attendants whose occupations are related to petrol and Herdsmen whose occupations do not entail direct exposure to petrol. Figures 3.2 and 3.3 respectively showed an auto-mechanic and a Fulani herdman who volunteered in the study

(b) Sampling Sites/ Sample Size

Sampling sites were selected for three occupations based on different modalities. For the auto-mechanics, the local government area was divided into six zones which coincides with their local union i.e. Oloje /Oko Olowo; Omoda/Ita-Ogunbo; Pakata/ Adeta; Agbo-Oba/ Azeez Alla; Taiwo/ New Yidi and GeriAlimi/Olorunsogo zones. The selection of shed or workshop was based on (a) accessibility of the shed, (b) the level of patronage and (c) the willingness of the owner of the shed to take part in the research. The selected sheds are shown in Table 3.1

The petrol stations were selected based on level of functioning (at least open and dispense fuel for four days in a week) and also on the willingness to take part. The selected petrol stations are shown in Table 3.2

The selection of cattle farms was based on settlements within the area, accessibility and willingness to take part. The selected farm settlements are shown in Table 3.3

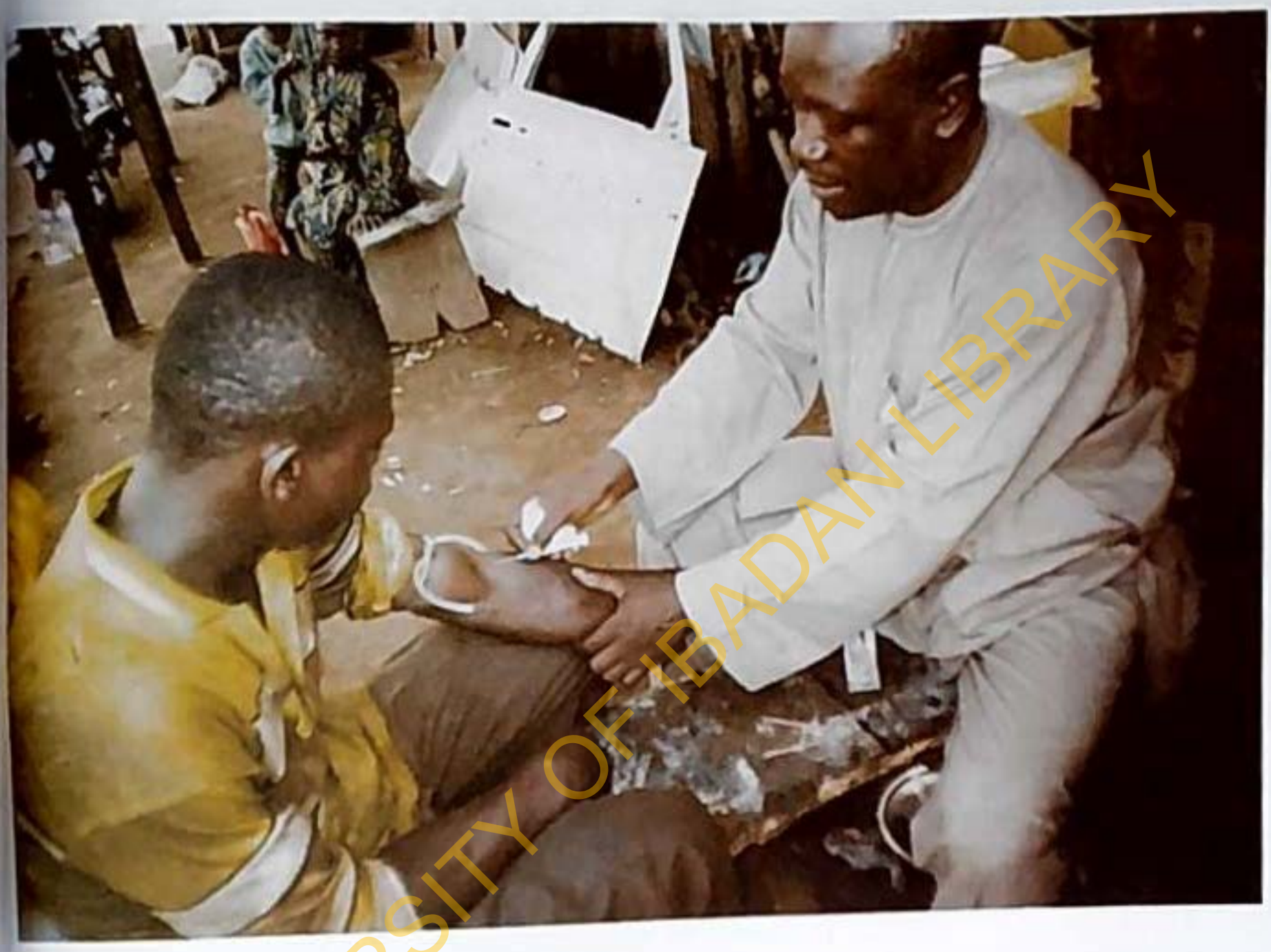

FIGURE 3.2: PHOTOGRAPH OF ONE OF THE MECHANIC VOLUNTEERS DONATING BLOOD FOR THE STUDY

FIGURE 3.3: PHOTOGRAPH OF ONE OF THE FULANI HERDSMEN THAT VOLUNTEERED IN THE STUDY

SAMPLE SITES

Table 3.1: Auto-mechanic Workshops

S/No	Location	Name of shed	Specialization	Population of auto-mechanics
1	Ogidi	Yinusa	Toyota lorry	4
2	"	Baba Taofik	Datsun	2
3	"	Olowolomona	Honda	3
4	Popo Igbonna	I'sho	General	6
5	Popo Igbonna	Ambali	Datsun/Toyota	4
6	Isale Aluko	Baba Nuru	General	4
7	Ita Nma	Kayode/Lateef	Carburettor	2
8	Agbo Oba	Shola	Mercedez	8
9	Adabata	Yellow	General	4
10	Azeez Atta	Mumini	Mech/ Brake	5
11	Taiwo road	Baba	General	3
12	"	Layi	Toyota	6
13	Ita Ogunbo	Rasak	General	5
14	Ode Adana	Raufu	General	5
15	Alausa	Loyo	Datsun/Toyota	3
13	Ansarul	Gani	General	5
14	Olorunsogo	Tunde	Mech/alignment	7
15	Olorunsogo	Abukunlowo	General	5
Total				81

Table 3.2: Petrol stations

S/No	Location	Petrol Station	Population of attendants
1	Ogidi	Ambali Petroleum	4
2	Oko Olowo	Ibrolak "	4
3	OkoOlowo	Ara Oje "	4
4	Ogidi	Giwa "	5
5	Oko Olowo	Lavel "	5
6	Ansarul	Lavel "	4
7	Ansarul	National "	6
8	Oloje	Uni-petrol	7
9	Adeta Round- about	Ali Petroleum	5
10	Adewole	Esinrogunjo "	4
11	Agbo-Oba	Peace "	3
12	Kuntu	Adisa Bakare "	5
13	Oja-Oba	Texaco	8
14	Oja tuntun junction	Uni-Petrol	6
15	Taiwo road.	Lubricon	8
Total			78

Table 3.3: Cattle Farms

S/No	Location	Name of Farm	Population of herasmen
1	Eruda	Gaa Akanbi Farm	8
2	Oloje	Gaa Lambo "	12
3	Adeta	Gaa Aremu "	9
4	Ansarul	Gaa Osibi "	7
5	Ogidi	Adisa "	11
6	Oko Olowo	Oniyangi "	10
Total			57

3.4 SURVEY MATERIALS AND METHOD

The research instruments used were questionnaires, which were semi-structured. In addition, samples of blood, water and fodder were analysed for lead, calcium and zinc levels.

(a) Questionnaire Design

The questionnaire was semi-structured. It contained fifty (50) questions of which two were open ended and forty eight (48) were close ended. The questionnaire was divided into five sections viz, demographic features, occupational features/activities, knowledge about lead, awareness of lead toxicity, perceived health problems and facilities used for treatment. The key variables were age, occupation, educational status, duration in the job, knowledge/awareness about lead and lead poisoning.

(b) Questionnaire Pre-test

The pre-test was carried out with 20 questionnaires. Fourteen (14) questionnaires were administered to auto-mechanics and 6 to petrol station attendants. The location was Bode Igbo in Iddo Local Government Area of Oyo State. My findings were

i. There was need to interepret the questionnaire in the language of some of the respondents because of their level of education.

ii. Some were evasive to some questions bordering on age, level of education, years in the job, personal hygiene and the heath facilities used for treatment.

iii. Many were impatient and responded hastily to end the interview quickly.

iv. Some were skeptical about the outcome of their responses on their job.

v. Some procrastinated by deferring response to some questions.

(c) Administration of Questionnaires

Five previously trained interviewers administered the 110 questionnaires to 110 respondents selected by purposive sampling.

3.5 Sample Size

Based on literature, the sample size was estimated with following parameter with standard deviation (σ) of 6.3 and standard error of 0. 03

$$d = Z \times S.E$$
$$= 1.96 \times 0.03$$
$$= 0.0588$$
$$n = \frac{Z^2 \alpha^2 \sigma^2}{d^3}$$
$$= \frac{(1.96)^2 \ (0.05)^2 \ (6.3)^2}{(0.0588)^3}$$
$$= 110.2$$

Where S.E. is the Standard Error

Z is the Reliability Coefficient at 95% Confidence Level

α is the level of significant that is. 5%

σ is the standard deviation

d is the interval

The target population was 216. The sample size was proportionally shared among the three groups.

3.6 Sampling Technique

The population was stratified based on different types of occupation. The sampling was purposive, based on a minimum of two years on the job and their willingness to take part in the study. Each occupational group had its population numbered separately and the volunteered subjects were subjected to simple random method. Ballot system was used to

select 110 subjects. The selected subjects were then used for the survey and blood samples donation. The relative proportion of each group was selected as shown below:

Population size = 216

Sample size = 110

Proportion estimation:

Number of mechanics:

$$\frac{81}{216} \times 110 = 41$$

Number of petrol attendants:

$$\frac{78}{216} \times 110 = 40$$

Number of herdsmen:

$$\frac{57}{216} \times 110 = 29$$

3.7 Method of Collection of Blood Samples

Venous blood was collected after simple swabbing using methylated spirit. Two (2) ml of blood was taken from each subject using sterile, pyrogen-free needle and syringe (Becton- Dickeson) of superior sharpness and smooth penetration. The blood samples were collected from the same subjects at different periods viz panic buying period, 2004 (sample P) and normal sale period, 2005 (sample N) within a year.

3.8 Pretreatment of Blood Samples

The usual pretreatment involving collection, concentration and purification of samples were not required in blood analysis. Digestion of sample with 2% trioxonitrate (v) acid was done. The content was centrifuged at 4 - 10 gravity to precipitate suspended particles. The supernatant liquid was filtered through 11 cm whatman filter paper No. 42 to obtain a light brown solution.

3.9 Laboratory Equipment

The materials required included, needles and syringes (5ml), polypropylene pipette tip, specimen bottles (EDTA bottles) and Teflon reagent bottles. Teflon (polytetrafluoroethylene) apparatus was used, to prevent adsorption of traces of metals sought for onto the wall of the container or leachate of lead if lead (II) borosilicate glass is used. Centrifuge, filtration gadget, graphite furnace, and atomic absorption Spectrophotometer (AAS) by Bulk Scientific (USA).

3.10 Chemicals and Reagents

The reagents required for the analysis were:

1. Trioxonitrate (v) acid (HNO_3): sub-boiling redistilled ultra pure concentrated HNO_3 or 98.00% HNO_3.
2. Diluent: The diluent and matrix modifier were 10.0 ml/l Triton X-100 (iso-Octylphenoxypolyethoxyethanol) and2.0 g/l. Ammonium dihydrogen tetraoxophosphate(V) (orthophosphate) $NH_4H_2PO_4$ (99.9% pure) in 0.2% HNO_3
3. Calibrator: Prepared from stock reference solution containing lead at 1000 µg/l and to be diluted to achieve final concentrations of 10, 20, 40 and 60 µg/dl and used to calibrate the instrument.
4. Blank: Prepared from distilled water treated with the diluent as done to the samples.
4. Comparative samples: Blood samples from the herdsmen.

3.11 Preparation of Standard Solutions

Calibration of standard graphs was done either from standard stock diluted to different concentrations or measured dry compounds ($Pb(NO_3)_2$, $CaCO_3$ and Zn/ HCl) . The standard solutions of lead, zinc, and calcium ions were used to check the values obtained from the AAS.

(a) Standard Lead Solutions

Stock standard was obtained from commercial sources and contained 1000 µg/ml Lead (II) trioxonitrate (V).

(b) Preparation of Standard Solution of Calcium

By Dissolving 0.2497 g $CaCO_3$ (heated to 180°C for 1 hour before weighing) in water with a minimum quantity of 1:1 HNO_3 and adding 10ml conc. HNO_3 then diluted to 1000 ml

1.00 ml contains 100 µg Ca was prepared as follows:

$$\frac{Ca}{CaCO_3} = \frac{40}{100}$$

$$\text{Mass of Ca in } CaCO_3 = \frac{40}{100} \times CaCO_3$$

$$= \frac{40}{100} \times 0.2497$$

$$= 0.0999 \text{ g}$$

$$= 0.1 \text{ g.}$$

0.1g in 1000 ml solution

1.0 ml of solution $= \frac{0.1}{1000}$

$= 100\,\mu g.$

(c) Preparation of standard Zinc solution

Dissolved 0.100 g of zinc metal in 20 ml 1+1HCl and diluted to 1000 ml with distilled water.

1.00 ml =100 µg Zn.

3.12 Quality Control

The quality controls observed were on blood samples collection, treatments and analysis.

(a) Blood sample collection

In sample collection, the following precautions were observed:

1. The needles and syringes were sterile and pyrogen free. The needle chosen were of superior sharpness and smooth penetration.
2. Sample label included number, date, time and place (workshop or duty post)
3. Plastic containers made of fluorinated polymer (FEP) or polypropylene were used so as to prevent either adsorption or leachate of lead ions possible with lead borosilicate glass container.
4. The containers were treated with 10% HNO_3 for one week to equilibrate them and then rinsed in triple distilled water.
5. Disposable hand gloves were necessary for personal protection.

6. Careful handling of blood sample was observed to prevent spilling.

7. The use of EDTA bottles (sodium or potassium type) was to prevent coagulation because lead is concentrated in the erythrocytes as shown in Fig. 3.4.

8. The sample was acidified to below pH of 2.0 to minimize precipitation and absorption of metals on to the wall of the containers.

9. The time interval between sample collection and its analysis was as short as possible.

(b) Sample digestion (treatment)

1. High-level phosphate detergent was used to mop surfaces and hands to remove lead contaminants, which could interfere with the assay.

2. The digestion procedure was done in dust-free laboratory to avoid contamination.

3. Digestion process was left overnight to allow enough time for the digestion and the containers were covered to minimize loss through froth.

(c) Sample analysis

The following precautions were taken during the analysis of blood samples:

1. Exposure of the blood samples to high level of chloride concentration was prevented because the chloride of lead is volatile at the charring temperature used in atomic absorption analysis. AAS Bulk 200 uses oxy-acetylene flame with a furnace temperature of about 3200°C.

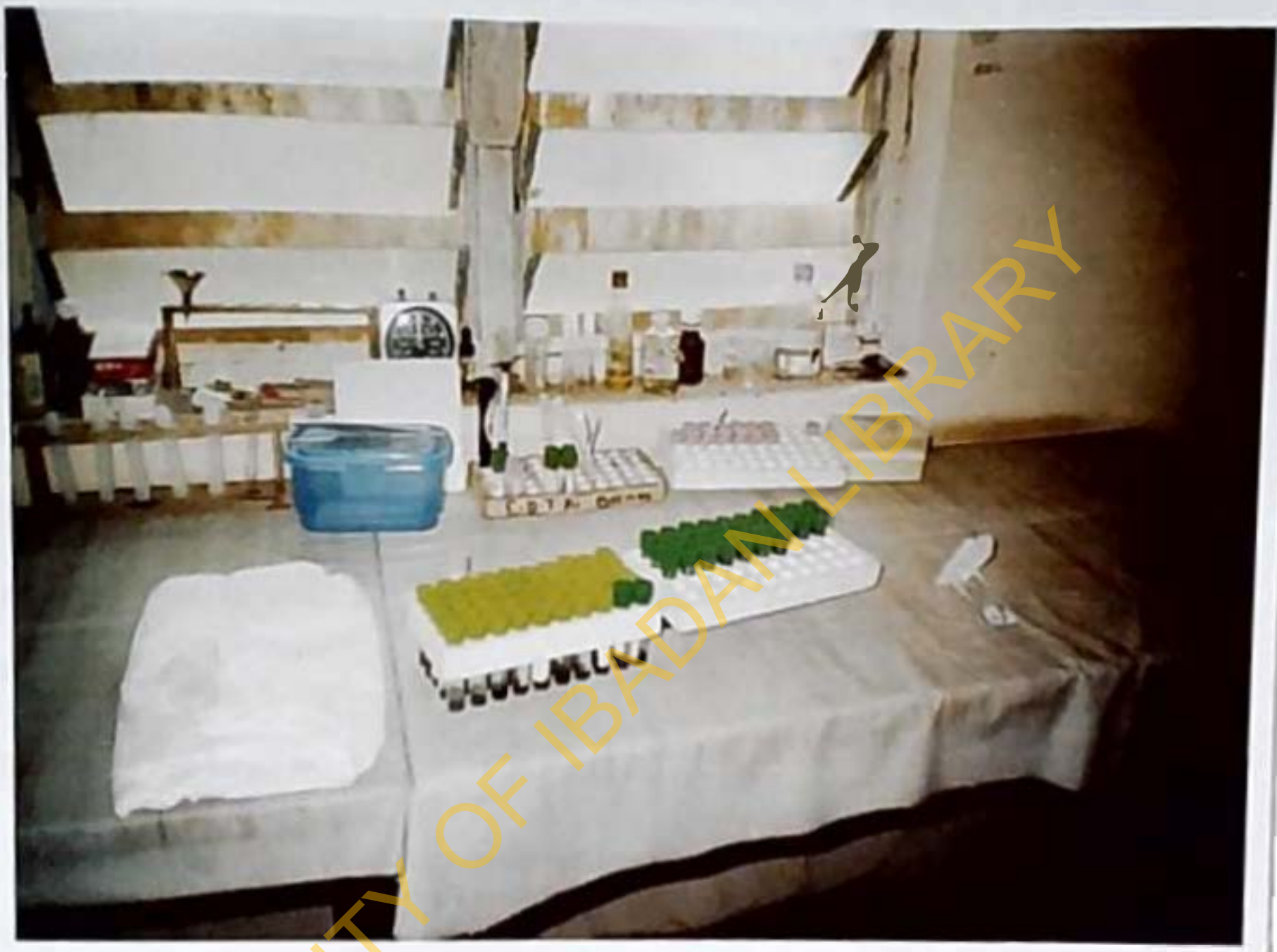

FIGURE 3.4: PHOTOGRAPH OF BLOOD SAMPLES COLLECTED IN No -EDTA BOTTLES

2. A variation of more than 10% in the results of triplicates indicate sample contamination during processing while a variation of less or equal to 10% was considered acceptable reproducibility.

