

THE RELATIONSHIP BETWEEN DAILY TRAFFIC VOLUME
AND THE DISTRIBUTION OF SOME HEAVY METALS IN
ROADSIDE SOIL, VEGETATION AND WATER.

BY

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A THESIS SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE MASTER OF SCIENCE
DEGREE IN ANALYTICAL CHEMISTRY.

DEPARTMENT OF CHEMISTRY,
FACULTY OF SCIENCE,
AHMADU BELLO UNIVERSITY,
ZARIA, NIGERIA.

MARCH, 1982.

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ACKNOWLEDGEMENT.

I wish to express my sincere and profound gratitude to my major advisors professor K. Singh and Dr. S. A. Thomas for their guidance during the graduate studies, and their patience in editing the write up.

My indebtedness also goes to professor J. Ndagi, Director of Institute of Education Ahmadu Bello University, Zaria for permitting me to do this course.

Sincere appreciation is also expressed to the Research Board, Institute of Education, Ahmadu Bello University, Zaria for the grant awarded me which made this study possible.

Finally, I am grateful to my wife, Mrs. Theresa Inikori, who gave me the necessary cooperation and encouragement throughout this work.

DECLARATION.

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any other University or Institution. Information derived from the published or unpublished work of others has been acknowledged in the text.

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.....

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CERTIFICATION.

We certify that this work was carried out by
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ABSTRACT.

The relationship between estimated daily traffic volume and the concentrations of the heavy metal pollutants, lead, cadmium, nickel, copper and chromium as determined by atomic absorption spectroscopic technique in soil, vegetation and water samples taken along sides of some major roads in seven state capitals in Nigeria has been established. The amounts of these metals in soil samples from three petrol stations in Zaria, the car park at the Kashim Ibrahim Library of the Ahmadu Bello University and that at the Advanced Teachers' College, Zaria and the Ahmadu Bello University Staff School, Samaru have been determined.

Lead, Cadmium and Copper concentrations in soil and vegetation samples show significant correlation with estimated daily traffic volumes. Correlation coefficients for the concentrations of nickel in soil, chromium in vegetation and cadmium in water are also significant. However, correlation coefficients for Lead, Nickel and Chromium concentrations in water samples are not significant.

The distribution of all the metals in the soil, vegetation and water samples except for nickel in vegeta-

tion samples show a decrease in concentration with increasing distance from the road in all the state capitals. The metal concentrations in soil samples were generally below threshold limits. The Lead concentrations in vegetation samples in all the state capitals except Calabar, exceed the specified limits. Nickel concentrations in water samples also exceed the threshold limit in all the state capitals.

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CHAPTER 1

INTRODUCTION

1.1 Heavy Metal Traffic Pollutants.

Much work has been done by various research workers in the past few years to study the distribution of some heavy metals in soil, water and vegetation thought to be polluted by motor traffic.¹⁻⁶ Lead, Cadmium, Nickel, Copper and Chromium are the major heavy metals reported as environmental pollutants associated with motor traffic. Each of these heavy metals has been found to accumulate in soil, vegetation and water near highways. The level and pattern of environmental pollution caused by Lead, Nickel, Copper and Chromium in roadside soil, water and vegetation in 12 different state capitals in Nigeria, namely, Lagos, Ibadan, Akure, Abeokuta, Ilorin, Kano, Makurdi, Maiduguri, Kaduna, Jos, Owerri and Sokoto have been studied.⁷

The elevation of atmospheric lead levels associated with increased road traffic volumes has been found to be mainly due to the emission of this heavy metal during gasoline combustion.⁸⁻¹⁰ With the exception of the emission by Lead Smelters, motor traffic has been found to account for about 98% of the total lead ejected into the environment.¹¹

Lead is added to gasoline in the form of Lead alkyl to increase the octane number so that engines can give high performance without damage arising from this and related phenomena of abnormal combustion. When gasoline containing anti knock fluids are burnt in an engine, the Lead alkyl compounds decompose and react to form the materials that are carried into the exhaust system. These inorganic Lead exhaust products are primarily Lead halides, $\text{NH}_4 \text{Cl} \cdot 2\text{PbCl}_2$, and $2\text{NH}_4\text{Cl} \cdot \text{PbCl}_2$ which on reaching the atmosphere probably undergo photolysis and eventually form PbO and other Lead oxides.¹¹ The Lead emitted is in a variety of particle sizes, from semimicron equivalent diameter to many microns in diameter. The larger particles settle near the source while the smaller particles remain airborne for longer periods in a manner similar to a gas.¹² Lead alkyl compounds also reach the atmosphere directly by evaporation from gas tanks, from carburetor vents and during filling at service station.

Cadmium may enter the environment through its use in pigments, galvanizing and electroplating however, traffic pollution due to cadmium has been associated with the presence of this heavy metal as an impurity in Zinc containing additives in motor oils and zinc compounds used in vulcanizing rubber tyres.⁴ Cadmium is present as impurity

in superphosphate fertilizer and the use of cadmium as a fungicide also results in the entry of the heavy metal into the environment.

Nickel occurs mainly in basic rock as pentlandite $(\text{FeNi})_9\text{S}_8$, although it is also found in other minerals such as garnierite, niccolite and millerite. The element is present to some extent in all soils and vegetation.¹³

Nickel is however emitted into the environment through gasoline combustion and other sources such as paint and smelting industry and in the use of fertilizers. Naturally nickel is present in crude gas oil. Distillate fractions, particularly high boiling gas oils used in catalytic cracking stock are apt to contain a considerable amount of Nickel. Nickel is also added to some gasoline as a deposit modifying agent. Aerial deposit from automobile exhaust is an important source of nickel in plants and animals.² Nickel has been found in high concentrations in soils and vegetation near highways and urban areas,²

Copper is widely distributed in soils and minerals; one of the most important copper mineral is chalcopyrite, CuFeS_2 , and another is chalcocite, Cu_2S .

Copper is added to fuel in form of copper chloride as a treating agent to remove mercaptans.¹⁴ Copper may also get into gas oils as a contaminant resulting from contact

with copper alloys used in valves, pumps and heat exchangers both in and beyond the refinery.¹⁴ Automobiles may therefore be an important source of the heavy metal in the environment especially in soils, water and vegetation near highways.

Chromium may occur as chromite, FeCr_2O_4 , and Magnesio-Chromite MgCr_2O_4 . Chromium is widely distributed in soils and vegetation although the concentrations are generally very low; the levels in some basic igneous soils such as serpentine are relatively high.¹⁵

Traffic pollution due to Chromium may arise from the emission of the heavy metal in the exhaust of automobiles during gasoline combustion. Other sources of Chromium in the environment include the discharge of waste products from electroplating and the manufacture of alloys.

1-2 Toxic Hazards Of Heavy Metal Pollutants In The Environment.

Lead, Cadmium, Nickel, Copper and Chromium are toxic to plants and animals if absorbed in excessive amounts.¹⁶ Toxic hazards due to excessive accumulation of these heavy metals are discussed in the following sections.

1-2.1 Lead.

Lead performs no biological function in man. When the tolerance level of Lead is exceeded in the body, symptoms of Lead poisoning include abdominal cramp constipation, loss of appetite, motor-nerve paralysis, anaemia, isomania, irritability and encephalopathy.¹⁶

Apart from the potential nutritional hazards of this heavy metal to man and animal, it has been established that lead inhibits photosynthesis and transpiration in plants and ~~depresses~~ radical elongation of maize seedlings.⁵ Significant inhibition of maize root elongation does not however occur at Lead concentrations below 250 μ g of Lead per gram of soil.⁵

1-2.2 Cadmium.

Cadmium causes hypertension and cancer in man. In 1966, Carroll¹⁷, published evidence of a relationship between cadmium in air and cardiovascular disease. Besides heart disease except those of rheumatic origin, arteriosclerotic heart disease and hypertensive disease also show significant correlations with cadmium concentrations in man. The toxicity of cadmium to plants has also been established.¹⁸ Besides increasing cadmium level in various plant parts,

cadmium treatment applied to soil resulted in significant yield depression for most plant parts. Potential hazardous levels in plants may therefore result from cadmium uptake from contaminated soils. Concentrations up to 96ppm of this heavy metal has been reported to inhibit photosynthesis and transpiration in plants.⁶

1-2.3 Nickel

Nickel enters the body mainly through inhalation and ingestion of food containing the element.¹⁹ In man, inhalation of nickel can produce cancer of the sinus and lungs; skin sensitization is the most commonly seen toxic reaction to nickel and this often results into chronic eczema.¹⁹

Plants appear to be more sensitive to nickel toxicity than animals. Except in minute quantities, nickel is toxic to plant growth and is partially responsible for the low fertility of soils derived from ferromagnesian rocks.¹²

1-2.4 Copper

Copper may enter human body through inhalation of dust or fumes and through the ingestion of copper contaminated foods. It becomes toxic to plants and animals if

absorbed in excessive amounts. Chronic human intoxication rarely occurs, but congestion of the nasal mucous membrane may take place.¹⁹ When copper particulates reach the gastrointestinal tract, they may act as irritants, producing salivation, nausea, vomiting, gastric pain and diarrhoea.¹⁹

In plants, excess copper prevents uptake and translocation of iron and magnesium.¹⁵

1-2.4 Chromium

Inhalation is the major route of chromium into the body. This heavy metal is toxic to animals particularly in the hexavalent state, although less so to plants.¹⁹ In the trivalent state it is of low toxicity. Chromium can cause dermatitis; inhalation can produce lung cancer while acute exposure to dust of chromium particulates may cause coughing, wheezing, headache and loss of weight.¹⁹

1-3 Aims And Objectives Of The Study.

With increasing number of vehicles on the roads in Nigeria, the possible environmental pollution caused by exhaust gases is becoming of serious concern. Lead, Cadmium, Nickel, Copper and Chromium are the major heavy

metals contained in the exhaust gases emitted from automobiles. Populations living near highways and road users are therefore exposed to some amount of these heavy metal traffic pollutants.