(d) Others

1. Five sample pots (used in sample aspiration) were rinsed in 2% HNO_3 for 24 hrs. The solutions were aspirated to check for possible lead leachate.

2. Fortified blank (distilled H_2O) and matrix modifier ($NH_4H_2PO_4$ (aq))were prepared by dissolving a known concentration of lead ion in them and left for 24 hrs. The solutions were aspirated to detect possible variations. Variations within 5% were acceptable.

3.13 Sample Preparation

1. The blood samples were prepared according to method adopted by the National Committee for Clinical Laboratory Standards (NCCLS) in the United States. That is 1+ 9 dilution of 50 µl whole blood with modifier off- line. The contents were left overnight to reduce froth.

2. Modifier Solution was prepared from 0.5% (w/v) of $NH_4H_2PO_4$ by adding 5 g of $NH_4H_2PO_4$ to 100 cm^3 of distilled water; 0.5%(v/v) of Triton X-100 by adding 5 cm^3 of Triton X-100 to 100 cm^3 of distilled water and 0.2% (v/v) HNO_3 by adding 2 cm^3 of concentrated HNO_3 to 100 cm^3 of distilled water. All were added together and made to 1000 cm^3 (1 litre).

3. The contents were filtered the following day using whatman filter paper of No. 42 (diameter = 11 cm) to obtain clear brown filtrate.

Instrumentation: wave length (λ) = 283.3 nm for Pb, 214 nm for Zn and 422 nm for Ca.

4. Blank solution: 1 cm^3 triple distilled H_2O + 9 cm^3 diluent left in the same laboratory conditions as the samples solutions.

3.14 Dilution of Standard (Stock) Lead Solution

The 1000 µg/dl Pb standard (stock) solution was diluted to various concentrations e.g. 10, 20, 40 and 60 µg/dl using 0.2% HNO_3. The procedure for the dilution of 1000 µg/dl to 10 µg/dl was as follows:

$Cc \times Vc = Cd \times Vd$

$1000 \times 1 = 10 \times Vd$

$Vd = 1000/10$

$= 100$ ml

Volume of 0.2% HNO_3 required = 99 ml

Cc = Initial Concentration of the sample.

Cd = Final Concentration of the sample.

Vc = Initial Volume of the sample.

Vd = Final Volume of the sample.

Further dilutions were done to obtain 10, 20, 40 and 60 µg/dl as shown below

Stock (1000 µg/dl)	Diluent (ml)	Calibrator (µg/dl)
1	99.0	10
1	49.0	20
1	24.0	40
1	14.2	60

3.15 Calibration

The calibration was constructed using the points (10, 20, 40. 60 µg/dl) and a blank for the construction of a standard curve) as shown in Fig. 3.5, 3.6 and 3.7.

3.16 Sample Analysis

The instrument used for the analysis of the samples was the Atomic Absorption Spectrophotometer; BULK 200 manufactured by BULK Scientific USA as shown in Fig. 3.8.

(a) Atomic Absorption Spectrophotometer

Principle: When a sample of treated blood mixed with modifier solution (1+ 9) was introduced through a capillary tube into the Gas (acetylene) furnace Atomic Absorption Spectrophotometer, the process of analysis involved three stages. First, a low current heated the sample to dryness between 130 and 200° C. Secondy, a charring stage destroyed organic matter and volatilizes other matrix components at an intermediate temperature of 600° C. Finally, a high current heated the tube to incandescence and atomizes the elements being determined in an inert atmosphere at 2,400° C. Vaporized lead absorbs energy at the 216.8 nm line emitted from a hollow cathode lamp. The absorption of the wavelength was specific for lead and proportional to its concentration. There are three types of AAS; the graphite furnace, the electro-thermal and the gas burner types. The gas burner was used.

The method was developed for the Perkin-Elmer 4100ZL (THGA) as referred by Parsons et al (1999).

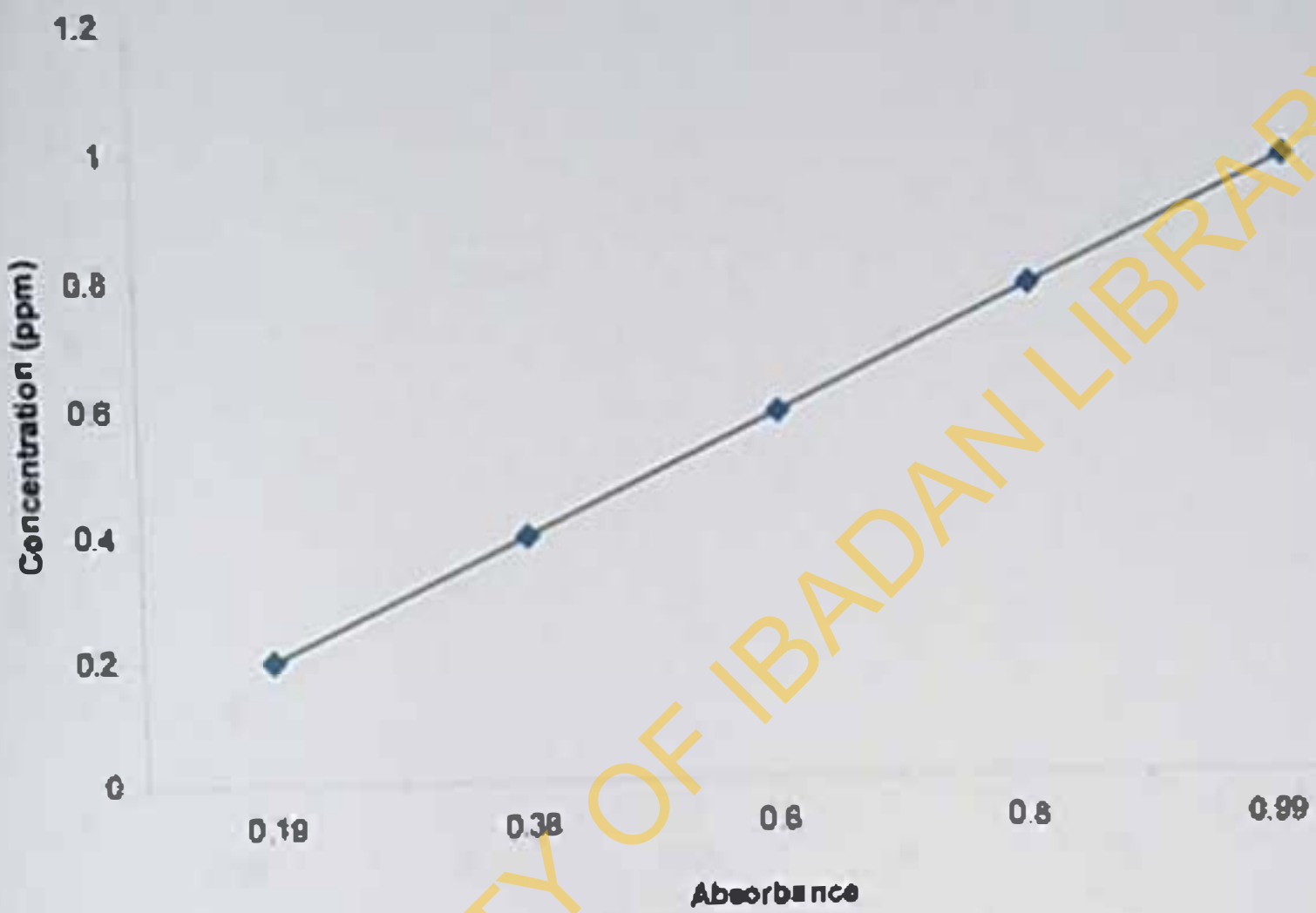

FIGURE 3.5: STANDARD CURVE OF LEAD

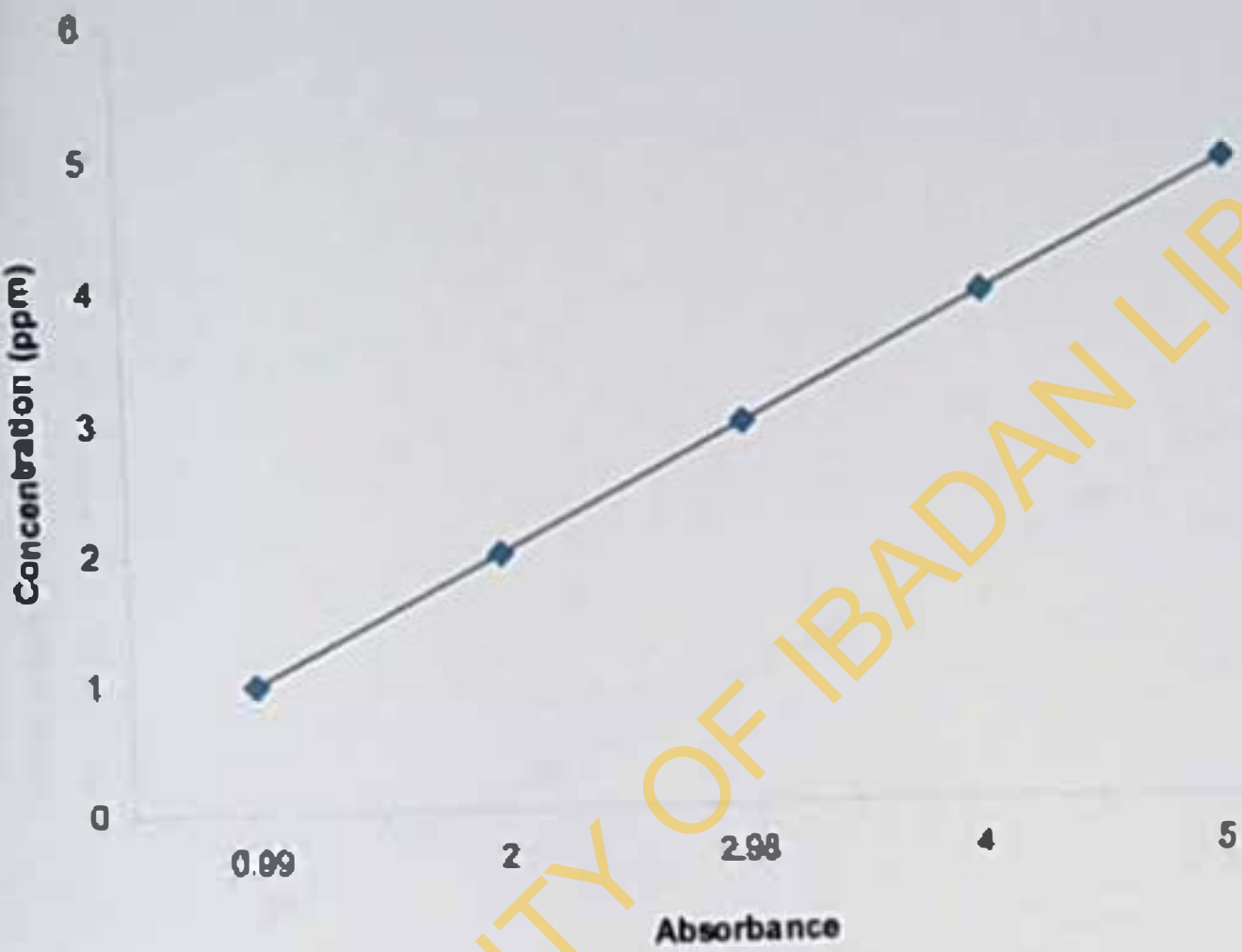

FIGURE 3.6: STANDARD CURVE OF ZINC

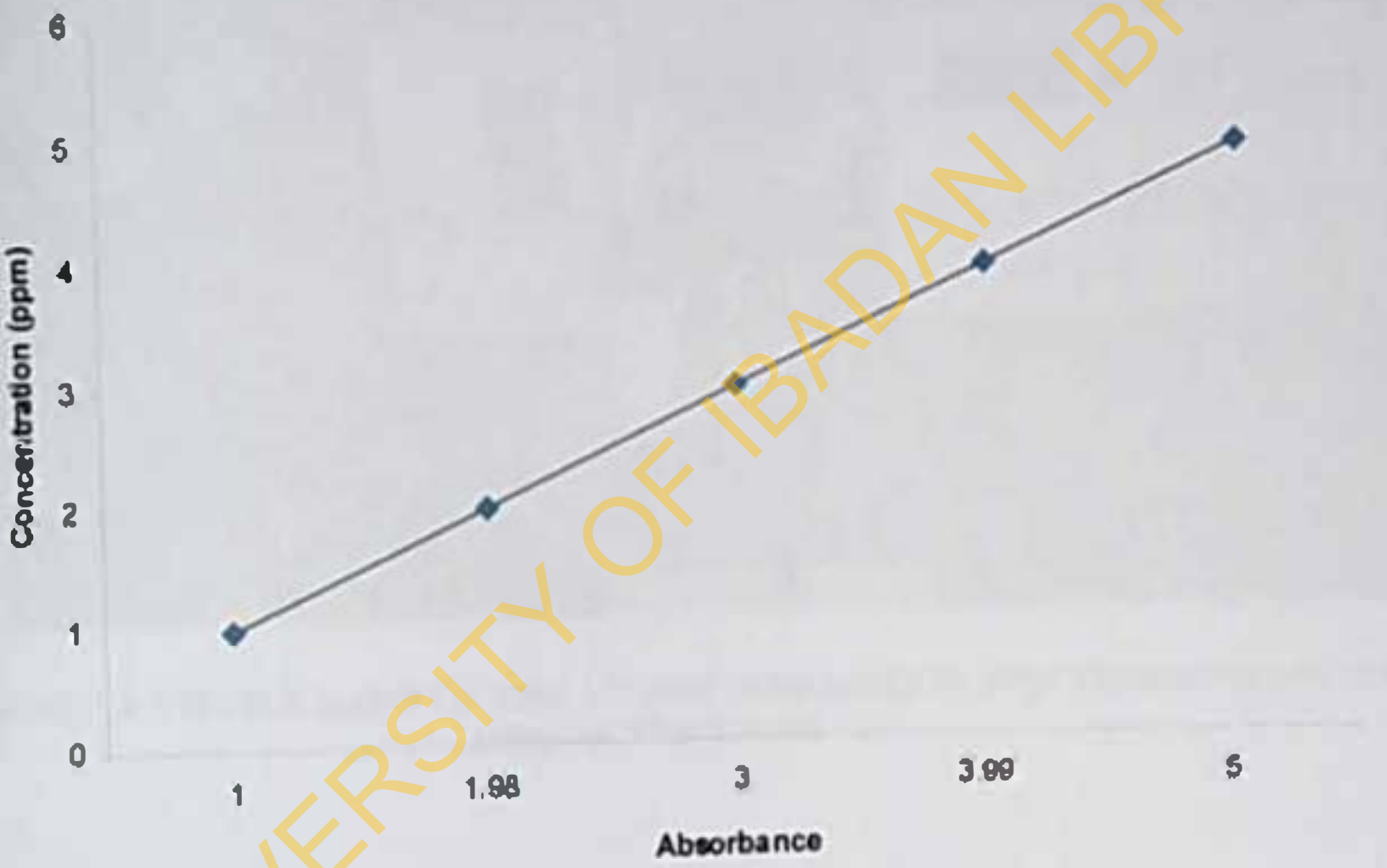

FIGURE 3.1: STANDARD CURVE OF CALCIUM

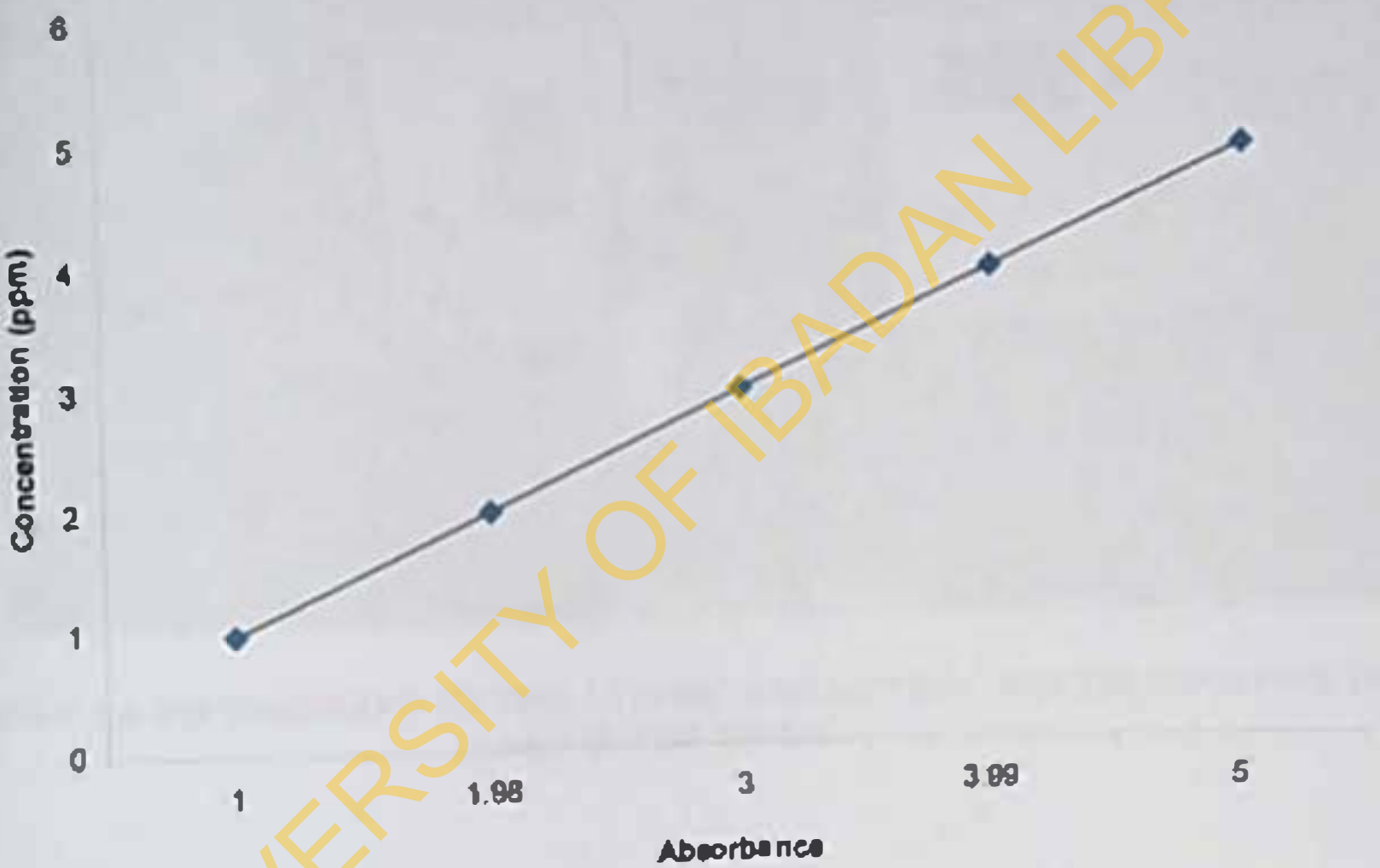

FIGURE 3.7: STANDARD CURVE OF CALCIUM

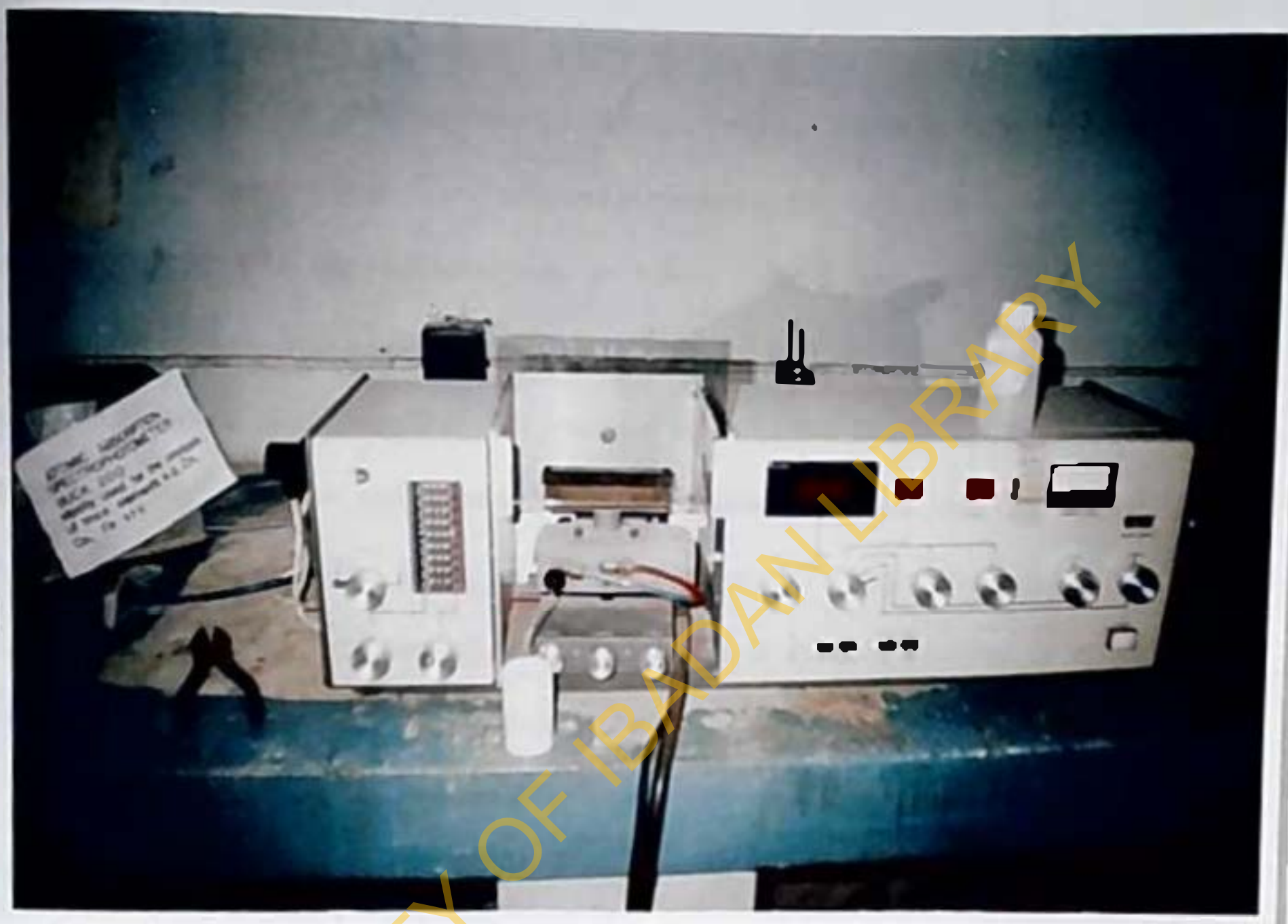

FIGURE 3.8: PHOTOGRAPH OF THE ATOMIC ABSORPTION SPECTROPHOTOMETER USED IN THE STUDY

(b) Measurement of Lead, Zinc and Calcium using Atomic Absorption Spectrophotometer.

Before the aspiration of the sample of interest, appropriate lamps were inserted into the turret slots according to the specification of the elements that the lamps can be used to determine. Bulk AAS has two turret slots for lamps 1 and 2. The lamp needed was warmed for 10 min with appropriate current (12 mA for lead and 10 mA for zinc and calcium according to specification). For lead, the desired wave length (216.8 nm) was selected using a selector and scanned until the required resonance line (the largest deflection from zero on the energy meter) was obtained. The aspiration rate of the nebulizer was already programmed into the machine. It enabled machine to set it automatically. The machine sucked in aliquots through a capillary tube.

The air valve was opened followed by the acetylene gas. The ignition button was pressed and released when the flame was produced at the burner head. The vertical alignment was checked by bringing down the flame (burner) and be sure the readout was zero and increase in burner resulted in increase in meter reading. The horizontal alignment was done by using the appropriate knob. The absorbance of the corresponding meter standard (0.1ppm for low and 1.0 ppm for high standards for lead) was read and noted before aspirating the sample. Absorbance/ concentration for the samples were accordingly noted.

(c) Samples from Foma Stream

Foma stream in Ilorin (study area) has been a regular source of water for animals and some remote villages. It also feeds the grasses along its bank as shown in Fig 3.9. Cattle and other animals regularly graze the grasses. Most of the streams in Ilorin west local Government are contaminated by waste water from car wash centres that have increased in number in the last decade. Most of the car wash centres are located near streams, which serve as sources of water as shown in Fig 3.10.

The presence of lead in the blood of herdsmen prompted the search for possibility through food chain because the Fulani herdsmen by nature of their life style never expose themselves to urban lifestyle but follow traditional ways of living. Water samples and fodders from the stream were analyzed for lead.

i. Treatment of Animal Fodder

This involved the digestion of the plants. Since extraction methods depend on the nature of the sample. To extract trace elements from the plants three different methods commonly used are

(a) Dry ashing

(b) Wet digestion including Aqua- regia ($HCl + HNO_3$ in ratio 3:1) method developed by American Public Health Association (APHA), 1998.

The method used for the digestion was dry ashing.

Apparatus: Muffle furnace, Sartorius balance (PT2100/000001 model), Oven (carbolite type), crucible, Milling machine (Thomas type), Heater, Volumetric flask (100ml) and Dry fibre filter paper.

FIGURE 3.9: PHOTOGRAPH OF FOMA STREAM WHERE WATER AND PLANTS SAMPLES WERE COLLECTED

FIGURE 3.10: PHOTOGRAPH OF SOME CAR WASH CENTRES THAT DISCHARGE THEIR WASTE-WATER INTO FOMA STREAM

Procedure: The samples were dried for three days in the oven then ground to powder in a milling machine. 2.0 g of each sample was put in a previously dried crucible then covered with lid and placed in a furnace at 460° C for 4 hrs to turn to ash. It was cooled and the following day 10ml of 1M HCl was added to the crucible. The content was heated for 2 or 3 sec. it was filtered into a volumetric flask and made up to 100 ml with distilled water. The lead content was then determined using AAS (Buck 200 model) at 283 nm.

Formula for Calculation of Lead in Plant Samples

$$\text{Lead (mg/kg)} = \frac{\text{Absorbance of sample}}{\text{Absorbance of Standard}} \times \frac{\text{Concentration of standard}}{\text{Mass of Sample}} \times 100$$

Or,

$$= \frac{\text{ppm of Sample}}{\text{Mass of Sample}} \times 100$$

ii Treatment/Analysis of the Water Samples From the Stream

The parameters determined from the water samples were

(a) Suspended solids

(b) Dissolved solids

(c) pH and conductivity

(d) Lead content.

The lead content of the water, which was the main concern, was reported in the study.

(c) **Suspended or Non-Filterable Solids (SS)**

The method of analysis was according to the methods described by USEPA, 1983.

Apparatus: Gooch funnel, filtering flask, oven, desiccator, vacuum pump, 100 ml pipette, dry filter paper and Satorious balance.

Procedure: Dry glass fibre filter paper; 5.5 cm in diameter was heated to a consant weight at 103-105° C in the oven and the weight noted. It was placed in a Gooch funnel with a pair of tongue. 100 ml of a thoroughly mixed water sample was poured into it. After the filtration, the filter paper was carefully removed and heated to a constant weight at 103-105° C. By subtracting the weight of the filter paper, the weight of the suspended solid was obtained.

$$\text{SS mg/l} = \frac{\text{SS (mg)}}{\text{Volume of sample (ml)}} \times 1000$$

(d) Dissolved or Filterable Solids (DS)

Dissolved solids can be estimated (a) by obtaining a known volume of the filtrate and heating it to dryness until a constant weight is obtained (b) by obtaining the total solid and deducting that of the suspended solids from it as shown below.

$$DS = TS - SS$$

(e) Total Dissolved Solids (TDS)

Apparatus: Evaporating dish, 100 ml pipette, steam bath, Satorious balance, oven and desiccator.

Procedure: A clean evaporating dish was heated to between 103 -105° C in an oven and cooled repeatedly until a constant weight was obtained (the weight was noted). 100 ml of thoroughly mixed water sample was pipetted into it and was evaporated to dryness on a steam bath. The outside of the dish was wiped then the content was dried in an oven at 103 -105 ° C for about 1 hour. The dish was transferred into a desiccator and weighed at

room temperature .the process was repeated until a constant weight was obtained to within 0.05 mg. The weight of dry dish was subtracted from it to obtain that of the solid.

(d) Lead content of water samples

Apparatus/ Reagent: Glass beads, Vacuum filter, Erlenmeyer flask, AAS. Nitric acid (1+1), Hydrochloric acid (1+1), deionized water, matrix modifiers (ammonium nitrate 10% w/v).

Procedure: The organic materials in the water was removed by first digesting it with conc. HNO_3 and filtered through a preconditioned and prewashed 0.4 µm pore- diameter membrane plastic filter. The filter was preconditioned by soaking in HNO_3 (1+1) and prewashed with deionized water. 500 cm^3 of the water sample was concentrated to 25 cm^3 (Abua, 1996). 5 cm^3 of HNO_3 and 5 cm^3 of 10% (w/v) ammonium nitrate were added to 25 cm^3 of the sample. The solution was diluted to 50 cm^3 then aspirated into the AAS (Atomic Absorption Spectropbotometer bulk 200). The solution was a ten - fold cooccotration.

3.17 DATA ANALYSIS

The raw data obtained from questionnaire responses and those from blood analysis were fed into a computer. The Statistical Package for Social Sciences (SPSS) Software Programme was employed to produce frequency tables and statistical tests.

CHAPTER FOUR
RESULTS

This chapter presents the socio-demographic characteristics of the respondents from the study area: occupational features that cause lead exposure; lead awareness and knowledge/ experience of lead poisoning. Also presented are the laboratory results of lead, calcium and zinc in the blood samples of the respondents.

4.1 Demographic Characteristics

In the three occupational groups, female respondents were absent among auto-mechanics. Occupation, sex, religious affiliation, ethnicity, age and educational status were considered as variables to assist the researcher in collecting relevant data on important aspects of the study.

The majority of the respondents sampled in the three groups were males numbering 83 (75.5%) and the females were 27 (24.5%). The difference was in the absence of female auto-mechanics, which might be due to societal perception of the profession as male profession. There was a significant relationship ($p < 0.05$) between gender and occupation as shown in Table 4.1.

The mean ages of the auto-mechanics, petrol attendants and the herdsmen were 32.41 ± 7.97, 32.65 ± 8.14 and 27.48 ± 7.44 respectively. The overall mean age of the respondents was 31.20 ± 8.14. The age distribution of the respondents is shown in Fig. 4.1. It was observed that 87 (79.1%) of the respondents were Moslems while 23 (20.9%) were Christians. A significant relationship ($p < 0.05$) was observed between the religious affiliation and occupation as shown in Table 4.2.

The ethnicities of the respondents were Yoruba, 75 (68.2%); Igbo 5 (4.5%); Hausa 1 (0.9%) and Fulani 29 (26.4%). There was a significant relationship ($p < 0.05$) between ethnicity and occupation as shown in Table 4.3.

The distribution of the respondents according to marital status indicated that 80 (72.7%) were married, 26 (23.6%) were single and 4 (3.6%) were separated. There was no significant relationship ($p > 0.05$) between marital status and occupation as shown in Table 4.4.

The educational background of the respondents as presented in Fig. 4.2 showed that primary education was the highest 43 (39.1%) followed by secondary education 11 (10.0%) and the least was polytechnic education 1 (0.9%). There was a significant relationship ($p < 0.05$) between education and the occupation.

Table 4.1: Sex Distribution of the Respondents by Occupation

Sex	Auto-mechanics	Petrol Attendants	Herdsmen	Total	χ^2	p-value
	No. %	No. %	No. %	No. %		
Male	41(100.0)	22 (55.0)	20 (69.0)	83 (75.5)	7.862	0.02
Female	0 (0.0)	18 (45.0)	9 (31.0)	27 (24.5)		
Total	41 (100.0)	40 (100.0)	29 (100.0)	110 (100.0)		

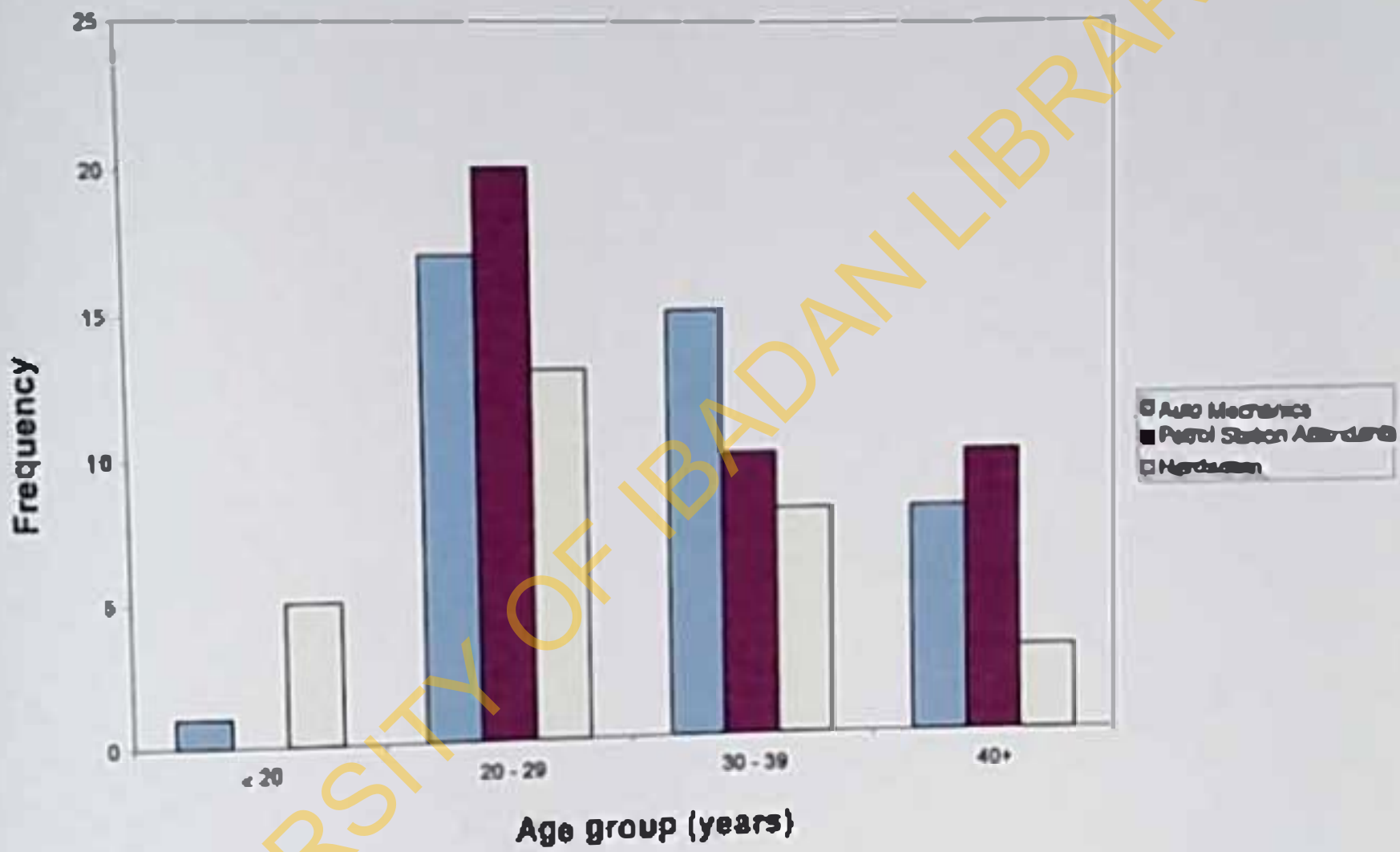

FIGURE 4.1: AGE GROUP OF THE RESPONDENTS

Table 4.2: Religious Affiliation of the Respondents

Religion	Auto-mechanics	Petrol Attendants	Herdsmen	Total	χ^2	p-value
	No. %	No. %	No. %	No. %		
Christianity	13 (31.7)	10 (25.0)	-	23 (20.9)	6.139	0.046
Islam	28 (68.3)	30 (75.0)	29 (100.0)	87 (79.1)		
Total	41 (100.0)	40 (100.0)	29 (100.0)	110 (100.0)		