At present, especially with the on-going "green revolution" campaign by the Federal Government of Nigeria, there is considerable interest in growing fruits and vegetables along roadside and around houses in urban areas by most people. The consumption of crops grown in areas contaminated by these heavy metals are therefore likely to pose potential health hazards to man. The need to ascertain the levels of these heavy metals in the environment cannot therefore be overemphasized. This study would give information regarding the extent and growing trend in pollution caused by these heavy metals along roadsides of seven state capitals in Nigeria, namely, Bauchi, Benin City, Calabar, Enugu, Minna, PortHarcourt and Yola. Already, similar study has been carried out with samples from the remaining twelve state capitals in Nigeria.⁷ This study is aimed at establishing:

- (i) the level and pattern of environmental pollution caused by Lead, Cadmium, Nickel, Copper and Chromium in soil, vegetation and water samples along

the side of a busy road in each of the seven state capitals by using Atomic absorption spectrometer;

- (ii) a correlation between daily traffic volume and the amounts of Lead, Cadmium, Nickel, Copper and Chromium in soil, vegetation and water samples along the sides of a busy road in each of the seven state capitals and suggest possible control for heavy metal traffic pollutants in the environment.

To achieve these objectives, soil samples were collected at distances between 1 to 15 meters from the roadside of a busy highway very close to a traffic control post in the seven state capitals. Soil samples were also collected from fuel stations within Zaria, the car park at K.I.L, and that at the Advanced Teachers' College, Zaria and the Ahmadu Bello University Staff School, Samaru.

Leaf samples were collected at the outskirts of the state capitals on both sides of a busy highway that leads into each of the state capitals.

Water samples were also collected from stagnant water at about 3 to 20 meters away from the highways.

The level of the heavy metal traffic pollutants in the soils, vegetation and water samples were determined by the use of Atomic absorption spectrometer, Sp 1900.

CHAPTER TWO

SAMPLING AND ANALYSIS

2-1 Sample Collection

2-1.1 Soil Samples:

Soil samples were collected at 1, 5, 10 and 15 meters away from the pavement of the road with a metal cylinder. The samples were collected between August and September, 1981, except for samples from Calabar and PortHarcourt which were collected in November, 1981. In all cases, Polythene bags were used for the storage of the soil samples after collection. The roads of the corresponding state capitals from where the soil samples were collected are shown in table 1.

2-1.2 Vegetation Samples:

Leaf samples were collected from trees of about 2 to 4 meters high. The leaf samples were collected at 2 and 20 meters from the roadsides of the corresponding roads as those for soil samples. The Leaf samples were collected in Polythene bags and stored in the cupboard.

2-1.3 Water Samples:

These were collected in Plastic containers from stagnant water bodies at about 2 and 20 meters away from

the road.

2-1.4 Estimated Number of Vehicles At The Location From Which Samples Were Collected:

An estimate of the number of vehicles plying the roads where the samples were collected was obtained from the traffic police on duty at the time of sample collection. The estimated number of vehicles passing between 7-9 a.m, 12-4 p.m and 5-7 p.m obtained from the traffic police were averaged to give a rough estimate of the number of vehicles passing per hour. This value when multiplied by 24 then gives an estimated daily traffic volume for each of the roads. In some cases I counted the number of vehicles plying the roads during the above time intervals as shown in table 2.

2-2 Atomic Absorption Spectroscopic Method For Determining Heavy Metals:

Atomic absorption spectroscopy is currently one of the most widely used method for the determination of heavy metals, especially those that occur at trace level in most environmental samples.¹⁴ It is an analytical tool in many laboratories due to its high sensitivity, accuracy and reproducibility, the ease of sample preparation and handling.

The principle of atomic absorption spectroscopy is

TABLE 2. ESTIMATED NUMBER OF VEHICLES AT THE LOCATION WHERE
SAMPLES WERE COLLECTED IN THE SEVEN STATE CAPITALS.

STATE	NO GIVEN BY TRAFFIC PERSONNEL				PERSONAL COUNT			AVERAGE PER HOUR	AVERAGE PER 24 HOURS (ESTIMATED DAILY TRAF. VOLUME)
	7-9a.m	2-4pm	5-7pm	7-9am	2-4pm	5-7pm			
Baconda	1383	1149	1002	1165	992	800	541	12984	
Benjin-City	2135	1913	1896	2240	1896	1892	996	23904	
Calphar	1120	1096	994	-	-	-	551	13224	
Enugu	1790	2135	1859	1911	1672	1800	931	22344	
Minneapolis	1436	1572	694	1310	1287	717	582	13968	
Portchar-Coult	2204	2057	2118	-	-	-	1069	25512	
Voia	1340	1865	797	1272	1122	826	602	14448	

first to vaporise atomically the metal containing material by some appropriate method. The ground state atom absorbs a specific wavelength of light through its atomic vapor layer. The absorption is analysed quantitatively using a photomultiplier apparatus.

The traditional type of atomic absorption spectrometer incorporates a furnace, apparatus. This consists of a nebulizer, dispenser and burner head.

The sample solution is sprayed into the flame. Here, the expected element is atomised to yield free atoms. A hollow cathode lamp containing the element to be determined is used as the light source. The atoms of this element in the flame absorbs at exactly the same wavelength as that emitted by the light source. The decrease in intensity is measured using a monochromator and detector systems. This decrease is related to the concentration of the element in solution.

The criteria governing the accuracy are: stability of light source (hollow cathode lamp), which depends on an appropriate current; smooth nebulization and cleanliness of the burner.

The factors affecting sensitivity are: the state of the flame; selection of burning gas; efficiency of the nebulizer, working condition of the light source;

optical system and dispersion ability of the diffraction grating.

In all cases, it is required that the flame temperature be high enough as to dissociate the element to be determined and produce free atoms. If the flame temperature is higher than usual, ground state atoms decrease, and excited state atoms increase, the overall sensitivity of the instrument remains below that with a low temperature flame.

Of 68 elements now detectable by atomic absorption spectroscopy, 38 can be detected with air-acetylene flame. The defects of this flame is that the temperature is too low for the detection of oxides which do not dissociate easily in the flame, and the flame absorption is quite strong at far ultra violet frequencies, rendering the signal of elements under 230 nm too weak.

The nitrous oxide-acetylene flame is characterised by its high temperature and reductive atmosphere, which permit the detection of very low concentrations of non-dissociable compounds that remain undetected with the air-acetylene flame. The elements detectable only by nitrous oxide-acetylene flame are Al, Be, B, Si, Ti, V, W, Eu, Gd, Hf, Ho, Ir, La, Lu, Nb, Nd, Pr, Re, Se, Ta, Tb, Tm, U, Y, Yb and Zr. These elements can form oxides which require a

large energy for dissociation, for which the temperature of the air-acetylene flame is too low but the nitrous oxide-acetylene flame is sufficient. Moreover, in the nitrous oxide-acetylene flame, these oxides cannot form readily due to the strong reductive atmosphere.

2-3 Experimental

2-3.1 Pre-treatment Of Samples:

Soil Sample:

Prior to chemical analysis by atomic absorption spectrometer, the soil samples were first dried at 105°C for 3 hours in an oven. The dried samples were ground and sieved with a 2mm sieve before being stored in sample bottles.

Vegetation Samples:

The leaf samples were air-dried and blended before being stored in sample bottles.

Water Samples:

The water samples were filtered until they became clear. The clear water samples were then concentrated from 50 to 30 cm³ and 10 cm³ of concentrated hydrochloric acid was added to prevent growth of micro-organisms.

2-3.2 Preparation Of Sample Solutions:

Soil Sample Solution:

Soil sample solutions were prepared by sodium carbonate fusion method. The fusion of minerals with anhydrous sodium carbonate brings them into forms which are soluble in hydrochloric acid.¹² Potassium nitrate was added to the sodium carbonate to give an oxidizing flux.

1_g of the soil sample was weighed into a clean silica crucible. To this, 3.0_g of anhydrous sodium carbonate and 0.3g of potassium nitrate was added. These were then mixed properly and heated on a Meker burner, heating gradually at first, until the mass became quiescent. After 15 minutes, the sample was allowed to cool and was subsequently washed with 10 cm³ of deionised water into 100 cm³ beaker. 10 cm³ of hydrochloric acid (50% V/V) was added and boiled for 1 hour on a hot plate at the temperature of 90° C. The content was then filtered into 100 cm³ standard flask and made up to the mark with deionised water.

Vegetation Sample Solution:

Dry ashing method was utilised for the preparation of the leaf sample solutions. The leaf samples were first air-dried and blended. 2 to 4g of the air-dried ground

sample was weighed into a silica crucible and charred with a Bunsen burner. The charred samples were put into a muffle furnace and the temperature gradually raised to and maintained at 450°C for 5 hours when a clean ash was obtained. The ash was cooled, 20 cm³ of concentrated hydrochloric acid added and boiled on a water bath to dryness. The residue was dissolved in 20 cm³ of hydrochloric acid (50% V/V) and made up to 100 cm³ with deionised water.

Water Sample Solutions:

Filtered water samples were concentrated from 50 to about 30 cm³ in a 50 cm³ standard flask and 5 cm³ of hydrochloric acid (50% V/V) was added. It was then made up to the mark with deionised water.

2-3.3 Instrument Used:

The Perkin-Elmer atomic absorption spectrometer model SP 1900 was used with an energy source (hollow cathode lamp) for each of the element.

2-3.4 Reagents And Chemicals:

All solutions were prepared by dissolving analytical grade materials in deionized water.

Lead nitrate
Potassium nitrate
Anhydrous sodium carbonate
Nickel nitrate hexahydrate
Copper sulphate pentahydrate (B.D.H.)
Potassium chromate
Hydrochloric acid
Nitric acid

2-3.5 Determination Of Lead:

Preparation Of Lead Standard Solutions:

Lead standard solutions were prepared from lead nitrate. The lead nitrate was first standardised by titration with standard solution of sodium hydroxide (0.1M) and EDTA (0.1M) solution using methyl red Bromo-cresol green-indicator.

Procedure: ²⁰ The lead nitrate solution was treated with ammonium chloride (1M, 10 cm³ for each 100 cm³ solution), and after adding the indicator it was brought to PH = 5 with NaOH. Few amount of EDTA solution was added and neutralisation was at once effected with the standard alkali. Further small amount of EDTA was added and the neutralisation carried out again. These operations were repeated until finally the addition of EDTA no longer

caused the PH to sink below PH = 5.

The result was calculated from the volume of standard alkali required, 1 Cm³ of 0.1M NaOH thus corresponding to 10.36 mg of Lead. From the titration results, stock solution of Lead standards containing 1000 ppm Lead was prepared, 1.599g of Lead nitrate was dissolved in 25 Cm³ of HNO₃ (1% V/V) and this was made up to 1 Litre with deionised water.

Working Standards:

Lead standards in the range of 0-10 ppm were prepared by dilution of the stock solution.