Table 4.3: Ethnicity of the Respondents by Occupation

Sex	Automechanics No. %	Petrol Attendants No. %	Herdsmen No. %	Total No. %	χ^2	p-value
Yoruba	38 (92.7)	37 (92.5)	-	75 (68.2)		
Igbo	2 (4.9)	3 (7.5)	-	5 (4.5)		
Hausa	1 (2.4)	-	-	1(0.9)	111.631	0.00
Fulani	-	-	29(100.0)	29 (26.4)		
Total	41(100.0)	40 (100.0)	29(100.0)	110 (100.0)		

Table 4.4: Marital Status of the Respondents

Marital Status	Automechanics No. %	Petrol Attendants No. %	Herdsmen No. %	Total No. %	χ^2	p-value
Single	9 (22.0)	6 (15.0)	11(37.9)	26 (23.6)		
Married	31(75.6)	31(77.5)	18 (62.1)	80 (72.7)		
Separated	1(2.4)	3 (7.5)	-	4 (3.6)	7.302	0.121
Divorced	-	-	-	-		
Widowed	-	-	-	-		
Total	41(100.0)	40 (100.0)	29 (100.0)	110 (100.0)		

Table 4.4: Marital Status of the Respondents

Marital Status	Automechanics No. %	Petrol Attendants No. %	Herdsmen No. %	Total No. %	χ^2	p-value
Single	9 (22.0)	6 (15.0)	11(37.9)	26 (23.6)		
Married	31(75.6)	31(77.5)	18 (62.1)	80 (72.7)		
Separated	1(2.4)	3 (7.5)	-	4 (3.6)	7.302	0.121
Divorced	-	-	-	-		
Widowed	-	-	-	-		
Total	41(100.0)	40 (100.0)	29 (100.0)	110 (100.0)		

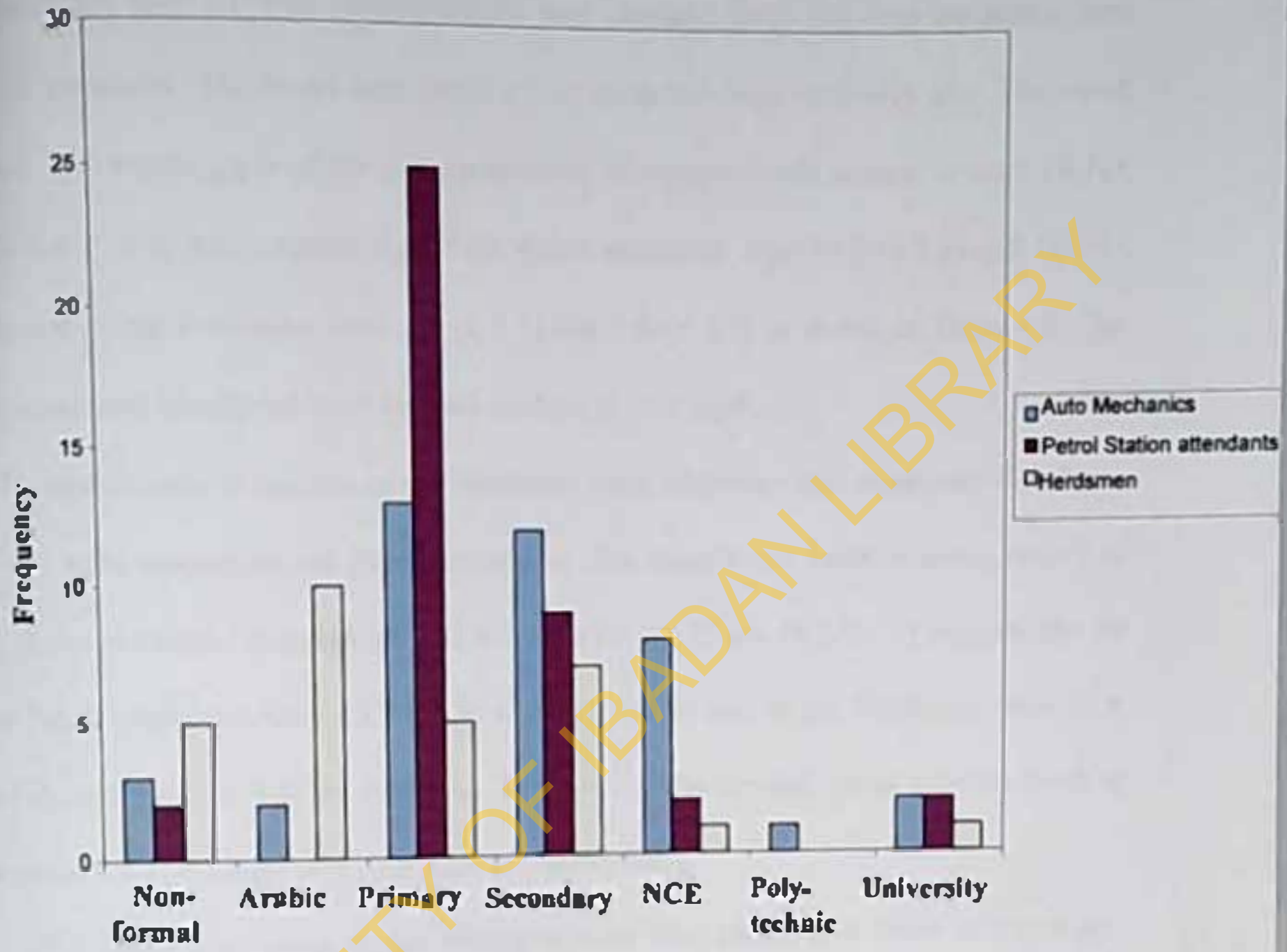

FIGURE 4.2: LEVELS OF EDUCATION OF THE RESPONDENTS

4.2 The Mean Blood Lead, Calcium and Zinc levels in relation to Occupation

Significant level of lead concentrations was obtained from the auto-mechanics and petrol attendants. The blood lead levels of the herdsmen were relatively low. The mean blood lead levels (µg/l) of the Auto-mechanics in sample P and sample N were 20.1(± 4.2) and 17.8 (± 4.6) respectively; of the Petrol attendants were 14.2 (± 3.2) and 11.5 (± 3.1) and of the Herdsmen were 2.2 (± 2.3) and 1.9 (± 2.1) as shown in Table 4.5. The recommended blood lead level for lead workers is 25.0 µg/dl.

The blood levels of calcium in the Herdsmen were relatively high compared with those of the Auto-mechanics and Petrol attendants. The mean blood calcium levels (mg/l) of the Auto-mechanics in samples P and N were 18.9 (±1.2) and 18.5 (±1.1) respectively; of the Petrol attendants were 13.7 (±1.9) and 13.3 (±1.9) and of the Herdsmen were 21.4 (±1.8) and 19.3 (± 5.6) as shown in Table 4.5. The normal blood calcium level is between 8.5 - 10.5 mg/l (4.5 - 5.6 mg/l in ionized state).

The blood zinc levels in the herdsmen were also higher than those of the Auto-mechanics and the Petrol attendants. The mean blood zinc levels (mg/l) in the Auto-mechanics in samples P and N were 5.0 (±0.8) and 4.1 (±1.0) respectively; of the Petrol attendants were 3.1(±0.7) and 2.4 (±0.6) and of the Herdsmen were 13.3 (±3.0) and 7.6 (±3.8) as shown in Table 4.5. The normal blood zinc level is 10 – 14 mg/l. Significant relationship occurred ($p < 0.05$) between the metals (lead, calcium and zinc) and occupation.

Table 4.5: The Mean Lead, Calcium and Zinc levels in relation to Occupation

	Lead Levels(µg/dl) Mean ± SD				Calcium Levels (mg/dl) Mean ± SD				Zinc Levels (mg/dl) Mean ± SD			
	Auto-mechanics	Petrol Attendants	Herds-men	Total	Automechanics	Petrol Attendants	Herds-men	Total	Auto-mechanics	Petrol Attendants	Herds-men	Total
Sample P	20.12	14.23	2.24	1326	18.85	13.73	21.41	17.66	4.96	3.13	13.29	6.49
	± 4.20	± 3.25	± 2.32	± 7.87	± 1.17	± 1.89	± 1.84	± 3.54	± 0.76	± 0.69	± 3.02	± 4.47
F	231.457				201.117				340.839			
p-value	0.000				0.000				0.000			
Sample N	17.76	11.48	1.86	11.28	18.48	13.33	19.33	16.83	4.06	2.40	7.57	4.38
	± 4.59	± 3.12	± 2.12	± 7.19	± 1.13	± 1.93	± 5.61	± 4.13	± 0.97	± 0.63	± 3.78	± 2.89
F	170.522				38.803				53.896			
p-value	0.000				0.000				0.000			

4.3 Blood Lead in Relation to Occupations

A significant relationship (p = 0.05) was observed between blood lead level and the nature of occupation. At 0.05 level of significance, the calculated values of F for both samples P and N were 231.457 and 170.522 respectively as shown in Table 4.6. Both values were greater than the Table value of 19.486 at the degree of freedom of 2, 107. This showed that the nature of occupation was a significant contributor to the level of lead in the blood. It was highly significant with $p < 0.05$ at the different periods of petrol sales.

4.4 Blood Lead Levels and Period of Petrol sale

The blood samples were collected from the same subjects a year interval. A strong correlation (r = 0.965) was observed between the two analyses. This is shown in Table 4.7. The first set of samples collected was in a period of inadequate supply of petrol which resulted in panic buying of the fuel but the replicate samples were collected during normal sales. It was a usual occurrence that during panic buying, plastic containers were freely used for carrying and storing petrol. Most of the containers were used for domestic purposes later during regular fuel supply.

4.5 Blood Lead Levels and Number of Years in the Job

There were significant correlations between the number of years in the occupation and the lead level of the blood in the P and the N samples in which r = 0.255 and r = 0.331 respectively as shown in Table 4.8.

Table 4.6: Blood Lead in Three different Occupations

Characteristics	Occupation	n	Mean± SD	F	p-value
Sample P	Auto-mechanics	41	20.12 ± 4.20		
	Petrol attendants	40	14.23 ± 3.25		
	Herdsmen	29	2.24 ± 0.23	231.457	0.000
			13.26 ± 7.87		
Sample N	Auto-mechanics	41	17.76 ± 4.59		
	Petrol attendants	40	11.48 ± 3.12		
	Herdsmen	27	1.86 ± 0.21	170.522	0.000
	Total	108	11.28 ± 7.19		

Table 4.6: Blood Lead in Three different Occupations

Characteristics	Occupation	n	Mean± SD	F	p-value
Sample P	Auto-mechanics	41	20.12 ± 4.20		
	Petrol attendants	40	14.23 ± 3.25		
	Herdsmen	29	2.24 ± 0.23	231.457	0.000
			13.26 ± 7.87		
Sample N	Auto-mechanics	41	17.76 ± 4.59		
	Petrol attendants	40	11.48 ± 3.12		
	Herdsmen	27	1.86 ± 0.21	170.522	0.000
	Total	108	11.28 ± 7.19		

Table 4.7: Blood Lead Levels in relation to period of Petrol sale

Characteristics	n	Mean ± SD (µg/dl)	r	p-value
Sample P	110	13.26 ± 7.87	0.965**	0.000
Sample N	108	11.28 ± 7.19		

Table 4.8: Blood Lead Levels in relation to Number of Years in the Job

Characteristics	N	r	p- value
Sample P	110	0.255**	0.007
Sample N	108	0.331**	0.000

** Significant at 0.01 level

4.6 Blood level of Calcium in relation to Occupation

From Table 4.9 below, in the sample P, the mean blood calcium level in the Auto-mechanics group was 18.85 ± 1.17, in the Petrol Attendants was 13.73 ± 1.89 and in the Herdsmen was 21.41 ± 1.84 mg/ l. This showed that the herdsmen had a higher level of calcium in the blood than the other groups. In the sample N, the mean blood calcium level of the Auto-mechanics group was 18.48 ± 1.13, the Petrol Attendants was 13.33 ± 1.93 and the Herdsmen was 19.32 ± 5.61. There was a significant relationship ($p < 0.05$) between blood calcium and the nature of occupation in both samples.

4.7 Blood level of Zinc in relation to Occupation

In sample P, as shown in Table 4.10, the mean blood zinc levels in the Auto-mechanics, Petrol Attendants and Herdsmen were 4.96 ± 0.76, 3.13 ± 0.69 and 13.29 ± 3.02 (mg/l) respectively. It was observed that the herdsmen had higher blood zinc than the other groups. In sample N, the mean blood zinc levels in the Automechanics, Petrol Attendants and Herdsmen were 4.06 ± 0.97, 2.40 ± 0.63 and 7.57 ± 3.78 mg/l respectively. It was established in both samples that occupation was significantly related ($p < 0.05$) to blood zinc level. The Table value of F was 19.486 at 0.05 level of significance and degree of freedom 2 and 107.

Table 4.9: Blood levels of Calcium in different Occupations

Characteristics	Occupation	n	Mean ± SD	F	p-value
Sample P	Auto-mechanics	41	18.85 ± 1.17		
	Petrol Attendants	40	13.73 ± 1.89		
	Herdsmen	29	21.41 ± 1.84	201.117	0.000
			17.66 ± 3.54		
Sample N	Auto-mechanics	41	18.48 ± 1.13		
	Petrol Attendants	40	13.33 ± 1.93		
	Herdsmen	27	19.32 ± 5.61	38.803	0.000
	Total	108	16.83 ± 4.13		

Table 4.10: Blood levels of Zinc in different Occupations

Characteristics	Occupation	n	Mean ± SD	F	p-value
Sample P	Auto-mechanics	41	4.96 ± 0.76		
				340.839	0.000
	Petrol Attendants	40	3.13 ± 0.69		
	Herdsmen	29	13.29 ± 3.02		
			6.49 ± 4.47		
Sample N	Auto-mechanics	41	4.06 ± 0.97		
	Petrol Attendants	40	2.40 ± 0.63	53.896	0.000
	Herdsmen	27	7.57 ± 3.78		
	Total	108	4.38 ± 2.89		

4.8 Blood Lead levels in relation to the Calcium and Zinc levels

(a) Blood levels of Lead and Calcium

The relationship between lead and calcium of the blood is shown in Table 4.11. In all cases there were negative correlation (r = -0.358, -0.063, -0.123 and -0.272) between the lead and calcium in the blood though not very strong.

(b) Blood levels of Lead and Zinc

The relationship between blood lead and zinc is shown in Table 4.12. below. In all cases, negative correlations (r = -0.693, -0.451, -0.633 and -0.409) occurred between the blood lead and zinc. The correlations were highly significant ($p < 0.05$) and stronger than those between lead and calcium.

Table 4.11: Blood levels of Lead and Calcium

Characteristics	n	Mean ± SD	r	p-value
Pb (Sample P)	110	13.26 ± 7.87		
Ca (Sample P)	110	17.66 ± 3.54	-0.358**	0.000
Pb (Sample P)	110	13.26 ± 7.87		
Ca (Sample N)	108	16.83 ± 4.13	-0.123	0.201
Pb (Sample N)	108	11.28 ± 7.19		
Ca (Sample P)	110	17.66 ± 3.54	-0.272**	0.004
Pb (Sample N)	108	11.28 ± 7.19		
Ca (Sample N)	108	16.83 ± 4.13	-0.063	0.514

Table 4.12: Blood levels of Lead and Zinc

Characteristics	n	Mean ± SD	r	p-value
Pb (Sample P)	110	13.26 ± 7.87		
Zn (Sample P)	110	6.49 ± 4.47	-0.693**	0.000
Pb (Sample P)	110	13.26 ± 7.87		
Zn (Sample N)	108	4.38 ± 2.89	-0.451**	0.000
Pb (Sample N)	108	11.28 ± 7.19		
Zn (Sample P)	110	6.49 ± 4.47	-0.633**	0.000
Pb (Sample N)	108	11.28 ± 7.19		
Zn (Sample N)	108	4.38 ± 2.89	-0.409**	0.000

4.9 Lead exposure among the Occupational groups

4.9.1 Petrol handlers

(a) Use of Petrol

A total of 80 (98.8%) of Auto-mechanics/Petrol attendants agreed that they used petrol as solvent for removing grease from machine parts while only 1(1.2%) did not. Seventy-nine 78 (96.3%) of the respondents dissolved grease with bare hands and 2 (2.5%) used hand gloves as shown in Table 4.13.

(b) Frequency of hand contact with Petrol

The frequency of hand contact with petrol is presented in Fig.4.3. Among the auto-mechanics the petrol hand contact were 9 (22.0%) once, 1(1.3%) twice and 3 (3.7%) thrice per week. Twenty six (32.1%) of the petrol attendants had the contact once a week and 41 (50.0%) of many times a week. The chart showed that the auto-mechanics were more exposed to leaded petrol among the three occupational groups. The herdsmen were not exposed to leaded petrol by the nature of their occupation

(c) Personal hygiene

On the personal hygiene which involved hand washing before eating while at work, 77 (95.1%) of the respondents did while 4 (4.9%) ate without washing their hands. Sixty-six 66 (85.7%) of those that washed their hands before eating did it always, 11 (14.3%) occasionally as shown in Table 4.14. Fifteen (13.6%) used water only, 43 (39.1%) used soap solution and 50 (45.5%) used detergent solution and 2 (1.5%) used cloth as means of cleaning their hands. Fig. 4.4 showed a higher proportion of petrol attendants used detergent solution which has a stronger cleansing power than the other means.

Table 4.13: Handling of Grease by Auto-mechanics and Petrol Attendants

Characteristics	Auto-mechanics	Petrol Attendants	Total	χ^2	p-value
	No. %	No. %	No. %		
a. Used petrol to dissolve grease on the hands or tools	40 (97.6)	40 (100.0)	80 (98.8)	59.4	0.00
Did not use petrol to dissolve grease	1(2.4)	-	1(1.2)		
b. Used hand gloves when handling petrol	1(2.4)	1(2.5)	2(2.5)		
Dissolved grease with bare hands	39 (95.2)	39 (97.5)	78 (96.3)	52.6	0.00
Uncertain	1(2.4)	-	1(1.2)		
Total	41(100.0)	40 (100.0)	81(100.0)		

FIGURE 4.3: FREQUENCY OF EXPOSURE TO PETROL BY HAND CONTACT (WEEKLY)

Table 4.14: Personal Hygiene practices at Work

Characteristics	Auto-mechanics	Petrol Attendants	Total	χ^2	p-value
	No. %	No. %	No. %		
a. Washed hands before eating.	40 (97.6)	37 (92.5)	77 (95.1)	1.164	0.559
Did not wash before eating.	1(2.4)	3 (7.5)	4 (4.9)		
b. frequency of hand washing:					
Always	35 (87.5)	31(83.8)	66 (85.7)	5.643	0.227
Occasionally	5 (12.5)	6 (16.2)	11(14.3)		
Total	40 (100.0)	37 (100.0)	77 (100.0)		

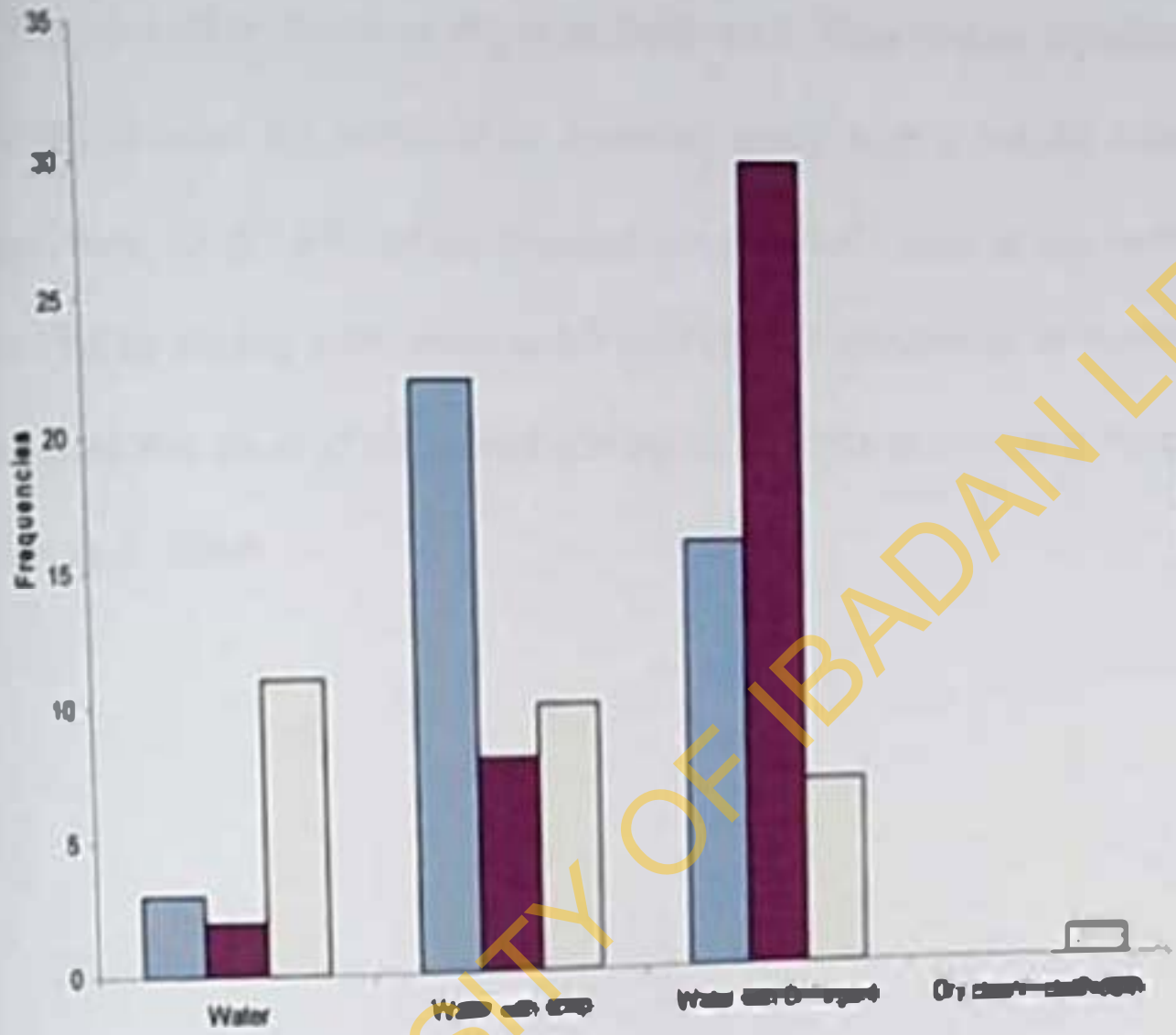

FIGURE 4.4: MODE OF CLEANING HAND BEFORE EATING AT WORK

4.9.2 Mode of siphoning of Petrol from Vehicle Tank

The method used to remove petrol (used as solvent to dissolve grease from motor parts) from vehicle tanks showed that of 81 respondents, 74 (91.4%) claimed that they sucked petrol with mouth with the aid of rubber hose, 4 (4.9%) used suction pump and 3 (3.7%) used other means as shown in Table 4.15. There was no significant relationship ($p > 0.05$) between the methods of removing petrol from a vehicle tank and occupation. Sixty-three 63 (79.8%) of the respondents removed traces in the mouth by spitting, 14 (14.4%) by rinsing with water and 2 (2.5%) used mouthwash as shown in Fig. 4.3. This indicated that most of them used spitting as a means of removing traces of leaded petrol from their mouth.

Table 4.15: Method of Siphoning Petrol from Vehicle Tank

Characteristics	Auto-mechanics No. %	Petrol Attendants No. %	Total No. %	χ^2	p-value
Using mouth and rubber hose	37 (90.2)	37 (92.5)	74 (91.4)		
Using suction pump or device	2 (4.9)	2 (5.0)	4 (4.9)	0.988	0.804
Used other means	2 (4.9)	1(2.5)	3 (3.7)		
Total	41(100.0)	40 (100.0)	81(100.0)		

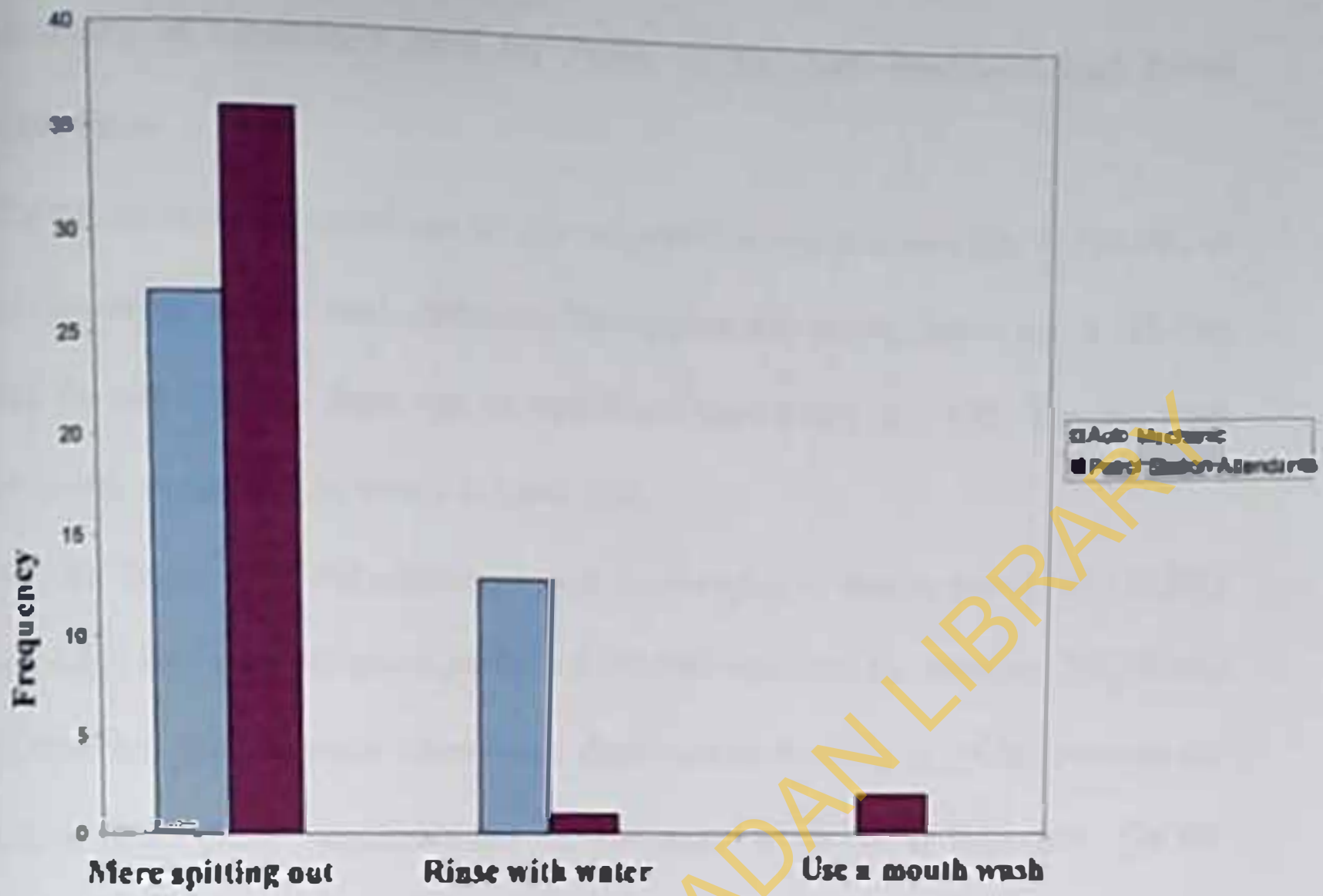

FIGURE 4.5: METHOD OF REMOVING TRACES OF PETROL IN THE MOUTH AFTER SIPHONING FROM VEHICLE TANK

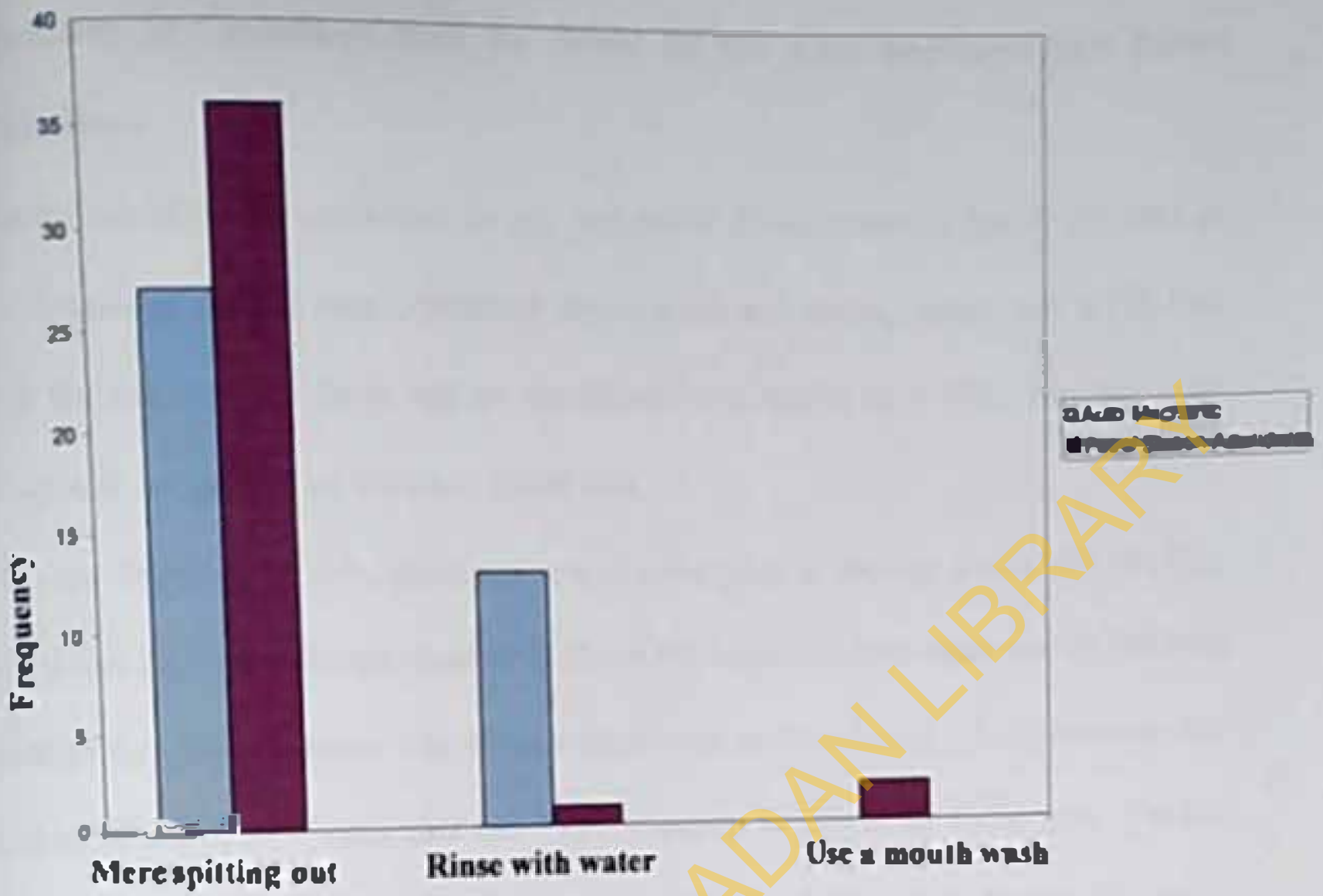

FIGURE 4.5: METHOD OF REMOVING TRACES OF PETROL IN THE MOUTH AFTER SIPHONING FROM VEHICLE TANK

4.9 Handling of Containers used for Petrol by the Auto-mechanics and Petrol attendants

On the use of plastic containers for carrying petrol, it was observed that 73 (89.9%) of the occupational groups used containers for carrying and storing petrol and 8 (10.1%) denied the use although there was no significant relationship ($p > 0.05$) between such practice and occupation as shown in Table 4.16.

On the handling of the containers used for carrying or storing petrol, 40 (49.4%) claimed that they were always discarded, 13 (16.0%) used them for water and 23 (28.4%) used them for other purposes. There was a significant relationship ($p < 0.05$) between the handling of the plastic containers and the occupation as shown in Table 4.16. On the means of cleaning the containers before they were used for water, among the auto-mechanics, 5 (12.2%) used cold water, 18 (43.9%) used hot water, 3 (7.3%) used soap solution and 15 (36.6%) used detergent solution. Among the petrol attendants, 12 (30.0%) used cold water, 26 (65.0%) used hot water and 2 (5.0%) used detergent solution as shown in Figure 4.6.

4.11 Exposure to automobile Exhaust by the Auto-mechanics and Petrol attendants

On the exposure to automobile exhaust during work, 35 (85.4%) of the auto-mechanics claimed that they were exposed to it out of which 26 (74.3%) were always exposed and the remaining 9 (25.7%) were occasionally exposed. Thirty-one (77.5%) of the petrol attendants claimed of exposure while 9 (29.0%) were always exposed. Although there was no significant relationship ($p > 0.05$) observed between exposure and occupation, a significant relationship ($p < 0.05$) occurred between frequency of exposure to exhaust and occupation as shown in Table 4.17.