Instrumental Conditions:

Wavelength	-	217.0 nm
Flame	-	Air/acetylene
Slit setting	-	0.15 - 0.2 mm
Air flow rate	-	0.8 - 1 Liter min ⁻¹
current	-	6 mA

Procedure:

The correct wavelength was selected and air/acetylene flow rate adjusted as appropriate. The Lead hollow cathode lamp was set and allowed to stabilize. The standard

solutions were first aspirated into the flame. The absorption intensities were measured and used to prepare a calibration curve. Subsequently, the sample solutions were aspirated into the flame and their absorption intensities obtained. Corresponding concentration of Lead in ppm in each sample solution was read off from the calibration curve. These were converted into $\mu\text{g g}^{-1}$ for soil and vegetation samples and $\mu\text{g L}^{-1}$ for water samples.

If C = ppm Lead obtained from the calibration curve, then, for:

Plant and soil samples,

$$\frac{C(\text{ppm}) \times \text{Sample Volume (cm}^3\text{)}}{\text{Sample weight (g)}}$$

Water samples,

$$\text{Pb } (\mu\text{g L}^{-1}) = C(\text{ppm}) \times 10^3,$$

2-3.6 Determination of Cadmium

Preparation of Cadmium Standard Solutions:

Cadmium standard solutions were prepared from cadmium nitrate. The cadmium nitrate was first standardized using the same procedure as that for the standardization of Lead. 1 cm³ of 0.1M NaOH however corresponding to 5.62 mg of cadmium. From the titration result obtained, stock solution of cadmium containing 100 ppm of cadmium was prepared.

0.21032g of cadmium nitrate was dissolved in 25 cm³ of nitric acid (1% V/V) and this was diluted to 1 litre with deionised water.

Working Standards:

Cadmium standards in the range of 0 - 1 ppm were prepared by dilution of the stock solution and adding concentrated hydrochloric acid as appropriate to match the sample solution.

Instrumental Conditions:

Wavelength	-	228.8 nm
Flame	-	Air/acetylene
Air flow rate	-	5 litre min ⁻¹
Lamp current	-	5 - 6 mA
Slit setting	-	0.1 - 0.15 mm
Acetylene flow rate	-	1 - 1.2 litre min ⁻¹

Procedure:

A wavelength of 228 nm was selected and other instrumental conditions adjusted. The cadmium hollow cathode lamp was allowed to stabilise. Preparation of calibration curve and determination of the amount of cadmium in the

sample solutions were carried out in the same manner as in lead determination.

2-3.7 Determination of Nickel

Preparation Nickel Standard Solutions:

Standard solutions of nickel were prepared from nickel nitrate hexahydrate. The Nickel salt was first standardized using the same procedure as in cadmium determination. However, 1 cm³ of 0.1M NaOH corresponds to 2.935 mg of Ni in this case. Standardization results obtained were used in the preparation of Nickel stock solution containing 100 ppm Ni. 0.4953 g of nickel nitrate hexahydrate was dissolved in 25 cm³ of deionised water and made up to 1 litre.

Working Standard Solutions:

Nickel standards in the range of 0 - 10 ppm were prepared by dilution of the stock solution with the addition of concentrated hydrochloric acid as appropriate to match the sample solutions.

Instrumental Conditions:

Wavelength	-	232.0 nm
Flame	-	Air/acetylene

Air flow rate - 5.0 Litres min⁻¹
Lamp current - 12 - 15 m A
Slit setting - 0.15 - 0.2 mm

Procedure:

Instrumental conditions were adjusted and determination of Nickel were carried out in the same manner as in cadmium determination and using nickel hollow cathode Lamp.

2-3.8 Determination Of Copper:

Preparation of Copper Standard Solutions:

Standard solutions of copper were prepared from copper sulphate pentahydrate. The copper sulphate pentahydrate was first standardised using the same procedure as in Nickel determination. 1 cm³ of the standard 0.1M NaOH in this case, corresponds to 3.171 mg Cu. Stock solution containing 100 ppm copper was prepared using the standardization results. 0.3930 g of copper sulphate pentahydrate was dissolved in 25 cm³ of deionised water and made up to 1 litre.

Working Standards:

Copper standards in the range of 0 - 1.0 ppm were

prepared by diluting appropriate amount of the stock solution and adding concentrated hydrochloric acid as appropriate to match the sample solutions.

Instrumental Conditions:

Wavelength	-	324.8 nm
Slit setting	-	0.15 - 0.20 mm
Flame	-	Air/acetylene
Lamp Current	-	8 - 10 mA

Procedure:

All instrumental conditions were adjusted and determination carried out as in nickel determination and using copper hollow cathode lamp.

2-3.9 Determination Of Chromium.

Preparation Of Chromium Standard Solutions:

Chromium standard solutions were prepared from potassium chromate. Stock solution containing 100 ppm chromium was prepared by dissolving 0.3735g of potassium chromate in 25 cm³ of deionised water which was then made up to 1 litre.

Working Standards:

Concentration range of 0 - 2.0 ppm chromium was prepared from the stock solution and adding concentrated hydrochloric acid as appropriate to match the sample solutions.

Instrumental Conditions:

Wavelength	-	357.8 nm
Lamp current	-	8 - 10 mA
Flame	-	Air/acetylene
Slit setting	-	0.1 - 0.15 mm
Acetylene Flow rate	-	1.0 - 1.2 litres min ⁻¹

Procedure:

All instrumental conditions were adjusted and determination of chromium carried out as in lead determination but using chromium hollow cathode lamp as the light source.

TABLE 4. LEAD CONCENTRATIONS ($\mu\text{g/g}$ -1) WITH ESTIMATED STANDARD DEVIATIONS OF SOIL SAMPLES ALONG ROADSIDES OF SEVEN STATE CAPITALS IN NIGERIA.

STATE CAPITAL	DISTANCE (METER) FROM LEFT SIDE OF THE ROAD		DISTANCE (METER) FROM RIGHT SIDE OF THE ROAD					
	1	5	1	5				
Bauchi	129.0 \pm 9.1	83.9 \pm 11.2	45.2 \pm 6.5	22.5 \pm 6.7	158.0 \pm 5.6	100.0 \pm 7.1	38.7 \pm 9.1	25.8 \pm 4.1
Benin-City	328.0 \pm 11.1	287.0 \pm 10.7	198.7 \pm 10.7	16.1 \pm 5.8	888.0 \pm 5.8	287.4 \pm 10.7	180.6 \pm 8.1	25.9 \pm 9.1
Culabar	206.4 \pm 10.2	112.9 \pm 8.3	41.9 \pm 5.6	22.8 \pm 2.7	187.1 \pm 11.2	87.1 \pm 10.7	81.3 \pm 10.7	29.0 \pm 5.6
Enugu	289.0 \pm 6.3	214.1 \pm 9.2	77.4 \pm 8.2	25.9 \pm 8.2	312.2 \pm 9.7	190.9 \pm 9.6	121.3 \pm 6.3	46.4 \pm 6.3
Minna	190.3 \pm 10.7	38.7 \pm 4.6	27.4 \pm 2.8	4.8 \pm 2.8	284.5 \pm 6.5	95.1 \pm 5.4	35.5 \pm 3.2	22.5 \pm 3.2
PortHarCourt	367.7 \pm 11.2	303.2 \pm 6.5	206.0 \pm 9.1	22.5 \pm 5.8	398.7 \pm 5.6	880.8 \pm 6.1	163.8 \pm 8.1	28.6 \pm 3.1
Yorba	209.6 \pm 8.1	119.3 \pm 10.7	51.6 \pm 3.1	43.1 \pm 5.6	167.7 \pm 9.1	87.1 \pm 5.5	32.3 \pm 6.5	29.0 \pm 5.5

TABLE 5. CAESIUM CONCENTRATIONS ($\mu\text{g/g}$ -1) WITH ESTIMATED STANDARD DEVIATIONS
OF SOIL SAMPLES ALONG ROAD SIDES OF SEVEN STATE CAPITALS IN NIGERIA.

STATE CAPITAL	DISTANCE(METER)FROM LEFTSIDE OF THE ROAD				DISTANCE(METER) FROM RIGHTSIDE OF THE ROAD.			
	1	5	10	15	1	5	10	15
Bauchi	15.4±0.9	11.6±1.1	4.6±1.2	3.0±0.9	12.2±0.9	8.9±1.2	5.1±0.9	3.5±0.5
Berlin-City	15.8±0.4	13.3±0.8	5.8±0.6	2.1±0.2	25.1±1.3	19.7±1.4	11.9±1.3	4.1±0.9
Calabar	17.3±0.8	10.8±0.8	7.8±0.47	4.1±0.5	15.9±0.9	12.4±0.5	8.4±0.5	5.4±0.8
Enugu	38.1±1.4	35.8±0.8	8.4±1.0	4.3±0.8	31.3±0.8	28.1±1.3	9.5±0.8	4.9±0.9
Minna	17.5±0.5	14.3±2.1	9.2±0.9	3.2±0.8	21.6±0.8	14.3±0.9	7.3±0.9	4.3±1.1
PortHarcourt	41.3±0.9	35.4±0.8	20.3±1.4	9.5±0.9	37.5±1.2	29.4±1.6	17.3±1.3	8.1±0.5
Yola	18.0±0.9	14.3±0.9	7.0±0.5	4.1±0.9	12.4±1.2	9.6±1.2	5.4±0.8	2.4±0.5

TABLE 8. NICKEL CONCENTRATIONS (µg/g-1) WITH ESTIMATION STANDARD DEVIATIONS
OF SOIL SAMPLES ALONG ROADSIDES OF SEVEN STATE CAPITALS IN NIGERIA.

STATE	DISTANCE(METER) FROM LEFTSIDE OF THE ROAD				DISTANCE(METER) FROM RIGHTSIDE OF THE ROAD			
	1	5	10	15	1	5	10	15
CAPITAL								
Abuja	69.9±4.9	50.8±5.8	26.3±3.0	34.0±3.6	76.8±7.8	61.2±3.0	29.8±3.0	19.3±3.0
Bauchi	108.1±7.0	58.3±3.0	39.4±5.8	22.8±3.0	75.3±5.8	56.3±5.8	48.0±7.0	18.3±4.4
Benin-City	49.1±5.0	36.8±3.1	28.5±3.5	19.3±3.0	64.8±5.8	43.8±3.0	39.0±5.0	28.8±4.1
Enugu	68.3±3.0	45.5±3.5	36.8±3.0	24.3±3.0	108.4±5.1	91.0±5.0	86.5±6.0	82.9±3.0
Minna	72.0±5.2	28.0±5.0	21.0±5.0	20.3±3.0	71.8±3.0	43.8±7.8	24.5±3.5	11.0±4.6
PortHarCourt	113.9±5.8	57.8±7.6	29.8±3.1	18.8±3.1	112.1±4.4	63.1±5.0	45.5±3.5	19.3±3.0
Yola	74.0±5.1	52.8±7.6	20.5±3.5	18.8±3.5	73.8±6.1	42.3±5.0	38.3±3.0	31.5±3.5

TABLE 7. COPPER CONCENTRATIONS (µg/g-1) WITH ESTIMATED STANDARD DEVIATIONS OF SOIL SAMPLES ALONG ROADSIDES OF SEVEN STATE CAPITALS IN NIGERIA.