Table 4.16: Use of Containers for Petrol and re-use of the containers

Characteristics	Auto-mechanics No. %	Petrol Attendants No. %	Total No. %	χ^2	p-value
a. Used plastic containers for petrol	38 (92.7)	35 (87.5)	73 (89.9)		
Not used plastic containers for petrol.	3 (7.3)	5 (12.5)	8 (10.1)	0.611	0.434
b. Discarded the containers used for petrol	11(26.8)	29 (72.5)	40 (49.4)		
Reused the containers for:				23.659	0.000
Water	7 (17.1)	6(15.0)	13 (16.0)		
Kerosene	4 (9.8)	1(2.5)	5 (6.2)		
Other purposes	19 (46.3)	4 (10.0)	23(28.4)		
Total	41(100.0)	40 (100.0)	81(100.0)		

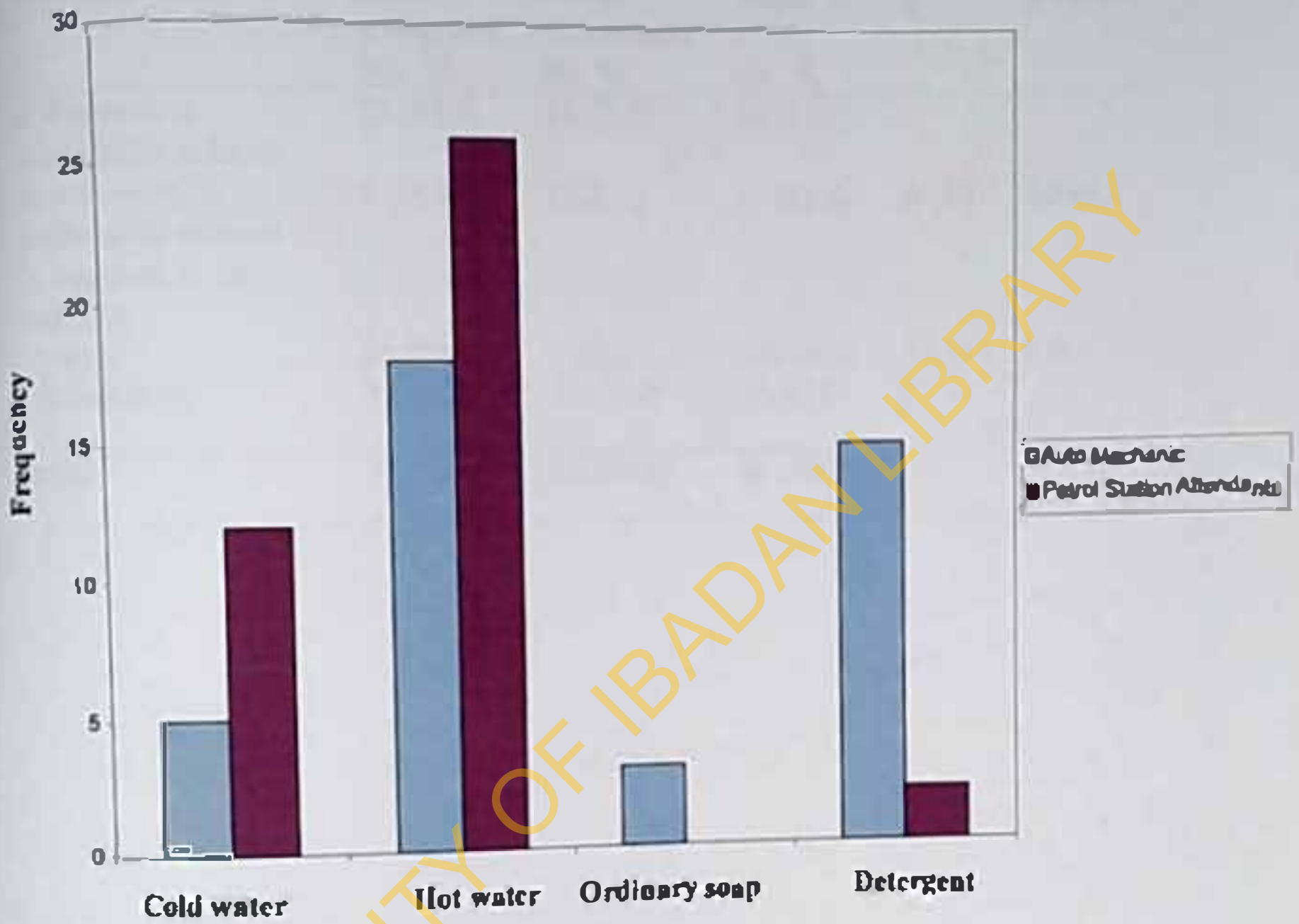

FIGURE 4.6: MEANS OF CLEANING THE CONTAINERS USED FOR STORING PETROL

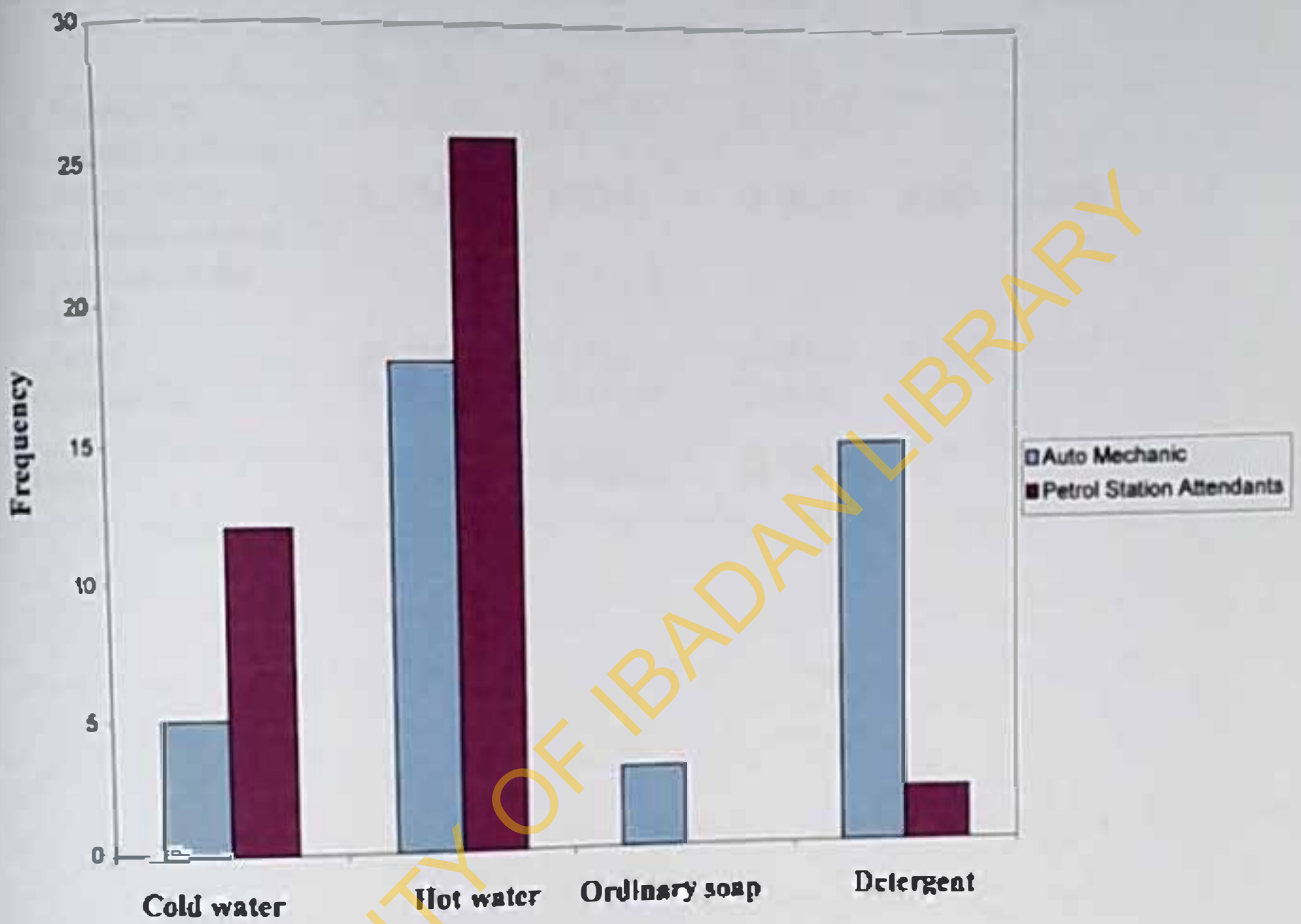

FIGURE 4.6: MEANS OF CLEANING TILE CONTAINERS USED FOR STORING PETROL

Table 4.17: Exposure to Vehicular Exhaust by the Auto-mechanics and Petrol attendants

Characteristics	Auto-mechanics No. %	Petrol Attendants No. %	Total No. %	χ^2	p-value
a. Exposed to automobile exhaust	35 (85.4)	31(77.5)	66 (81.5)		
Not exposed to automobile exhaust	6 (14.6)	9 (22.5)	15 (81.5)	0.362	0.266
b. Exposed to the exhaust:					
always	26 (74.3)	9 (29.0)	35 (53.0)	13.812	0.000
occasionally	9 (25.7)	22 (71.0)	31(47.0)		
Total	35 (100.0)	31(100.0)	66 (100.0)		

4.12 Knowledge about Lead and Blood Lead levels

(a) Awareness of Lead

On the awareness of lead, 52 (47.3%) of 110 respondents were aware of the element. Forty-three 43 (63.6%) of the 52 respondents claimed that they knew of its presence in petrol. There was a significant relationship ($p < 0.05$) between the knowledge of lead and occupation though no significant relationship existed ($p > 0.05$) between the sources of information and occupation as shown in Table 4.18.

(b) Knowledge about Lead in relation to Blood Lead levels

The prior awareness of the existence of lead is shown in Table 4.19. The mean blood lead of 43 respondents that had a previous knowledge of lead in the first set of samples and the replicate were 16.54 ± 5.95 (µg/dl) and 14.30 ± 5.93 respectively while the mean blood lead of the 67 respondents that claimed ignorant were 11.16 ± 6.27 and 9.34 ± 7.30 (µg/dl). A significant relationship ($p < 0.05$) was observed between awareness of lead and mean blood lead levels in both periods. From the result, previous awareness of lead did not reduce the exposure to it although there were significant relationships between them.

Table 4.18: Knowledge and Sources of information about Lead

Characteristics	Auto-mechanics No %	Petrol Attendants No %	Herdsmen No %	Total No %	χ^2	p-value
a. Awareness of lead	24 (58.5)	25 (62.5)	3 (10.3)	52 (47.3)	21.674	0.00
Ignorance of lead	17 (41.5)	15 (37.5)	26 (89.7)	58 (52.7)		
b. Knowledge of the presence of lead in petrol	21 (51.2)	20 (50.0)	2 (6.9)	43 (63.6)	17.156	0.00
Ignorant of the presence of lead in petrol	20 (48.8)	20 (50.0)	27 (93.1)	67 (36.4)		
c. Informed:						
By friends	4 (9.8)	5 (12.5)	-	9 (8.2)		
By the boss	4 (9.8)	1(2.5)	-	5 (4.5)		
Through news papers	18 (43.9)	26 (65.0)	1 (50.0)	45 (40.1)	5.453	0.487
Through other sources	5 (12.2)	4 (10.0)	1 (50.0)	10 (9.1)		
Uninformed	10 (24.4)	4 (10.0)	27 (24.5)	41 (37.3)		
Total	41 (100.0)	40 (100.0)	29 (100.0)	110 (100.0)		

Table 4.19: Knowledge about Lead and Blood Lead level

Characteristics	Responses	n	Mean ± SD	t	p-value
Sample P	Those with previous knowledge about lead	43	16.54 ± 5.95	3.687	0.000
	Those without previous knowledge about lead	67	11.16 ± 6.27		
Sample N	Those with previous knowledge about lead	43	14.30 ± 5.93	3.731	0.000
	Those without previous knowledge about lead	67	9.34 ± 7.30		

4.13 Awareness of Lead Poisoning in relation to blood Lead levels

(a) Awareness of Lead Poisoning

On the awareness of lead poisoning, of 110 respondents, 26 (63.4%) auto-mechanics, 38 (95.0%) petrol attendants and 1 (3.4%) of the herdsmen were aware of it. A significant relationship occurred ($p < 0.05$) between awareness of lead poisoning and occupation. Of 110 respondents, only 18 (43.9%) of the auto-mechanics, 11 (27.5%) of the petrol attendants and 1 (3.4%) of the herdsmen got the correct meaning of lead poisoning. No significant relationship ($p > 0.05$) occurred between knowledge of the meaning of lead poisoning and occupation as shown in Table 4.20.

(b) Causes of Lead Poisoning

Only 3 (7.3%) of the auto-mechanics, 1 (2.5%) of the petrol attendants knew the true cause of lead poisoning and a total of 92 (83.6%) of the three occupational groups had no idea about the cause. No significant relationship ($p > 0.05$) occurred between the cause of lead poisoning and occupation as shown in Table 4.21.

(c) Knowledge about Lead Poisoning and Blood Lead levels

On the previous knowledge about lead poisoning and blood lead level, there was no significant relationship ($p > 0.05$) between knowing the correct meaning of lead poisoning and the mean blood lead in both periods as shown in Table 4.22. This implied that the previous knowledge of lead poisoning did not affect the handling of leaded petrol as well as exposure to lead.

Table 4.20: The Awareness and understanding of Lead Poisoning

Characteristics	Auto-mechanics No. %	Petrol Attendants No. %	Herdsmen No. %	Total No. %	χ^2	p-value
a. Knew about Lead poisoning	26 (63.4)	38 (95.0)	1(3.4)	65 (59.1)		
Ignorant about Lead poisoning	15(36.6)	2 (5.0)	28 (96.6)	45 (40.9)	58.796	0.000
b. Knew lead poisoning as:						
High Blood Lead	18 (43.9)	11(27.5)	1(3.4)	30 (27.3)		
Obesity	3 (7.3)	3 (7.5)	-	6 (5.5)	12.331	0.055
Smoking	6 (14.6)	23 (57.5)	-	29 (26.4)		
Lung disease	1 (2.4)	1(2.5)	-	2(1.8)		
An unknown vector	13 (31.7)	2 (5.0)	28 (96.6)	43(39.1)		
Total	41(100.0)	40 (100.0)	29(100.0)	110(100.0)		

Table 4.21: Causes of Lead Poisoning

Characteristics	Auto-mechanics No. %	Petrol Attendants No. %	Herdsmen No. %	Total No. %	χ^2	p-value
Lead poisoning was due to:						
Ingestion of lead	3 (7.3)	1(2.5)	-	4 (3.7)		
Smoking	1(2.4)	-	-	1(0.9)		
Heredity	1(2.4)	-	-	1(0.9)	11.981	0.152
Food	7 (17.1)	2(5.0)	1(3.4)	10(9.0)		
No idea	29 (70.7)	35 (87.5)	28 (96.6)	92 (83.6)		
No response	-	2 (5.0)	-	2 (1.8)		
Total	41(100.0)	40 (100.0)	29 (100.0)	110 (100.0)		

- indicates none.

Table 4.22: Knowledge about Lead Poisoning and Blood Lead levels

Characteristics	Responses	n	Mean ± SD	F	p-value
Sample P	High blood lead	30	16.73 ± 5.18		
	Obesity	6	19.50 ± 4.46		
	High blood pressure	29	15.48 ± 4.30	1.549	0.211
	Lung disease	1	12.00		
			16.36 ± 4.81		
Sample N	High blood lead	30	14.07 ± 5.21		
	Obesity	8	17.33 ± 4.93		
	High blood pressure	29	12.90	1.543	0.212
	Lung disease	1	11.00 ± 4.41		
	Total	66	13.80 ± 4.90		

4.14 Education in relation to Blood Lead levels

In both samples, there was no significant relationship ($p > 0.05$) between the educational status of the Auto-mechanics and petrol attendants and the blood lead levels as shown in Tables 4.23 and 4.24. Among the auto-mechanics, the sample P showed that the highest average blood lead level occurred among respondents with university education (12.51 - 28.49 µg/dl) followed by those with primary education (17.39 -25.99 µg/dl). In sample N, also the highest blood lead level occurred in those with university education (9.51 - 26.49 µg/dl). In the petrol attendants, the highest average blood lead levels in both samples occurred in those with non formal education (6.93 - 21.07 µg/dl) and (8.64 - 21.36 µg/dl) respectively. All this implied that the manner of handling leaded petrol was not related to the level of education.

4.14 Education in relation to Blood Lead levels

In both samples, there was no significant relationship ($p > 0.05$) between the educationnl status of the Auto-mechanics and petrol attendants and the blood lead levels as shown in Tables 4.23 and 4.24. Among the auto-mechanics, the sample P showed that the highest average blood lead level occurred among respondents with university education (12.51 - 28.49 µg/dl) followed by those with primary education (17.39 -25.99 µg/dl). In sample N, also the highest blood lead level occured in those with university education (9.51 - 26.49 µg/dl). In the petrol attendants, the highest average blood lead levels in both samples occurred in those with non formal education (6.93 - 21.07 µg/dl) and (8.64 - 21.36 µg/dl) respectively. All this implied that the manner of handling leaded petrol was not related to the level of education.

Table 4.23: Education and Blood Lead levels in Auto-mechanics

Characteristics	n	Mean ± SD (µg/dl)	F	p-value
Sample P:				
No formal Education	3	22.67 ± 0.58		
Arabic	2	13.50 ± 0.71	1.837	0.121
Primary	13	21.69 ± 4.30		
Secondary	12	18.67 ± 4.03		
N C E	8	20.13 ± 2.90		
Polytechnic	1	23.00		
University	2	20.00 ± 8.49		
		20.12 ± 4.20		
b. Sample N:	3	20.00 ± 1.00		
No formal Education				
Arabic	2	12.00 ± 1.41		
Primary	13	19.69 ± 5.22	1.498	0.208
Secondary	12	15.92 ± 4.36		
N C E	8	17.63 ± 2.77		
Polytechnic	1	20.00		
University	2	18.00 ± 8.49		
Total	41	17.76 ± 4.59		

Table 4.24: Education and Blood Lead levels in Petrol attendants

Characteristics	n	Mean ± SD (µg/dl)	F	p-value
a. Sample P:				
No formal Education	2	14.00 ± 7.07		0.332
Primary	25	14.72 ± 3.05	1.190	
Secondary	9	13.56 ± 3.28		
N C E	2	10.00 ± 1.41		
University	2	15.50 ± 0.71		
		14.23 ± 3.25		
b. Sample N:				
No formal Education	2	15.00 ± 6.36		
Primary	25	12.04 ± 2.65	1.677	1.77
Secondary	9	10.88 ± 3.55		
N C E	2	6.50 ± 0.71		
University	2	12.00 ± 2.83		
Total	41	11.48 ± 3.12		

4.15 Associated Health problems among the three Occupational Groups

Although symptomatic intoxication due to lead begins with blood lead level of 40 - 60µg/dl, asymptomatic but impaired abilities occur from 10 - 25µg/dl blood lead level. Table 4.25, showed that 71 (64.5%) experienced headache always, 31(28.2%), occasionally and 8 (7.2%) rarely. Fifty six (50.9%) experienced irritability always and 23 (20.9%) occasionally. Fifty four (49.1%) had constipation always, 24 (21.8%) occasionally. Lethargy was experienced always by 55 (50.0%) and occasionally by 28 (25.5%). Loss of memory was experienced always by 30 (27.3%) mainly auto-mechanics and petrol attendants and occasionally by 35 (31.8%) of them.

4.16 Comparing the Health problems that occurred always

The associated health problems as shown in Table 4.26 affected petrol attendants more than the other occupational groups although all were at asymptomatic stage according to Lewis (1990) grouping of symptoms and signs of lead poisoning. Herdsmen were the least affected among the three occupational groups. It could be attributed to their less exposure to lead.