STATE CAPITAL	DISTANCE (METER) OF SAMPLE FROM LEFT SIDE OF THE ROAD.				DISTANCE (METER) FROM RIGHT SIDE OF THE ROAD			
	1	5	10	15	1	5	10	15
Jawuni	9.4±0.4	7.0±0.4	3.4±0.5	1.9±0.7	11.4±0.8	8.5±1.1	4.6±0.8	2.7±0.4
Benin-City	22.5±1.1	16.7±1.1	11.9±0.8	8.2±1.1	20.1±0.8	19.1±1.5	12.1±1.1	6.1±1.3
Oshogbo	12.4±0.7	8.7±0.7	6.0±0.1	4.5±0.8	9.8±0.4	6.5±0.8	5.3±0.5	3.6±0.7
Ewu	31.6±0.7	27.3±0.8	9.9±1.4	7.7±0.7	31.1±0.8	26.3±1.7	11.5±1.2	8.9±1.1
Ado	17.2±0.8	15.0±1.7	7.0±0.4	4.8±0.5	19.1±0.4	11.4±1.1	6.8±1.4	3.4±0.8
Port Harcourt	36.3±0.7	27.0±0.8	12.0±0.5	8.8±0.4	33.7±1.0	29.4±1.4	17.5±0.8	10.8±1.2
Yola	15.5±1.2	10.9±0.8	8.0±0.4	4.4±0.5	17.4±1.2	8.7±0.7	6.3±0.5	4.6±0.4

TABLE 3.
CHROMIUM CONCENTRATIONS (PPM) WITH ESTIMATED STANDARD DEVIATIONS OF SOIL SAMPLES ALONG ROADSIDES OF SEVEN STATE CAPITALS IN NIGERIA.

STATE	DISTANCE (METER) FROM LEFTSIDE OF THE ROAD.					DISTANCE (METER) FROM RIGHT SIDE OF THE ROAD.				
	1	5	10	15	1	5	10	15		
CAPITAL										
Bauchi	10.2±0.7	6.1±0.4	4.6±0.2	1.3 ±0.5	9.7±0.5	4.7±0.7	2.9±0.2	1.7±0.4		
Benin-City	15.4±0.6	13.2±0.2	5.1±0.5	2.9 ±0.6	14.4±0.6	12.5±0.3	4.8±0.2	1.4±0.3		
Calabar	19.3±0.7	14.9±0.6	3.9±0.5	2.2 ±0.4	17.1±0.5	15.4±0.6	2.8±0.4	1.5±0.2		
Enugu	21.6±0.4	13.9±0.4	3.9±0.9	1.1 ±0.4	18.9±0.7	10.8±0.8	6.0±0.6	1.5±0.2		
Ibadan	13.5±0.8	10.4±0.5	3.2±0.2	1.8 ±0.2	11.7±0.4	7.4±0.7	5.0±0.4	2.1±0.2		
Kaduna	13.5±0.8	10.4±0.5	3.2±0.2	1.8 ±0.2	11.7±0.4	7.4±0.7	5.0±0.4	2.1±0.2		
Port-Harcourt	10.5±0.5	5.6±0.6	2.9±0.6	0.69±0.2	9.5±0.3	7.0±0.7	3.5±0.2	1.3±0.3		
Yola	9.9±0.6	5.0±0.5	1.4±0.3	0.69±0.2	11.3±0.5	8.6±0.3	5.0±0.4	0.97±0.2		

TABLE 9.

AMOUNTS OF LEAD ($\mu\text{g g}^{-1}$) IN LEAF SAMPLES WITH
ESTIMATED STANDARD DEVIATIONS ALONG ROADSIDES
OF SEVEN STATE CAPITALS IN NIGERIA.

STATE CAPITAL	DISTANCE (METER) FROM LEFTSIDE OF ROAD		DISTANCE (METER) FROM RIGHTSIDE OF THE ROAD	
	2	20	2	20
Bauchi	22.9 \pm 3.9	10.8 \pm 2.7	31.9 \pm 2.8	12.3 \pm 1.4
Benin-City	47.4 \pm 7.5	29.4 \pm 4.0	57.2 \pm 4.9	20.4 \pm 4.6
Calabar	12.3 \pm 2.7	5.7 \pm 1.4	9.0 \pm 1.4	6.5 \pm 2.3
Enugu	39.2 \pm 5.2	19.6 \pm 4.0	45.8 \pm 9.0	25.3 \pm 3.6
Minna	16.9 \pm 2.7	7.3 \pm 1.4	22.6 \pm 2.3	7.3 \pm 1.4
PortHarcourt	44.3 \pm 3.5	32.3 \pm 2.3	52.4 \pm 4.8	36.3 \pm 2.8
Yola	29.4 \pm 3.9	12.3 \pm 1.4	28 \pm 1.5	12.5 \pm 1.1

TABLE 10.

AMOUNTS OF CADMIUM ($\mu\text{g g}^{-1}$) IN LEAF SAMPLES
WITH ESTIMATED STANDARD DEVIATIONS ALONG
ROADSIDES OF SEVEN STATE CAPITALS IN NIGERIA.

STATE CAPITAL	DISTANCE IN METER FROM LEFT SIDE OF ROAD		DISTANCE IN METER FROM RIGHT SIDE OF THE ROAD	
	2	20	2	20
Bauchi	2.3±0.1	0.62±0.1	1.3±0.3	0.9±0.3
Benin-City	5.4±0.3	3.6 ±0.1	4.2±0.3	0.8±0.3
Calabar	2.8±0.3	2.0 ±0.3	3.2±0.1	2.3±0.1
Enugu	5.0±0.4	1.4 ±0.3	5.8±0.3	4.6±0.6
Ninna	6.5±0.6	1.9 ±0.4	5.2±0.3	2.2±0.4
PortHarcourt	6.1±0.2	3.4 ±0.1	5.6±0.3	2.8±0.3
Yola	1.7±0.2	0.7 ±0.1	2.2±0.2	1.3±0.2

TABLE 11.

AMOUNTS OF NICKEL ($\mu\text{g g}^{-1}$) IN LEAF SAMPLES
WITH ESTIMATED STANDARD DEVIATIONS ALONG
ROADSIDES OF SEVEN STATE CAPITALS IN NIGERIA.

STATE CAPITAL	DISTANCE IN METER FROM LEFTSIDE OF ROAD.		DISTANCE IN METER FROM RIGHTSIDE OF THE ROAD.	
	2	20	2	20
Bauchi	1.0±0.2	0.4±0.1	1.3±0.1	0.3±0.1
Benin-City	2.4±0.8	4.1±0.4	2.0±0.4	1.7±0.4
Calebar	0.9±0.1	0.3±0.1	1.1±0.1	0.6±0.1
Enugu	4.6±0.4	0.7±0.4	5.3±0.6	1.1±0.4
Minna	0.6±0.1	0.3±0.1	1.0±0.4	0.2±0.2
PortHarcourt	2.0±0.1	0.9±0.1	1.4±0.1	0.6±0.1
Yola	4.1±0.9	3.8±0.8	3.1±0.8	3.6±0.8

TABLE 12.

AMOUNTS OF COPPER ($\mu\text{g g}^{-1}$) IN LEAF SAMPLES
WITH ESTIMATED STANDARD DEVIATIONS ALONG
ROADSIDES OF SEVEN STATE CAPITALS IN NIGERIA.

STATE CAPITAL	DISTANCE IN METER FROM LEFTSIDE OF ROAD.		DISTANCE IN METER FROM RIGHT SIDE OF THE ROAD	
	2	20	2	20
Bauchi	6.5±0.3	1.0±0.2	5.7±0.3	1.3±0.3
Benin-City	10.1±0.4	7.1±0.5	10.9±0.8	5.0±0.5
Calabar	7.4±0.2	4.1±0.3	4.1±0.3	3.8±0.3
Enugu	10.4±0.4	5.9±0.4	8.8±0.5	5.2±0.4
Minna	9.7±0.3	3.8±0.3	9.3±0.5	4.3±0.4
PortHarcourt	11.2±0.3	5.7±0.3	9.9±0.4	4.5±0.4
Yola	7.3±0.3	2.5±0.1	6.8±0.3	1.9±0.3

TABLE 13.

AMOUNTS OF CHROMIUM ($\mu\text{g g}^{-1}$) IN LEAF SAMPLES
WITH ESTIMATED STANDARD DEVIATIONS ALONG
ROADSIDES OF SEVEN STATE CAPITALS IN NIGERIA.

STATE CAPITAL	DISTANCE IN METER FROM LEFTSIDE OF THE ROAD.		DISTANCE IN METER FROM RIGHTSIDE OF THE ROAD.	
	2	20	2	20
Bauchi	3.0±0.3	2.2±0.4	4.0±0.8	1.4±0.3
Benin-City	6.1±0.4	3.3±0.7	6.7±0.8	3.8±0.7
Calabar	3.5±0.7	1.5±0.3	4.3±0.7	1.4±0.2
Enugu	6.0±0.6	3.4±0.4	5.0±0.8	2.8±0.4
Minna	3.5±0.5	2.1±0.2	3.9±0.7	2.0±0.2
PortHarcourt	6.8±0.8	3.1±0.2	6.3±0.7	2.0±0.2
Yola	6.4±0.5	2.9±0.2	5.6±0.4	1.9±0.3

TABLE 14.

AMOUNTS OF LEAD (μgL^{-1}) IN WATER SAMPLES WITH
ESTIMATED STANDARD DEVIATIONS ALONG ROADSIDES
OF SEVEN STATE CAPITALS IN NIGERIA.

STATE CAPITAL	DISTANCE IN METER FROM LEFTSIDE OF THE ROAD.		DISTANCE IN METER FROM RIGHTSIDE OF THE ROAD.	
	3	20	3	20
Bauchi	18.4 \pm 1.9	3.2 \pm 0.7	15.2 \pm 1.4	4.8 \pm 1.1
Benin-City	22.3 \pm 1.9	5.5 \pm 0.6	21.9 \pm 1.6	7.7 \pm 1.6
Calabar	25.8 \pm 0.9	6.8 \pm 1.4	28.7 \pm 0.6	4.2 \pm 0.6
Enugu	16.8 \pm 1.3	3.6 \pm 0.6	14.5 \pm 1.4	7.4 \pm 1.1
Minna	12.9 \pm 1.6	2.9 \pm 0.6	15.2 \pm 0.6	7.7 \pm 0.9
PortHarcourt	10.8 \pm 0.6	6.9 \pm 1.2	17.2 \pm 1.6	8.2 \pm 1.2
Yola	3.9 \pm 0.9	1.6 \pm 0.6	8.1 \pm 1.4	0.97 \pm 0.6

TABLE 15.

AMOUNTS OF CADMIUM (μgL^{-1}) IN WATER SAMPLES
WITH ESTIMATED STANDARD DEVIATIONS ALONG ROAD
SIDES OF SEVEN STATE CAPITAL IN NIGERIA.

STATE	DISTANCE (METER) FROM LEFTSIDE OF THE ROAD.		DISTANCE (METER) FROM RIGHTSIDE OF THE ROAD.	
	3	20	3	20
Bauchi	4.2 ± 0.4	2.4 ± 0.2	3.1 ± 0.3	2.1 ± 0.3
Benin-City	4.7 ± 0.4	1.8 ± 0.7	4.4 ± 0.7	2.0 ± 0.2
Calabar	2.1 ± 0.5	1.8 ± 0.3	3.4 ± 0.3	1.6 ± 0.5
Enugu	3.1 ± 0.5	1.3 ± 0.4	5.0 ± 0.7	3.2 ± 0.4
Minna	2.3 ± 0.6	1.9 ± 0.5	6.3 ± 0.2	1.0 ± 0.3
PortHarcourt	2.7 ± 0.5	0.9 ± 0.2	3.6 ± 0.8	1.8 ± 0.4
Yola	4.3 ± 0.5	1.4 ± 0.5	2.8 ± 0.5	1.4 ± 0.2

TABLE 16.

AMOUNTS OF NICKEL(μgL^{-1}) IN WATER SAMPLES WITH
ESTIMATED STANDARD DEVIATIONS ALONG ROADSIDES
OF SEVEN STATE CAPITALS IN NIGERIA.

STATE CAPITAL	DISTANCE IN METER FROM LEFTSIDE OF THE ROAD.		DISTANCE IN METER FROM RIGHTSIDE OF THE ROAD.	
	3	20	3	20
Bauchi	420.0 \pm 4.8	297.5 \pm 3.0	443.3 \pm 8.7	186.7 \pm 3.3
Benin-City	875.6 \pm 3.0	299.5 \pm 3.0	770.0 \pm 8.6	472.5 \pm 3.0
Calabar	455.0 \pm 6.1	140.0 \pm 5.0	350.0 \pm 5.0	122.8 \pm 5.8
Enugu	513.3 \pm 3.2	46.7 \pm 3.3	373.3 \pm 6.6	93.3 \pm 3.1
Minna	350.0 \pm 5.7	163.3 \pm 3.2	462.1 \pm 2.5	147.6 \pm 3.1
PortHarcourt	536.7 \pm 3.3	262.5 \pm 5.8	542.5 \pm 5.8	297.5 \pm 3.0
Yola	542.5 \pm 3.0	402.5 \pm 5.8	577.6 \pm 5.4	420.0 \pm 4.8

TABLE 17.

AMOUNTS OF COPPER (μgL^{-1}) IN WATER SAMPLES WITH
 ESTIMATED STANDARD DEVIATIONS ALONG ROADSIDES
 OF SEVEN STATE CAPITALS IN NIGERIA.

STATE	DISTANCE IN METER FROM LEFTSIDE OF THE ROAD.		DISTANCE IN METER FROM RIGHTSIDE OF THE ROAD.	
	3	20	3	20
Bauchi	47.1 \pm 4.3	21.4 \pm 4.3	40.7 \pm 7.1	15.0 \pm 3.7
Benin-City	62.1 \pm 3.7	25.7 \pm 6.1	53.6 \pm 9.3	38.6 \pm 4.3
Calabar	45.0 \pm 9.3	15.0 \pm 3.1	36.4 \pm 3.7	16.1 \pm 5.1
Enugu	57.9 \pm 7.1	32.1 \pm 3.7	49.3 \pm 7.1	21.4 \pm 4.3
Minna	47.1 \pm 4.3	36.4 \pm 3.1	45.0 \pm 3.7	21.4 \pm 4.3
PortHarcourt	66.4 \pm 3.7	23.7 \pm 7.1	68.6 \pm 6.1	15.0 \pm 3.7
Yola	23.8 \pm 3.7	10.7 \pm 3.2	32.1 \pm 3.5	12.9 \pm 4.1

TABLE 18.

AMOUNTS OF CHROMIUM (μgL^{-1}) IN WATER SAMPLES
WITH ESTIMATED STANDARD DEVIATIONS ALONG ROAD-
SIDES OF SEVEN STATE CAPITALS IN NIGERIA.

STATE CAPITAL	DISTANCE IN METER FROM LEFTSIDE OF THE ROAD.		DISTANCE IN METER FROM RIGHTSIDE OF THE ROAD.	
	3	20	3	20
Bauchi	4.1 \pm 0.3	1.3 \pm 0.3	5.0 \pm 0.2	0.69 \pm 0.1
Benin-City	2.1 \pm 0.1	1.2 \pm 0.2	2.4 \pm 0.3	1.3 \pm 0.2
Calabar	5.4 \pm 0.3	1.3 \pm 0.3	3.4 \pm 0.8	1.9 \pm 0.3
Enugu	1.1 \pm 0.2	0.60 \pm 0.1	1.9 \pm 0.3	0.87 \pm 0.1
Minna	1.1 \pm 0.2	0.41 \pm 0.2	0.96 \pm 0.1	0.46 \pm 0.1
PortHarcourt	5.5 \pm 0.3	1.7 \pm 0.3	4.4 \pm 0.2	1.7 \pm 0.2
Yola	3.2 \pm 0.2	1.3 \pm 0.2	3.8 \pm 0.2	2.3 \pm 0.4

CHAPTER FOUR

DISCUSSION OF RESULTS AND CONCLUSION

4-1 Correlation Between Estimated Daily Traffic Volume (EDTV) And Concentrations Of Heavy Metal Pollutants In Soil, Vegetation And Water Samples.

Tables 19-21 give the Pearson correlation coefficients of the estimated daily traffic volumes with the amounts of Lead, Cadmium, Nickel, Copper and Chromium in soil, vegetation and water samples from sides of some major roads in the seven state capitals. The correlation coefficients were tested for significance at 0.05 probability and $n-2$ degree of freedom (n = number of state capitals).

The concentrations of Lead, cadmium and copper in soil and vegetation samples show significant correlation with estimated daily traffic volume. Correlation coefficients for the concentrations of nickel in soil, chromium in vegetation and cadmium in water samples are also significant. However, amounts of Lead, nickel and chromium in water samples did not show significant correlation with EDTV. Similarly, concentrations of chromium in soil samples

show no significant correlation with EDTV.

The correlation coefficients would suggest that the bulk of lead, cadmium and copper in the environment along the roadside are of vehicular origin. Concentrations of nickel in soil and those of chromium in vegetation in the roadside environment also appear to be of vehicular origin. Nevertheless, contribution from other sources of Nickel and Chromium in the environment are probably more important.

TABLE 19 . CORRELATION OF ESTIMATED DAILY TRAFFIC VOLUMES WITH CONCENTRATIONS OF HEAVY METAL POLLUTANTS IN SOIL SAMPLES.

HEAVY METAL POLLUTANTS	CORRELATION COEFFICIENTS	CALCULATED t - VALUES	CRITICAL t - VALUE AT P = 0.05 AND n-2df	RELATIONSHIP
Pb	0 . 98	11 . 43	2 . 02	Significant
Cd	0 . 83	3 . 38	2 . 02	Significant
Ni	0 . 92	5 . 36	2 . 02	Significant
Cu	0 . 92	5 . 36	2 . 02	Significant
Cr	0 . 18	0 . 39	2 . 02	Not significant

TABLE 20 CORRELATION OF ESTIMATED DAILY TRAFFIC VOLUMES WITH CONCENTRATIONS OF HEAVY METAL POLLUTANTS IN VEGETATION SAMPLES.

HEAVY METAL POLLUTANTS	CORRELATION COEFFICIENTS	CALCULATED t - VALUES	CRITICAL t - VALUES AT P = 0.05 AND n-2df	RELATIONSHIP
Pb	0 . 95	7 . 01	2 . 02	Significant
Cd	0 . 72	2 . 56	2 . 02	Significant
Mn	0 . 30	0 . 71	2 . 02	Not Significant
Cu	0 . 83	3 . 36	2 . 02	Significant
Cr	0 . 66	2 . 09	2 . 02	Significant

TABLE 21 CORRELATION OF ESTIMATED DAILY TRAFFIC VOLUMES WITH CONCENTRATIONS OF HEAVY METAL POLLUTANTS IN WATER SAMPLES.

HEAVY METAL POLLUTANTS	CORRELATION COEFFICIENTS	CALCULATED t - VALUES	CRITICAL t - VALUES AT P = 0.05 AND n-2df	RELATIONSHIP
Pb	0 . 05	0 . 12	2 . 02	Not Significant
Cd	0 . 69	2 . 35	2 . 02	Significant
Ni	0 . 42	1 . 14	2 . 02	Not significant
Cu	0 . 80	2 . 98	2 . 02	Significant
Cr	0 . 04	0 . 08	2 . 02	Not significant

4-2 THE DISTRIBUTION OF HEAVY METAL TRAFFIC POLLUTANTS
IN SOIL AND VEGETATION SAMPLES ALONG ROADSIDES.

4-2.1 LEAD

As can be seen from tables 4,9,22, and 23 and figures 1 and 2, the amounts of lead in soil and vegetation samples decrease rapidly with increasing distance from the road in all the state capitals. The highest concentration of lead in soil is found at 1 meter from the road and this is reduced to background concentration at 15 meters from the road. These results are in agreement with the findings of Wheeler and Rolfe³ and Adediran²¹ and the observation that emitted lead from vehicle exhausts is generally not actively transported to long distances and levels are highest near the roads.²² Lead concentrations in soil samples are higher on the left side of the roads than on the right side for all the state capitals except Calabar and Yola. This is probably due to the wind direction along the different roads.²³ Local variation in natural concentration of Lead may also contribute.