Table 4.25: Perceived Health Problems

Characteristics	Auto-mechanics	Petrol Attendants	Herdsmen	Total	χ^2	p-value
	No. %	No. %	No. %	No. %		
a. Headache:						
Always	29 (70.7)	38 (95.0)	4 (13.8)	71 (64.5)	50.1	0.000
Occasionally	10 (24.4)	2 (5.0)	19 (65.5)	31 (28.2)	55	
Rarely	2 (4.9)	-	6 (20.7)	8 (7.2)		
b. Irritability:						
Always	22 (55.0)	34 (85.0)	-	56 (50.9)		
Occasionally	15 (37.5)	5 (12.5)	3 (10.3)	23 (20.9)		
Rarely	1 (2.5)	1 (2.5)	16 (55.2)	18 (16.4)	87.883	0.000
Never	2 (5.0)	-	10 (34.5)	12 (10.9)		
No response	1 (2.4)	-	-	1 (0.9)		
c. Constipation:						
Always	24 (58.5)	27 (67.5)	3 (10.7)	54 (49.1)	54.257	0.000
Occasionally	11 (26.8)	9 (22.5)	4 (14.3)	24 (21.8)		
Rarely	5 (12.2)	-	11 (37.9)	16 (14.5)		
Never	1 (2.4)	-	10 (34.5)	11 (10.0)		
No response	-	4 (10.0)	1 (3.4)	5 (4.5)		
d. Lethargy:						
Always	22 (53.7)	27 (67.5)	6 (20.7)	55 (50.0)		
Occasionally	16 (39.0)	11 (27.5)	1 (3.4)	28 (25.5)	61.727	0.000
Rarely	2 (4.9)	-	14 (48.3)	16 (14.5)		
Never	1 (2.4)	1 (2.5)	8 (27.6)	10 (9.1)		
No response	-	1 (2.5)	-	1 (0.9)		
e. Loss of memory:						
Always	8 (19.5)	22 (55.0)	-	30 (27.3)	79.430	0.000
Occasionally	19 (46.3)	15 (37.5)	1 (3.4)	35 (31.8)		
Rarely	8 (19.5)	2 (5.0)	5 (17.2)	15 (13.6)		
Never	5 (12.2)	-	23 (79.3)	28 (25.5)		
No response	1 (2.4)	1 (2.5)	-	2 (1.8)		
Total	41 (100.0)	40 (100.0)	29 (100.0)	110 (100.0)		

- indicates none.

Table 4.26: Comparing the Health Problems that occurred always

Characteristics	Auto-mechanics	Petrol Attendants	Herdsmen	Total
	No. %	No. %	No. %	No. %
Headache	29 (27.6)	38 (25.7)	4 (30.8)	71 (26.7)
Irritability	22 (21.0)	34 (23.0)	-	56 (21.1)
Constipation	24 (22.9)	27 (18.2)	3 (23.0)	54 (20.3)
Lethargy	22 (21.0)	27 (18.2)	6 (46.2)	55 (20.7)
Loss of Memory	8 (7.6)	22 (14.9)	-	30 (11.3)
Total	105 (100.0)	148 (100.0)	13 (100.0)	266 (100.0)

4.17 Health Facilities and level of usage for treatment of Health conditions

Various health facilities were used for the treatment of health problems. The options indicated by the respondents were Hospital/Clinic, Patent medicine vendors, Traditional/Herbal homes and Self-medication. On comparing the health facilities frequently used, it was observed that Hospital/Clinic Self medication were equally used. Headache 44 (26.7%), irritability 40 (24.2%) were treated by self medication. Constipation 25 (15.2%) and lethargy 36(21.8%) were treated in the Hospital. Loss of memory 40 (32.0%) was treated in Traditional/herbal clinic as shown in Table 4.27.

Table 4.27: Level of Usage of Health Facilities for treatment of health conditions

Characteristics	Hospital/ Clinics	Patent medicine vendor	Traditional clinic	Self medication	Total
	No. %	No. %	No. %	No. %	No. %
Headache	31 (18.8)	19 (38.8)	14 (11.2)	44 (26.7)	108 (21.4)
Irritability	24 (14.5)	7 (14.3)	12 (9.6)	40 (24.2)	83 (16.5)
Constipation	25 (15.2)	9 (18.4)	24 (19.2)	24 (14.5)	82 (16.3)
Lethargy	36 (21.8)	10 (20.4)	13 (10.4)	27 (16.4)	86 (17.1)
Loss of Memory	25 (15.2)	2 (4.1)	40 (32.0)	4 (2.4)	71 (14.1)
Total	165 (100.0)	49 (100.0)	125 (100.0)	165 (100.0)	504 (100.0)

4.18 Food intake Habits of the Auto-mechanics, Petrol attendants and Herdsmen

Food intake habit of the three occupational groups was carried out by purposive selection of 10 subjects from each group to determine the source of calcium in the blood. It was observed that all the ten herdsmen respondents consume Nunu and Fura/Nunu daily as shown in Tables 4.28. Nunu, a fresh Cow milk and Fura is a millet derivative. The herdsmen also consumed fish more than the other groups but consumed less meat than the auto-mechanics and the petrol attendants.

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Table 4.28: Food intake Habit of the Auto-mechanics, Petrol attendants and Herdsmen

Food	Auto-mechanics		Petrol attendants		Herdsmen		Total
	Once/ day	Twice or more/week	Once/ day	Twice or more/week	Once/ day	Twice or more/week	
Pounded yam	1 (5.3)	-	3 (13.0)	2 (15.4)	-	3 (11.1)	9(6.6)
Amala	8 (42.1)	1 (4.8)	8 (34.8)	1 (7.7)	-	1 (3.7)	19 (14.0)
Tuwo	6 (31.6)	1 (4.8)	7 (30.4)	-	8 (24.2)	1 (3.7)	23 (16.9)
Rice	3 (15.8)	3 (14.3)	2 (8.7)	-	-	2 (7.4)	10 (7.4)
Fish	1 (5.3)	7 (33.3)	3 (13.0)	6 (46.2)	4 (12.1)	15 (55.6)	36 (26.5)
Meat	-	9 (42.9)	-	4 (30.8)	5 (15.1)	2 (7.4)	20 (14.7)
Fura/Nunu	-	-	-	-	9 (27.3)	1 (3.7)	10 (7.4)
Nunu only	-	-	-	-	7 (21.2)	2 (7.4)	9 (6.6)
Total	19 (100.0)	21 (100.0)	23 (100.0)	13 (100.0)	33 (100.0)	27 (100.0)	136 (100.0)

- indicates none.

4.18 Possible source of Lead exposure to Herdsmen

The herdsmen should have no significant blood lead level by virtue of their life style. The low level of lead detected in their bloods indicated some level of exposure possibly through food chain or inhalation in their nomadic lifestyle. Car wash centres were proliferated in the study area and were mostly sited close to the streams, which served as sources of water for their need. Wastewater from car wash centres are constantly channeled into the streams. Foma stream and some fodders grown in and around it were used in the study because it was bigger than the other streams, often survived dry season and more grazed by cattle. Although water samples from the stream contained low lead level (0.06 ± 0.04 mg/l) compared with the recommended standard of 0.015 mg/l (EPA, 1993). Most of the fodders showed higher lead levels (0.13 ± 0.04 mg/kg). There was no significant relationship ($p > 0.05$) between the water sources and their lead content. Four different types of fodder that were present on the bank of the Foma stream were Guinea grass *(Panicum maximum)*, Stubborn grass *(Eleusine indica)*, Elephant grass *(Pennisetum purpureum)* and Northern Gamba grass (*Andopogon Gayanus*). A significant variation ($p < 0.05$) was observed between the plants and lead content of the plants as shown in Table 4.29. Guinea grass *(Panicum maximum)*, had the highest lead level (0.19 ± 0.004 mg/kg) and Stubborn grass *(Eleusine indica)* had the lowest lead level (0.09 ± 0.001 mg/kg).

Table 4.29: Mean Lead levels in the samples of water and Fodder from Foma grazing field

(a) Water samples

Water samples	pH	Conductivity μScm^{-1}	Dissolved solids (mg/l)	Suspended solids (mg/l)	Pb (mg/l)
1	6.97 ± 0.15	11222.67 ± 2.52	17.60 ± 0.26	104.93 ± 0.25	0.08 ± 0.04
2	6.80 ± 0.01	10965.67 ± 2.08	12.33 ± 0.15	126.87 ± 0.64	0.06 ± 0.02
3	6.90 ± 0.10	11618.33 ± 10.41	14.50 ± 1.19	116.97 ± 0.21	0.03 ± 0.01
F	1.462	8175.314	16.892	2129.065	0.93
p-value	0.304	0.000	0.003	0.000	0.426

(b) Plant samples

Characteristic	Mean ± SD (mg/kg)	F	p-value
Fodders:			
Panicum maximum (Guinea Grass)	0.19 ± 0.004		
Eleusine indica (Stubborn Grass)	0.09 ± 0.001		
Pennisetum purpureum (Elephant Grass)	0.14 ± 0.004	349.143	0.000
Andopogon Gayanus (Northern Gamba Grass)	0.11 ± 0.004		
Mean	0.13 ± 0.04		

CHAPTER FIVE

BLOOD LEAD LEVELS IN AUTO-MECHANICS, PETROL STATION ATTENDANTS AND FULANI HERDSMEN IN ILORIN WEST LOCAL GOVERNMENT AREA OF KWARA STATE, NIGERIA

DISCUSSION

Lead is probably the oldest human-made atmospheric and occupational chemical dating back at least 8000years (World Resources, 2001). Lead pollution has been a global phenomenon due to the anthropogenic sources, which superseded natural sources. Anthropogenic sources dispersed enormous quantities of lead into the environment, which presently pose serious health implications. Automobile emission through the use of leaded petrol has been the dominant source of lead in Africa (Nriagu et al, 1996). According to 'REC- Phase-out of leaded petrol rationale,' human exposure to lead is one of the most serious health problems facing populations especially children.

'Global Lead network' (2002), showed that out of only 47 countries of the world had phased out leaded petrol by year 2002.

Increasing industrialization and urbanization in Africa coupled with improper management of both solid and liquid wastes further add occupational diseases to the present environmental (communicable) diseases ravaging the continent (WHO, 1995). Nriagu, (1979) observed that in Nigeria, 15-30% of urban children had blood levels higher than 25 µg/dl.

The deregulation of the oil sector in Nigeria has not reduced the persistent fuel shortage that usually result into panic buying which also causes reckless handling of petroleum products. The result is usually the ingestion of petroleum products. A large volume of work has been done on lead in the past and even at present, but the

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involvement of the Fulani herdsmen is presently necessary to be able to assess the trend of contamination or pollution by some chemicals due to industrialization and urbanization.

The study was to determine the blood lead levels of the workers whose occupation were related to leaded petrol and those who were occupationally remote to it and also examined the occupational features that predisposed them to lead toxicity. Those whose occupations were unrelated to petrol should have no lead in their blood. According to Shwartz (1993), scientist has not yet identified a level below which no adverse effects of lead occur.

5.1 Knowledge Attitude and Occupational Practices of Auto-mechanics, Petrol Attendants and Herdsmen

It was observed that those that had previous knowledge of lead and lead poisoning had more lead in the blood than those without previous knowledge. This could be because of their attitude to leaded petrol and the way it was always handled as shown in Tables 4.19 and 4.21. There were many occupational features that exposed the auto-mechanics and the petrol attendants to lead. It was observed that 80 (98.8%) of them used petrol for removing grease from hands and machine parts as shown in Table 4.13. In such action. 78 (96.3%) of them used bare hands. On the rate of contact per week, the figure obtained for the auto-mechanics was almost twice that for the petrol attendants as shown on Fig. 4.3.

Although a high number 77(95.1%) claimed to have washed their hands before eating at work place. their were possibilities of lead ingestion based on the mode and level of hand washing as well as food contamination by air-borne lead particles (not

estimated). The highly frequent bad practice of handling leaded petrol occurred during inadequate fuel supply that usually resulted in panic buying using plastic containers by people from various professions. The frequency of carrying petrol in plastic containers was higher in auto-mechanics than in petrol attendants (Table 4.16) and could be due to the need to remove grease from their hands and engine parts. These plastics were often reused at home for water. It was also a common practice by the workers to suck out petrol with mouth and rubber hose when needed for cleaning as shown in Fig 5.1. Table 4.15 showed that 74 (91.4%) of them practiced it.

5.2 Nature of Occupation and the Blood Lead levels

According to Sithisarankul et al (1997), lead workers are more predisposed to lead absorption. In 2004 sample, the mean blood lead (µg/dl) of the Auto-mechanics, Petrol attendants and Herdsmen were 20.12 ± 4.20, 14.23 ± 3.25 and 2.24 ± 0.23 respectively. In 2005 sample, they were 17.76 ± 4.59, 11.48 ± 3.12 and 1.86 ± 0.21 respectively as shown in Table 4.5. The results were in support of the observation of Grimsley and Adams- Mount (1994) on significant relationship between occupation and lead burden and intoxication. In the three occupational groups, the Auto-mechanics and Petrol attendants were often exposed to lead by nature of their occupations. Brugnone et al (1986) observed that increase in blood lead and exhaled benzene in service station workers was due to increased levels of lead and benzene in inhaled petrol vapors. Although the WHO recommended blood lead level for lead workers is 25 µg/dl, the average lead level of 20.1µg/dl that occurred in the auto-mechanics called for caution towards further accumulation.

The reduced lead observed in herdsmen was partly due to their regular dietary calcium intake from cow milk. This was corroborated by the interview on the dietary habit of some representatives from the groups.

The possible area of exposure to lead by the herdsmen might be through the food chain. Analysis of the grasses at a common grazing area showed they contained lead. Discharges (effluents) from car wash centres into streams form a pathway for lead exposure.

FIGURE 3.1: PHOTOGRAPH OF AN AUTOMECHANIC SIPHONING PETROL FROM A VEHICLE UNDER REPAIR

5.3 Length of contact with Lead and Blood Lead level

The length of contact was assumed to be the number of years on the occupation. According to Anctor et al (1999), lead accumulates over a long period of low-level exposure. This implied that blood lead level will always rise with increase in the length of exposure simply expressed as the number of years on the job. Positive correlations were observed between the number of years and lead levels in the replicates showing exposure- effect relationship as shown in Table 4.8

5.4 Petrol sales condition and Blood Lead levels

In the first sample P collected during panic buying period, the mean value of lead was 13.26 ± 7.87 and in the sample N collected during normal sales, the level was 11.28 ± 7.19 as shown in Table 4.7. A general drop in the levels of blood lead within a year could either be as a result of gradual reduction of the lead contents of petrol or reduction in dose of lead intake when the sales normalized. This was in line with the observation of Rabinowitz and Needleman, (1983) that a significant correlation between petrol sales and blood lead level exist.

5.5 Nature of Occupation and the Blood Calcium level

In the three occupational groups, Herdsmen had the highest calcium levels of 21.41 ± 1.84 and 19.33 ± 5.61 in the samples P and N respectively which could be related to their nutritional habits which contained fresh cow milk (Nunu) and consumed daily as shown in Tables 4.5, and 4.28. It contained 120mg/100g of calcium (Pike 1979). The Auto-mechanics had higher blood calcium than the Petrol attendants in both periods as shown in Table 4.5. According to Rosen (1985), decrease intake of essential minerals such as iron, zinc and calcium promotes absorption of lead. The normal blood calcium

level is between 8.5 mg/dl and 10.5 mg/l, but 4.5 and 5.6 mg/dl if ionized (Amherst 2001).

5.6 Nature of Occupation and the Blood Zinc level

Herdsmen had the highest zinc levels of 13.29 ± 3.02 and 7.57 ± 3.78 mg/l in samples P and N respectively among the three occupational groups. The Petrol ancadants had the least of 3.13 ± 0.69 and 2.40 ± 0.63 mg/l respectively as shown in Table 4.5. The level of zinc could also be affected by nutritional intake but could also be as a result of cell toxicity. Normal blood zinc level is between 10 mg/l and 14 mg/l. Low level of zinc in the blood influenced lead absorption and accumulation (WHO, 1989; WHO,1995).

According to Clayton and Clayton (1982), zinc prevents inhibitory effect of lead on δ- amino levulinic acid (ALA) dehydratase by inducing more synthesis of the enzyme for which it is essential component. The high blood zinc levels in the herdsmen could account for their low blood lead levels.

5.7 Previous Knowledge about Lead and Blood Lead level

Surprisingly those that had previous knowledge of lead had higher blood lead levels than those that had no knowledge of it. In sample P, the mean blood lead of those that had knowledge of lead was 16.54 ± 5.95 and for those without the knowledge was 11.16 ± 6.27. The result was similar in sample N as shown in Table 4.19. This indicated that the knowledge had no impact on the habit of handling leaded petrol. Although Poliuka (1999) observed a positive impact of knowledge of lead poisoning on rural residents, this study showed that the previous awareness of lead poisoning had no impact on the handling of leaded petrol. Those that had previous knowledge of lead also had high blood lead level despite that the awareness of lead poisoning was alluded to 1986 cases of

imported toxic fuel. Significant relationship was not established between the true meaning of lead poisoning and blood lead level as shown in Table 4.22.

5.8 Educational Status and Blood Lead

Although there was no significant relationsbip between the educational attainment and the blood lead levels, in the auto-mechanic group, the mean blood lead level of respondents with university educational status was the highest in both samples with values of 20.00 ± 8.49 and 18.00 ± 8.49 respectively as shown in Table 4.23. In the petrol attendant group, the mean blood lead level of respondents with non formal educational status was the highest in both samples P and N with values of 14.00 ± 7.07 and 15.00 ± 6.36 respectively as shown in Table 4.24.

5.9 Relationship between Blood Lead and Calcium

According to Dosumu et al (2005), high blood lead occurred with low blood calcium. This study also showed negative correlations (r = -0.358, r = -0.123, r = -0.272 and r = - 0.063) between blood lead and calcium in panic and normal periods although not strong as shown in Table 4.7.3. High calcium level naturally reduces lead binding as well as posing inhibitory effects on it (Stephens & Waldron, 1975). This could account partly for the low lead level observed in the Herdsmen

5.10 Relationship between Blood Lead and Zinc

There were negative correlations between blood lead and zinc as shown in Table 4.12. The strongest correlation was observed between lead and zinc in sample P with r = -0.693. Clayton and Clayton (1982) observed that at low lead level, there is a rise in zinc protoporphyrin level due to the tendency of zinc to prevent the inhibitory effect of lead on δ-amino levulinic acid (ALA) dehydratase. This could be used to explain why the

blood zinc level in the auto-mechanic group was higher than those of the petrol attendants. Also, the total concentration of zinc alone was not a good predictor of lead toxicity (IPSC, 2001). The high blood zinc in the herdsmen could not be a result of lead toxicity but of nutrition

5.11 Lead in the Blood of Herdsmen

The study showed that the herdsmen had lead in their blood despite their traditional life style and non-exposure to urban style of living. The presence of lead in the blood of some herdsmen indicated a certain level of exposure and called for further research for areas of lead contact. Car wash centres were possible sources of lead into the food chain. The low level of lead in the herdsmen may be as a result of the diet, which included milk from cattle. According to Pike (1979), the calcium content of fresh milk is 120 mg/100g, while that of meat is 10mg/100g. That is milk belonged to the group of food that are good sources of calcium while meat belonged to the moderately good sources and rice, poor sources of calcium (Pike, 1979).