The amounts of lead in vegetation samples as shown in tables 9 and 23 are generally lower than that found in soil samples, but decrease with increasing distance from the

road. Probably the amount of lead estimated from the leaf samples were derived from direct deposition from the atmosphere and absorption through the roots of the sample plants. Concentrations from the former are therefore likely to be affected by strong winds and by rain water. In addition, plants absorb metals only in its soluble form and there may be limited translocation to the shoots²⁴. These factors may probably account for the low concentrations of lead obtained from the leaf samples.

4-2.2 CADMIUM.

The distribution of cadmium in soil and vegetation samples along the roadsides as shown in figures 3 and 4, and tables 2, 6, 22, and 23, show similar trend as that of lead. The amounts of cadmium in soil samples are highest at 1 meter from the road and this is reduced to background levels at 15 meters. For example, in soil samples, Bauchi has cadmium concentration of $13.8 \mu\text{g g}^{-1}$ at 1 meter and this decreases to $3.2 \mu\text{g g}^{-1}$ at 15 meters away from the road. The same is true for the amounts of cadmium in vegetation and water samples. This probably suggests that cadmium concentrations along the roadsides

decrease with increasing distance from the road, which is in agreement with the findings of Lagerwerff and Pecht.⁴

4-2.3 NICKEL

The concentrations of nickel in soil samples as shown in figures 5 and 6, tables 3 and 22, also decrease with increasing distance from the road though not as consistent as that for cadmium. The amounts of nickel in vegetation samples show little or insignificant change with distance from the road. For example, Benin City has nickel concentrations of $2.2 \mu\text{g g}^{-1}$ in vegetation sample at 2 meters and $2.6 \mu\text{g g}^{-1}$ at 20 meters from the road; also in Yola, the nickel concentrations in vegetation samples are $3.6 \mu\text{g g}^{-1}$ at 2 meters and $3.7 \mu\text{g g}^{-1}$ at 20 meters from the road. This may probably be accounted for by an earlier suggestion that apart from direct absorption through the roots, the sample plants may also have derive the metals from the atmosphere. Wind direction and rain water may also be responsible for the aparent insignificant change in the distribution of nickel in vegetation samples.

4-2.4 COPPER

The distribution of copper in soil samples show a similar trend as that for Lead. The amounts of copper in the soil samples at 1, 5, 10 and 15 meters away from the road, as shown in figures 7 and 8 and tables 4, 9 and 22 indicate a decrease with increasing distance from the road. For example Bauchi has copper concentration of $10.4 \mu\text{g g}^{-1}$ at 1 meter and this decreased to $2.3 \mu\text{g g}^{-1}$ at 15 meters away from the road. The same is true for the vegetation samples as shown in tables 12 and 23.

4-2.5 CHROMIUM

The concentrations of chromium in the soil and vegetation samples show similar distributional trend as those for copper as shown in figures 9 and 10 tables 8, 13, 22 and 23. The amounts of chromium in the samples decrease with increasing distance from the road. Chromium concentrations in soil samples are higher on the left side than on the right side of the road for all the state capitals except Yola and PortHarcourt.

TABLE 22.
 AMOUNTS OF LEAD, CADMIUM, NICKEL, COPPER AND CHROMIUM
 (µg/g-1) IN SOIL SAMPLES WITH ESTIMATED DAILY TRAFFIC
 VOLUME IN THE SEVEN STATE CAPITALS.

STATE CAPITAL	DAILY TRAFFIC VOLUME	1 METER FROM ROAD					5 METERS FROM ROAD					10 METERS FROM ROAD					15 METERS FROM ROAD				
		Pb	Cd	Ni	Cu	Cr	Pb	Cd	Ni	Cu	Cr	Pb	Cd	Ni	Cu	Cr	Pb	Cd	Ni	Cu	Cr
Bauchi	12034	143.5	13.8	74.3	10.4	10.0	91.9	10.2	56.0	7.7	5.4	41.9	4.8	28.0	4.0	3.8	24.1	3.2	26.6	2.3	15
Benin City	43904	343.0	20.4	91.7	21.3	14.9	287.2	16.5	51.0	17.9	13.8	159.8	8.7	43.7	12.0	5.0	20.9	3.1	20.5	7.1	2.2
Calabar	13224	196.7	16.6	56.9	11.1	18.2	100	11.6	40.3	8.1	15.2	51.6	8.1	33.7	5.6	3.3	21.8	4.7	24.0	4.1	1.9
Enugu	22344	300.6	34.7	88.3	31.3	20.3	202.5	31.8	68.2	28.8	12.4	99.5	3.9	51.8	10.7	5.0	36.1	4.6	28.5	8.3	1.3
Minna	13968	227.4	19.5	71.9	18.1	12.6	66.9	14.3	35.9	13.2	8.9	31.4	8.2	22.7	6.9	4.1	13.6	3.7	15.6	4.1	2.0
Port Harcourt	25632	382.2	39.4	113.0	35.0	10.0	306.4	32.4	60.4	28.2	6.3	184.9	18.8	37.6	14.7	3.2	28.9	8.8	19.0	9.8	1.0
Yola	14448	101.6	15.2	73.8	16.4	10.6	103.2	11.9	47.4	47.4	9.8	441.9	6.2	28.4	7.20	3.2	22.5	3.2	25.1	4.5	0.83

TABLE 29. AMOUNTS OF LEAD, CADMIUM, NICKEL, COPPER AND CHROMIUM (µg g⁻¹) IN LEAF SAMPLES WITH ESTIMATED DAILY TRAFFIC VOLUME IN SEVEN STAFF CAPITALS IN NIGERIA.

STATE CAPITAL	ESTIMATED DAILY TRAFFIC VOLUME	2 METERS FROM ROAD					20 METERS FROM ROAD				
		Pb	Cd	Ni	Cu	Cr	Pb	Cd	Ni	Cu	Cr
Bauchi	12,984	27.4	1.0	1.1	6.1	4.0	11.5	0.76	0.8	11.2	1.8
Jerin-City	23,904	52.3	4.8	2.2	10.5	6.4	24.9	2.2	2.6	6.1	3.9
Calabar	13,224	10.7	3.0	1.0	7.6	3.9	6.1	2.7	0.8	4.0	1.5
Enugu	22,344	42.5	5.4	5.0	9.6	5.5	22.5	3.0	0.61	4.1	2.0
Port-Harcourt	25,632	48.4	5.9	1.7	10.6	6.6	34.3	3.1	0.96	5.1	2.6
Yola	14,448	28.7	2.0	3.6	7.1	6.1	20.2	1.0	3.9	2.2	2.4

4-3 THE DISTRIBUTION OF HEAVY METAL TRAFFICE POLLUTANTS
IN WATER SAMPLES ALONG ROADSIDE.

The amounts of Lead, Cadmium, Nickel, Copper and Chromium in the water samples are shown in tables 14 - 18. Their concentrations show a general decrease with increasing distance from the road.

The concentrations of cadmium, nickel and copper are much higher in the water samples than in the soil samples, while lead shows a decrease. While stagnant surface waters may receive metals by direct deposition from the atmosphere, additional sources of metal input to stagnant surface waters would be running water which flows into them, particularly during the rains. This would probably explain the enhanced metal concentrations in the water samples. While the heavier metal lead is most probably deposited at the bottom of the pools, the lighter metals, nickel, copper and cadmium could be held as suspended particles. An analysis of the sediments from the sampled pools might be informative in this regard.

TABLE 24.
AMOUNTS OF LEAD, CADMIUM, NICKEL, COPPER AND CHROMIUM
(µg/L-1) IN WATER SAMPLES WITH ESTIMATED DAILY TRAFFIC
VOLUME IN SEVEN STATE CAPITALS IN NIGERIA.

STATE CAPITAL	ESTIMATED DAILY TRAFFIC VOLUME.	2 METERS FROM ROAD.					20 METERS FROM ROAD.				
		Pb	Cd	Ni	Cu	Cr	Pb	Cd	Ni	Cu	Cr
Benue	12,984	16.8	3.7	431.7	43.9	4.6	4.0	2.3	242.9	18.2	1.0
Benin-city	23,904	22.1	4.5	822.8	57.9	2.3	6.6	1.9	386.0	32.2	1.3
Calabar	13,224	27.3	2.8	402.5	40.8	4.4	5.5	1.7	131.4	15.6	1.6
Enugu	22,344	15.7	4.1	443.0	53.6	1.5	5.5	2.3	20.0	26.8	0.7
Minna	13,968	14.1	4.3	406.0	46.1	1.0	5.3	1.5	155.5	28.9	0.4
North-Court.	25,632	14.0	3.7	539.0	67.5	5.0	7.6	1.4	280	19.4	1.7
Yola	14,448	6.0	3.5	472.4	27.9	3.5	1.3	1.4	411.0	11.8	2.3

4-4 ENVIRONMENTAL POLLUTION THAT MAY RESULT FROM
PRESENT LEVEL OF HEAVY METAL TRAFFIC POLLUTANTS.

Table 25 shows the threshold limits of some traffic pollutant heavy metals in the environment. From the results of this study as shown in tables 3 - 18, it will be seen that the amount of lead in soil and water samples in the seven state capitals is not high enough to cause environmental pollution. Cadmium, Copper and Chromium concentrations in water samples are also below the permissible thresholds. However, nickel concentrations in water samples exceed the specified limits in all the state capitals. The lead concentrations in vegetation samples in all the state capitals except Calabar exceed the specified limits. The levels of the other metals as found in the vegetation samples are generally below specified limits.

4-5. SUGGESTION FOR FURTHER RESEARCH

The following further studies are proposed:

- (1) Analysis of the amounts of traffic pollutant heavy metals which are airborne in urban areas,

TABLE 25

THRESHOLD LIMITS OF SOME HEAVY METALS IN
THE ENVIRONMENT*

METAL	Plants ($\mu\text{g g}^{-1}$)	Water ($\mu\text{g L}^{-1}$)	Soil ($\mu\text{g g}^{-1}$)
Pb	12 - 20	50	500**
Cd	-	5 - 10	-
Ni	10 - 12	30 - 40	-
Cu	10 - 15	100 - 200	-
Cr	10 - 12	150 - 200	-

*(WHO, 1971)

** (BINI, 1973)

- (ii) Analysis of the level of traffic pollutant heavy metals in mammals living adjacent to highways in Nigeria and
- (iii) Behavioural abnormalities consistent with the long term effects of traffic pollutant heavy metals.

4-6 CONCLUSION

Daily traffic volume shows a significant correlation with the distribution of heavy metal traffic pollutants except chromium in soil samples along the roadsides studied. This is in agreement with the findings of Lagerwerff and Specht⁴, Wheeler and Rolfe³, Motto et al¹ and Sing et al.⁷ However, their concentrations as obtained from this work do not appear to pose very serious environmental problem at the moment.

The distribution of Lead, Cadmium, Copper and Chromium in soil, vegetation and water samples decrease with increasing distance from the road. At about 15 meters from the road the amount of these metals are reduced to background levels. The distribution of nickel in vegetation samples does not show a consistent

decrease with increasing distance from the road.

Generally, effort should be made to control the release of these metals particularly lead, cadmium and nickel into the environment. This may become very necessary as the level of industrialisation in the country is raised and the number of vehicles plying our roads increase. The use of unleaded petrol seems a plausible option, but this must be balanced against the reduced octane number, modification of engine components to cope with the lower octane fuels and increased cost of producing alternative high octane fuels using aromatics and branched alkanes.²⁶ Already, the Kaduna refinery in Nigeria has started the use of aromatics and branched alkenes as anti-knock agents. Another option is the use of exhaust filters, which reduce the lead content of the exhausts, without a reduction of the lead content of the fuel.²⁷

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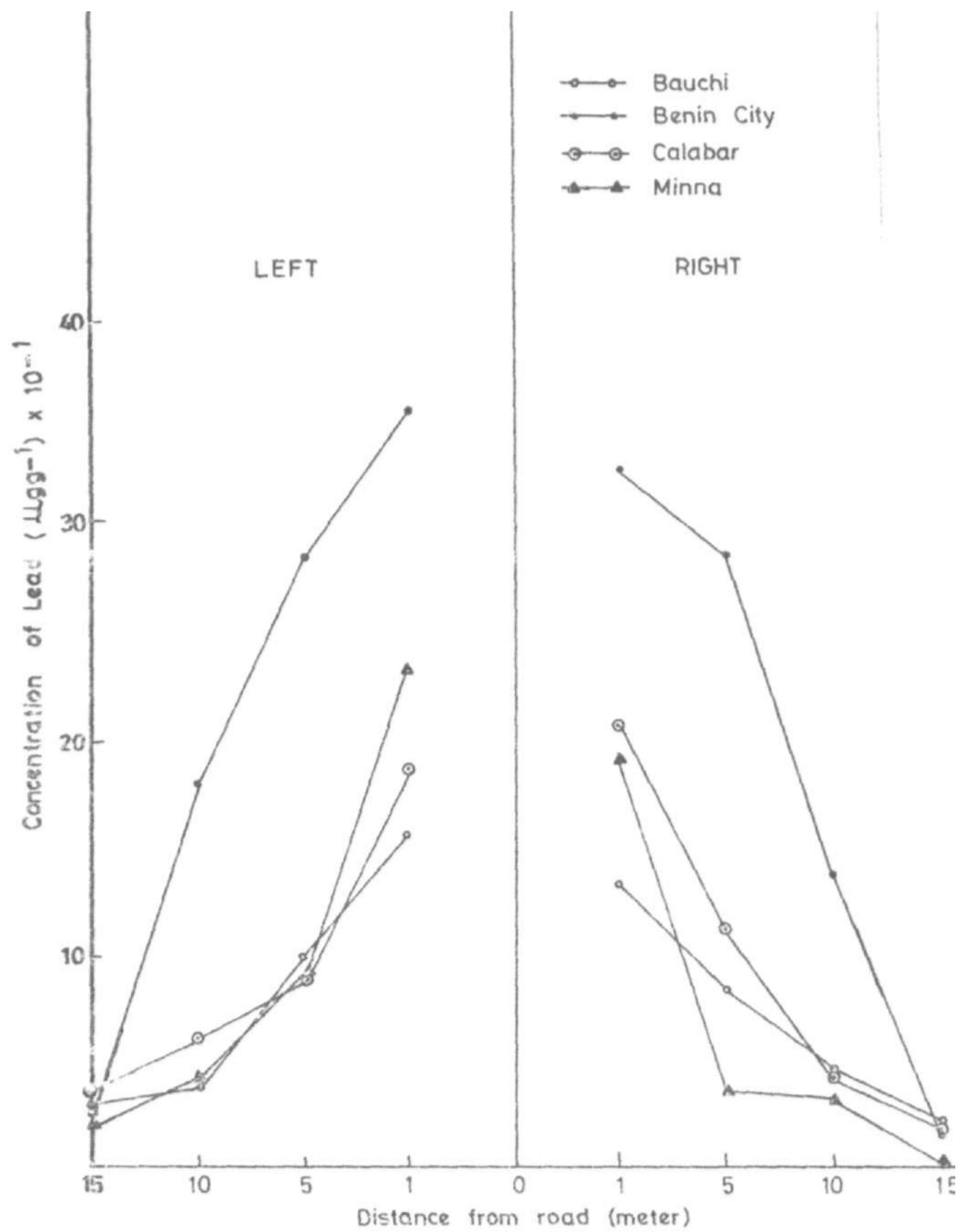


FIG. 1. DISTRIBUTION OF LEAD IN SOIL SAMPLES ALONG ROADSIDE IN FOUR STATE CAPITALS IN NIGERIA.

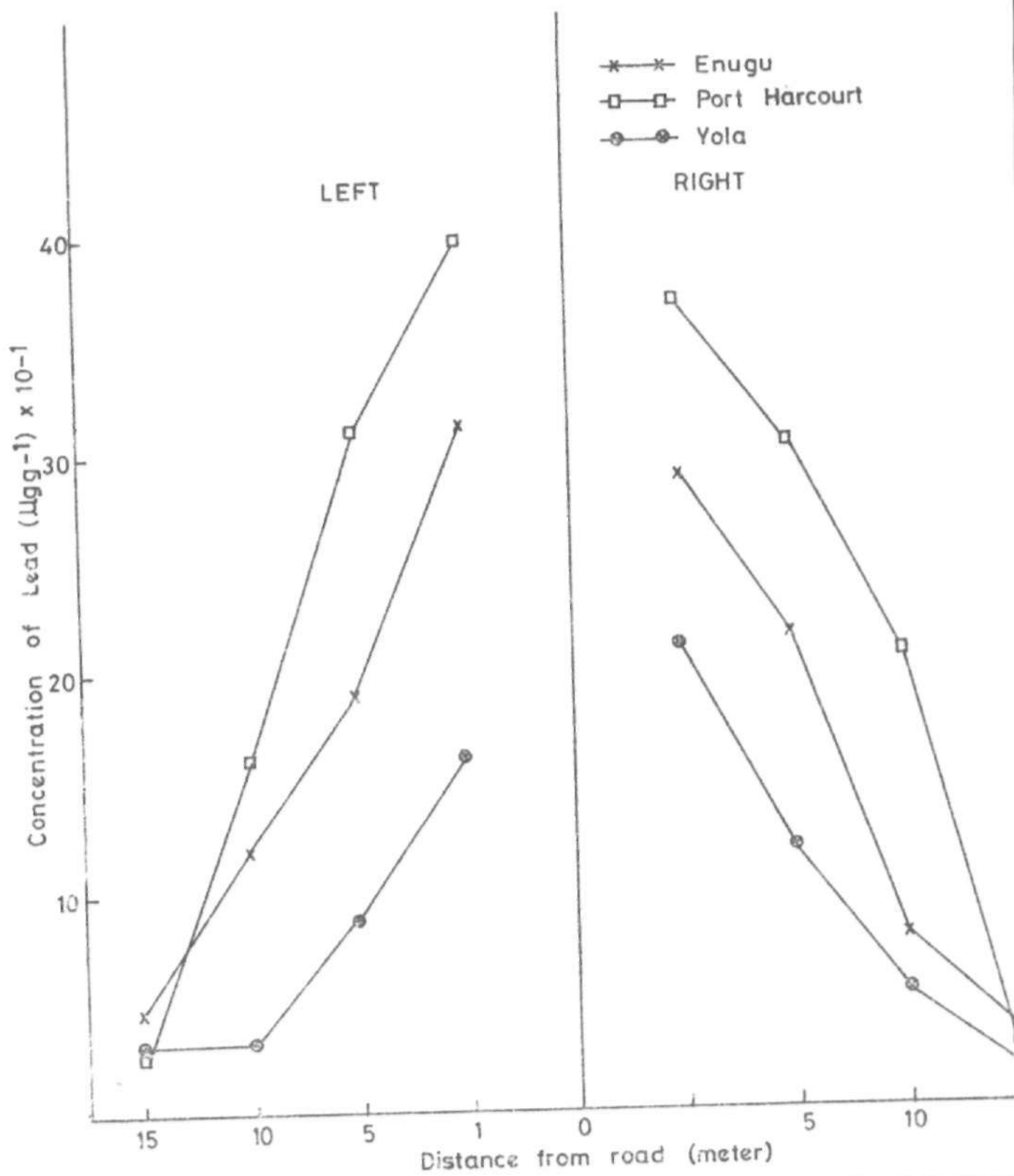


FIG. 2. DISTRIBUTION OF LEAD IN SOIL SAMPLES ALONG ROADSIDE IN THREE STATE CAPITALS IN NIGERIA.