Analysis of water and plant samples from Foma stream often consumed by cattle gave the mean lead contents of 0.06 ± 0.04 (mg/l) and 0.13± 0.04 (mg/kg) respectively. Though the lead level of water was lower than the WHO recommended level of 0.1 mg/l, the presence of lead in the fodders growing in and around the stream indicated bioaccumulation of lead and possible distribution through the food chain.

5.12 Food intake Habits of the Occupational groups

From the Table 4.28, it was observed that the herdsmen consumed foods that are richer in calcium than the other occupational groups. Nunu is fresh whole milk while Fura is a derivative of millet. According to Pike (1979), fresh whole milk contains more

calcium (120 mg/100g) than fish (except sardines, 409 mg/100 g). Beef contains 10 mg/100 g of calcium. Calcium might have accounted for the low level of blood lead recorded in the herdsmen since it is known to either prevent the binding of lead or chelate it from the binding sites (Kerper & Hinkle, 1997).

CONCLUSIONS AND RECOMMENDATIONS

5.13 CONCLUSIONS

The study was to determine possible exposure to lead by three occupational groups viz auto-mechanics, petrol attendants and herdsmen in Ilorin west LGA of Kwara State. Whole blood lead level as well as calcium and zinc levels were measured. The following conclusions were drawn based on the results obtained from this study.

- The average lead (samples P and N) in the auto-mechanic group was 18.94 ± 4.40 (µg/dl). Those of the petrol attendants and herdsmen were 12.85 ± 3.17 and 2.05 ± 0.22 (µg/dl) respectively.
- The high level of lead in the auto-mechanic group was likely due to the occupational features such as the sucking of petrol with mouth and hose, dissolution of grease from vehicle parts with bare hand and use of petrol as hand wash as well as inhalation of exhaust.
- The petrol attendants were likely exposed to lead through vehicular exhaust, petrol vapour as well as spills during off-loading into the underground tanks and filling of jerycans especially when there was fuel crisis.
- Only nine of the herdsmen had blood lead level undetectable, the others showed evidence of exposure to lead.
- The general decrease in the lead levels of all the groups might be due to difference in sales condition because the first set of blood samples was collected during panic buying period while the second was collected during normal condition of sales.

- Blood lead 20-30 µg/dl indicated that regular exposure was occurring.
- Blood lead less than 0.5 µmol/l (10.4 µg/l) is desirable. 0.72 µmol/l (14.9 µg/l) whether in less than 10 years or adult is a notifiable disease to medical officer and 1.9 µmol/l (39.3 µg/l) requires chelation. This showed that many of the auto-mechanics and petrol attendants had blood lead at notifiable levels and could become high risks.

5.15 RECOMMENDATIONS

some intervention can be employed to either reduce or completely eliminate exposure to lead from petrol source.

1 Educating the professionals whose jobs are leaded petrol related on lead awareness and handling of leaded petrol is necessary and could be as follows:

(a) Handling of fuel (leaded petrol) by refraining from

i. use of containers such as plastic kegs to carry it from one place to another

ii. use of mouth and hose to siphon fuel from a storage which often leads to accidental ingestion of the fuel or its vapour.

iii. direct/ intentional application of petrol to fresh wounds as First- aid.

iv. personal hygiene required by washing their hands prior eating while at work.

(b) The knowledge on the health implications of ingesting lead will improve their handling as well as application of leaded petrol.

All containers that are used previously for petrol should not be used for any other household use. High phosphate detergent or 5 – 8 % trisodium phosphate should be used to wash them if they must be used

(b) Exposure to vehicular exhaust during servicing or repairing or refueling of vehicles. Since this type of exposure is inevitable and difficult to totally prevent, the need for reduced exposure should be the main focus which could be on the enforcement of gas mask while at work.

(c) The use of hand gloves where direct hand contact with leaded petrol is inevitable and the subsequent cleaning with soap or preferably detergent before eating. The use of apron will also reduce exposure from splashing.

Since panel-beaters are always at a close proximity to mechanics, the use of face (gas) mask is necessary for all professionals to protect them from exposure through aerosol during spraying. The gas mask will also reduce exposure from exhaust.

2. Food intake: Regular as well as balanced diet is necessary to reduce lead absorption since lead is fast absorbed on empty stomach. The implication was obvious in the blood lead level of the herdsmen and their dietary pattern, which contained more calcium, obtained from Nunu (fresh cow milk).

3. Drastic reduction in the leaded petrol supply as well as regular screening of the lead level of imported fuel. Reduction of rickety vehicles by creating opportunities for new ones.

4.Total replacement of leaded petrol with unleaded one despite its higher cost. There should be a bill enacted to back it because the promise of introduction of vehicle that can use absolute spirit as fuel will also help to reduce lead pollution.

5.Finally, Government should ensure regular supply of fuel because shortfalls in supply always result in panic buying with the use of jerry cans/plastic containers and also ensures total phase out of leaded petrol (Punch 2004 in appendices I and II).

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Ethical Consideration

(1) Confidentiality of Data

The respondents were assured of absolute confidentiality of all information obtained from them.

(2) Statement of translation of protocol to local language for easy communication

The content of the questionnaire was interpreted to the illiterate respondents.

(3) Beneficial to participants

The participants were informed of the benefits of treatment if they were found to have high blood lead level.

(4) Non- maleficent to participant. They were assured of no injury in the course of participating

(5) Right to decline/withdraw from study without loss of benefits. The participants had the right to decline or withdraw during the study

APPENDIX 1

News Paper Publication titled Succour for Children as Nigeria phases out Lead in Fuel

The PUNCH, Monday, March 1, 2004 Page 31

Monday

Homes & Property

8188144

Succour for children as Nigeria phases out lead in fuel

The Environment

Michael Sunday

By 2004, Nigeria may already have eliminated the lead

According to Integrated Refinery to produce only unleaded gasoline. In the last 18 months, gasoline from Kaduna and Warri refineries is unleaded, the NNPC GED told the gathering made up of another NNPC official, a oil con-

sultant to the World Bank and a member of the National Automotive Council, adding that High-octane gasoline from Port Harcourt refinery or one imported is used to blend the product from the two refineries to increase their octane rating. If necessary, the NNPC may use of MMT as octane enhancers in future, he declared.

The GED emphasized that NNPC is ... by adding additional units to ... High-RON ... rather than using ... enhancers, but the plan is ... Continued on Page 41

Traders' influx triggers rent explosion in Ikeja 'Computer Village'

Real Estate

Nigeria phases out lead in fuel

Continued from Page 34

government to privatise the refineries has put the rehabilitation of the additional units on hold.

The NNPC official and the oil consultant [illegible] that development [illegible] that it should [illegible] some degree of [illegible]. The Department of Petroleum Resources [illegible] confirmed that all petrol used in Nigeria is lead free [illegible] which [illegible] Standards Organisation of Nigeria (NIS 116:2000) allows zero lead.

Indeed, Africa and a few countries of Eastern Europe and Asia are the only countries still using leaded gasoline already indicted in various health defects. The Nigerian Action Plan had stated that "although there are no national surveys of blood lead levels in the general Nigerian population, isolated studies indicate these levels are very high compared to [illegible] acceptable limits [illegible] have correlations [illegible] associated with various pathological conditions such as anaemia, neurobehavioural deficits, renal impairment, reproductive abnormalities and suppressed body defence system."

Essentially, lead is considered a poison and, according to experts, there is no safe level of lead in the human body. Emissions from vehicles running on leaded fuel are absorbed directly into the body and indirectly through the food chain. [illegible] children are particularly vulnerable to lead poisoning. Lead causes disabling and irreversible neurological damage in children leading to learning disabilities, lower levels of intelligence, behavioural problems, growth impairment, permanent visual and hearing impairment and other damage to the brain and nervous system. Exposure to high doses of [illegible] result in [illegible] and death.

[illegible] the NNPC meeting [illegible] in Abuja [illegible] the DPR, which checks the quality of both imported and locally produced gasoline to ensure they conform to standards, has prescribed a maximum lead level of 0.2 g/l, a far cry from that established by the Standards Organisation of

[illegible] system."

[illegible] maximum lead content of 0.05 g/l.

The [illegible] of the [illegible] Port Harcourt [illegible]

[illegible] three NNPC refineries [illegible] Port Harcourt [illegible]

[illegible] with high-octane gasoline.

[illegible] at the refinery or at Lagos depot. The use of MMT as an octane booster is being considered. The refinery has been undergoing annual maintenance and would be ready [illegible] 110,000 barrels per day [illegible] Kaduna Refinery and Petrochemical Complex has [illegible] FCC and CRU units [illegible] installed at WRPC and KRPC to produce unleaded fuel without using chemical enhancers, according to the NNPC. The following [illegible] figures are to be made:

• [illegible] of [illegible] plants in both KRPC and WRPC to upgrade [illegible] naphtha;

• Upgrade and [illegible] the CRU to CCR plants to run in balance with CCR at 100 per cent [illegible] at both refineries;

• Upgrade the FCC in WRPC and upgrade the converter technology of the KRPC FCC; and

• Installation of [illegible] for lead [illegible]

[illegible] The SON [illegible] to review diesel specification (NIS 149:1998) which [illegible] high sulphur [illegible] specified (0.5 per cent by weight max).

Water-related disasters

APPENDIX II

News Paper Publication titled Imported Petrol is dangerous

'Imported petrol is dangerous'

Tunde Odesola, Osogbo

AN environmentalist and lecturer at the Obafemi Awolowo University, Ile-Ife, Prof. Olusola Ogedengbe, raised an alarm on Tuesday, that petroleum products currently being imported into the country, were dangerous.

Ogedengbe, who delivered the third Samuel Fadahunsi annual lecture entitled, Nigeria's Environmental Nightmare: Taming the Monster, at the Oduduwa Hall of the University, said research had shown that the petroleum products being imported into the country were dangerous to automobiles, machines and the environment.

According to the don, the type of petrol used in Nigeria had been outlawed in many countries of the world, noting that the petrol contained lead which combustion released poisonous gases.

Explaining why unleaded petrol was not in use in the country, he said vehicles in the country would "need appropriate carburettor and or engine modification."

Describing the petrol used in the country as an unwholesome product, he said leaded petrol caused environmental pollution, "which is dangerous to living."

Also condemning manufacturers of detergents in the country, he said it was worrisome that Nigerian detergent manufacturers did not state the composition of their products on the packs or said so in ambiguous language.

Environment

He said: "The detergents sold in supermarkets and in open markets throughout the country, would not be allowed into most countries of Europe, America, and Asia especially.

"Picking up a packet of detergent in any of these countries, one finds that the ingredients (composition) are unambiguously stated, as well as the substances specifically stated. Detergents available in Nigeria list the ingredients in vague terms."

Disproving the claim by a popular detergent manufacturer that its product contained linear alkyl benzene sulphonate, the professor said the product, instead, contained branched ABS rather than linear ABS.

He pointed out that branched ABS had been banned since 1970 in the United States of America, Germany, Japan, Thailand and several other countries, stressing that they had been replaced with the linear variety, which is environmentally-friendly.

"Branched ABS has been found to be non-biodegradable and causing foam-related environmental problems in surface and underground water," he stated.

The Punch, Friday, June 10 2005 Page 19.

APPENDIX III

BLOOD LEAD LEVELS IN RELATION TO ZINC AND CALCIUM AMONG SELECTED OCCUPATIONAL GROUPS IN ILORIN WEST LOCAL GOVERNMENT AREA OF KWARA STATE, NIGERIA

Dear Respondent,

I am Mr. Siddik Sulaiman Oba, a postgraduate student of the department of environmental heath, University of Ibadan. I am conducting research project on lead in the blood with a focus on exposure through gasoline (petrol fraction) or exhaust gases from combustion engines.

Lead is a poisonous, harmful metal, which is vastly distributed in air, dust, water, soil, food and in many objects that are extremely beneficial to man.

Kindly answer the under listed questions to the best of your knowledge and at the same time, I am assuring you that your answers will be treated with utmost confidentiality.

I thank you in advance for anticipated cooperation.

LOCAL GOVERNMENT AREA .....CODE.....

HOUSE NO.....STATIONWORKSHOP NO.....

SECTION A: SOCIO-DEMOGRAPHIC INFORMATION

1. Gender: Male ☐ Female ☐
2. Age .....Years
3. Occupation:
   1. Auto mechanic ☐
   2. Petrol station attendance ☐
   3. Commercial driving ☐
   4. Fulani herdsman ☐
   5. Painting/Spraying ☐
   6. Panel beating/Welding ☐
   7. Re-wiring/Battery charging ☐
   8. Others (specify) .....
4. Ethnicity:
   1. Yoruba ☐
   2. Igbo ☐
   3. Hausa ☐
   4. Fulani ☐
   5. Others (specify) .....
5. Marital Status:
   1. Single ☐
   2. Married ☐
   3. Divorced ☐
   4. Separated ☐
   5. Widower ☐

6. Religion:

1. Islam ( )
2. Christianity ( )
3. Traditional ( )
4. Others .....

7. Highest level of education attained:

1. No formal education ( )
2. Arabic education ( )
3. Primary education ( )
4. Secondary education ( )
5. National Certificate of education ( )
6. Polytechnic ( )
7. University ( )
8. Others (specify) .....

LEAD CONTACT FROM OCCUPATIONAL ACTIVITIES

8 How many years have you been on the job?

Years .....

9. Do you degrease (wash away grease) with petrol?

1. Yes ( )
2. No ( )

10. When de greasing machine parts, which of the following methods do you use?

1. Bare hand ( )
2. Hand gloves ( )
3. A tool ( )

4. Others (specify) .....

11. How often do your hands come in contact with petrol in a week ?

1. Once ☐
2. Twice ☐
3. Thrice ☐
4. Many times ☐

12. Do you clean / wash your hands before you eat while at work?

1. Yes ☐
2. No ☐

13. How often do you clean/wash your hands before eating at work?

1. Always ☐
2. Occasionally/sometimes ☐
3. Never ☐

14. When there is need for you to clean/wash your hands before you eat, what cleaning method do you use?

1. Water only ☐
2. Water with soap ☐
3. Water with detergent ☐
4. Dry cleaning with cloth ☐
5. Others (specify) .....

15. When there is need to use petrol as a solvent to dissolve out grease from any part under repair, by what means do you remove the petrol from the vehicle?

1. Suck out with mouth ☐

2. Mechanical suction pump ☐

3. Others (specify) .....

16 Assuming that you use mouth to suck out the petrol, how do you remove the traces of the petrol left in your mouth?

1. Mere spitting out ☐
2. Rinse with water ☐
3. Use a mouthwash ☐

17. When you buy petrol for use, do you use Jerycans or other containers?

1. Yes ☐
2. No ☐

18. What do you do to such container after use?

1. Discard ☐
2. Use for water ☐
3. Use for kerosene ☐
4. Use for other purposes ☐

19. If there is any need to use the container for water, what prior treatment (cleaning) do you give to it?

1. Rinse with cold water ☐
2. Rinse with hot water ☐
3. Wash with ordinary soap ☐
4. Wash with detergent ☐

20. While at work, are you often exposed to exhaust from automobiles?

1. Yes ☐

2. No

21. How often are you exposed to exhaust?

1. Occasionally

2. Always

22. Do you know there is a metal lead, which is different from lead in pencil?

1. Yes

2. No

23. Have you ever heard that such metal lead is present in petrol?

1. Yes

2. No

24. What is your source of information?

1. Friends

2. Oga (master)

3. Newspapers

4. Others (specify) .....

HEALTH KNOWLEDGE

25. Have you ever heard about lead poisoning?

1. Yes

2. No

26. What is lead poisining?

1. It is a diseases that is associated with high level of lead in the body

2. A disease that is associated with Obsity.

3. A disease that is associated with high blood pressure.

4. a disease of the lung.

27. How do people get lead poisoning?

1. Infection from certain disease
2. Smoking
3. Hereditary
4. Food
5. Don't know
6. Others (specify) .....

28. How often do you have the following experiences (tick ✓):

Conditions	Always	At times	Rarely	Never
Headache				
Dizziness				
Irritability				
Hot temper				
Convulsion				
Constipation				
General weakness (Lethargy)				
Restlessness				
Loss of Memory				
High blood pressure				
others Specify.....				

29. Have you ever been told to go on bed rest by a doctor or health worker?

1. Yes
2. No

30. How many times have you been on sick leave or bed rest in the last 3 months?

1. Once
2. Twice
3. Thrice
4. Many times

31. Where do you go for care when you have the experiences I will list to you now and how often (use the table below).

Conditions	Hospital /Clinic	Patent Medicine vendor	Traditional	Self Medication	How often	
					Always	Occasionally
Headache						
Dizziness						
Irritation						
Hot tempered						
Convulsion						
Constipation						
General weakness						
Restlessness						
Loss of Memory						
High blood pressure						
Others Specify.....						

APPENDIX IV

QUESTIONAIRE ON DIETARY PATTERN (24-HOUR DIETARY RECALL) OF THE SUBJECTS

Answer the following questions to the best of your knowledge:

How many times do you eat in a day

(i) Once ( ) (ii) Twice ( )

(iii) Thrice ( ) (iv) More than three ( )

Which meal do you miss in a day

(i) Breakfast ( ) (ii) Lunch ( )

(iii)Dinner ( ) (iv) None ( )

Why do you miss it?

(i) Yes ( ) (ii) No ( )

Please tick the food commonly consumed in respect to breakfast, lunch and dinner. Tick where appropriate,

FOOD	BREAKFAST	LUNCH	DINNER
Yam			
Pounded yam			
Amala			
Lafun			
Fufu			
Tuwo			
Rice			
Gari (Eba)			
Plantain			
Soup(Okro)			
Soup (Vegetable)			
Soup(Gbegiri)			
Fish			
Meat			
Chicken			
Egg			
Bread			
Snacks			
Fura and Nunu			
Nunu only			
Others (specify)			

FOOD FREQUENCY : Kindly tick the appropriate time(s) the food below is taken

Food	Every day	At least thrice A weak	Twice a weak	Once a weak
Yam				
Pounded yam				
Amala				
Lafun				
Fufu				
Tuwo				
Rice				
Gari(Ebu)				
Plantain				
Soup(Okro)				
Soup (Vegetable)				
Soup(Gbegiri)				
Fish				
Meat				
Chicken				
Egg				
Bread				
Snacks				
Fura and Nunu				
Nunu only				
Others (specify)				