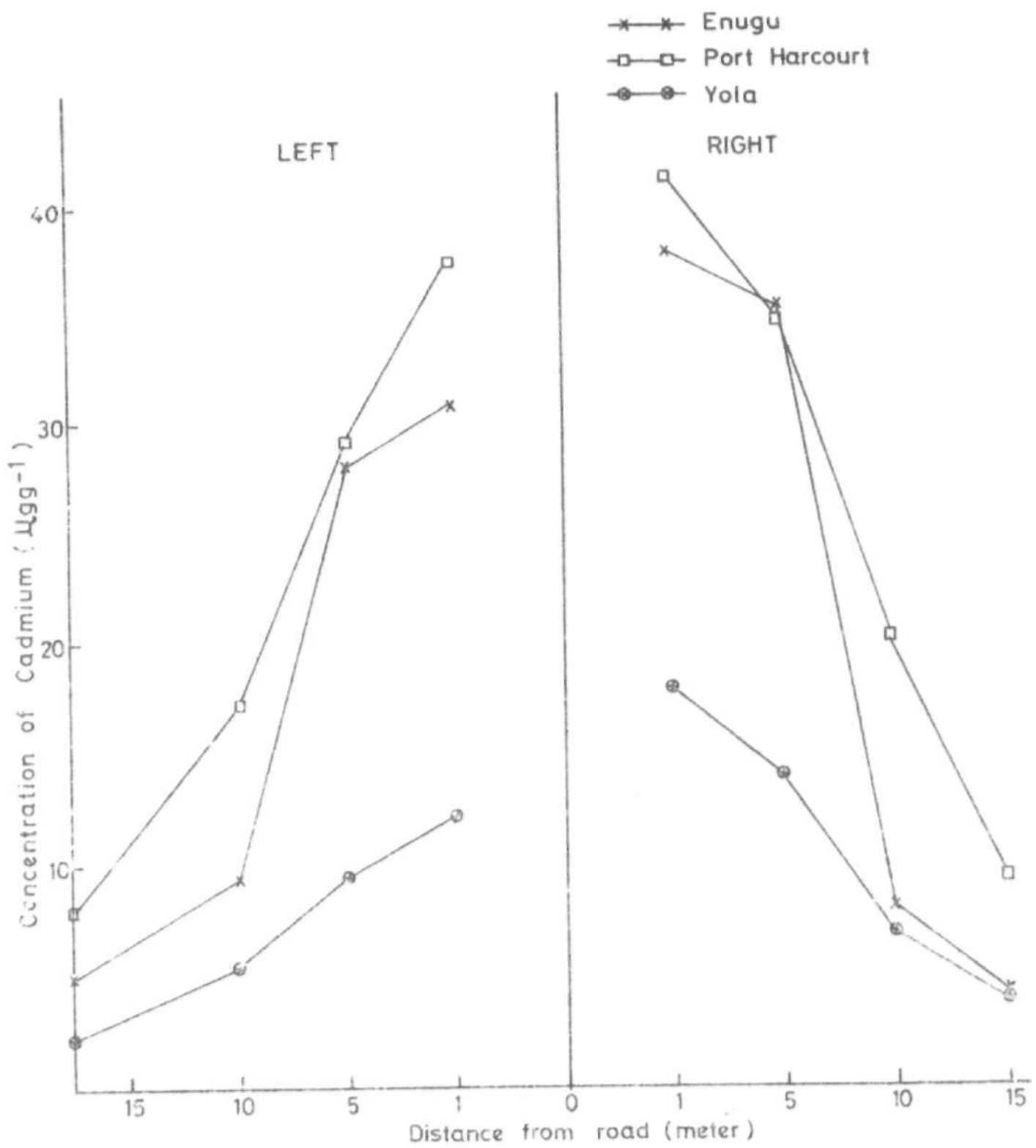


FIG.3. DISTRIBUTION OF CADMIUM IN SOIL SAMPLES ALONG ROADSIDE THREE STATE CAPITALS IN NIGERIA.

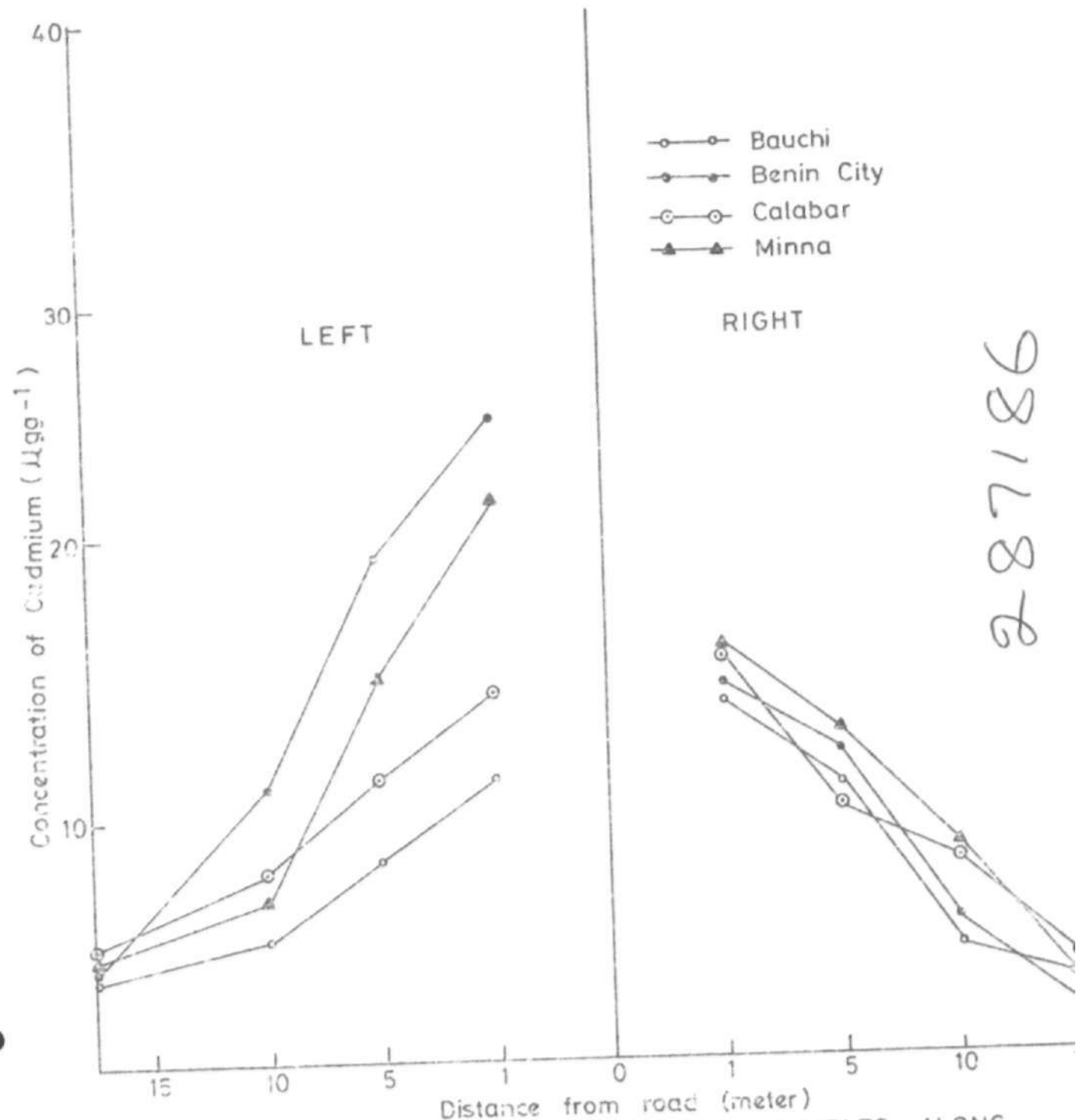


FIG. 4. DISTRIBUTION OF CADMIUM IN SOIL SAMPLES ALONG ROADSIDE IN FOUR STATE CAPITALS IN NIGERIA.

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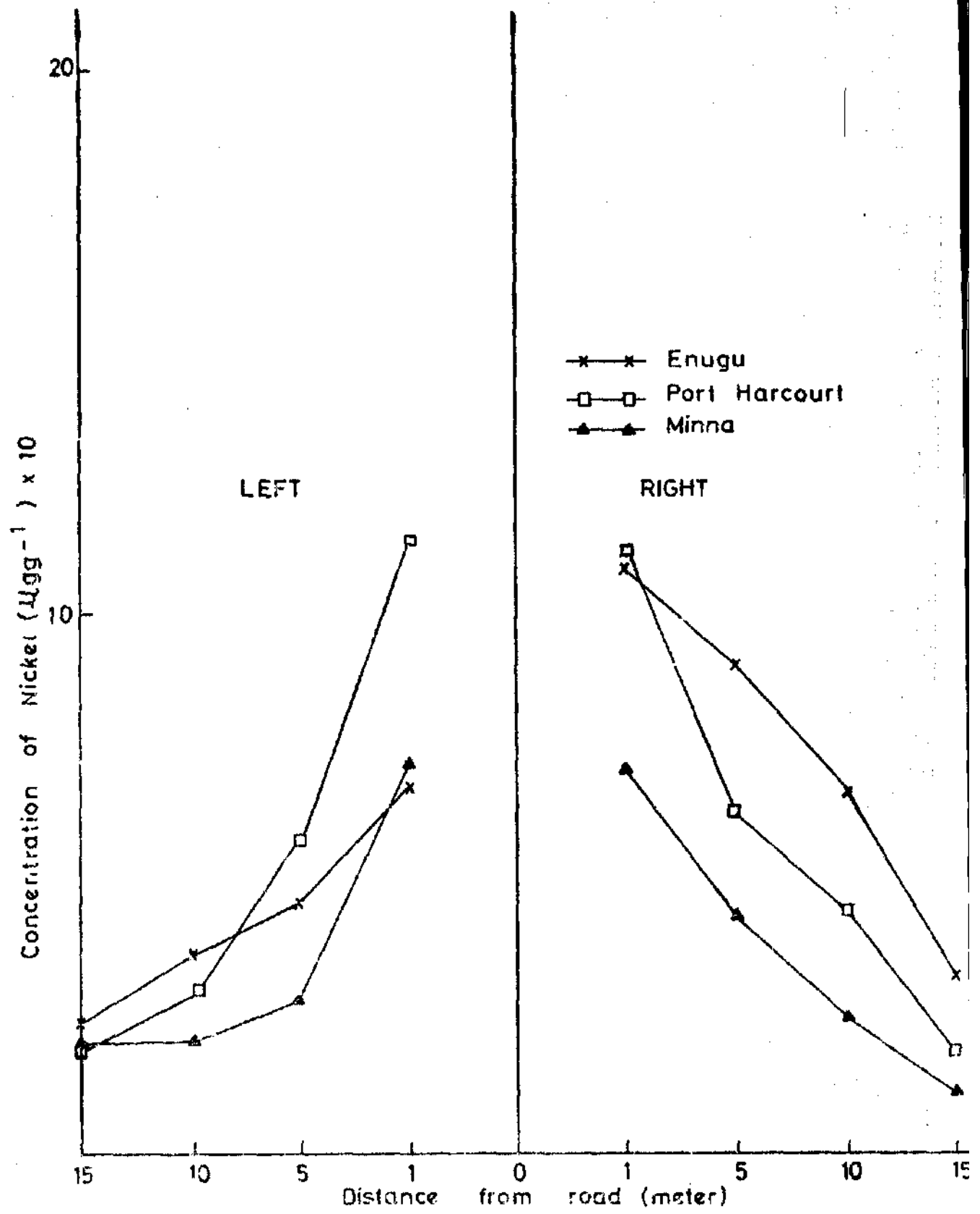


FIG.5. DISTRIBUTION OF NICKEL IN SOIL SAMPLES ALONG ROADSIDE OF THREE STATE CAPITALS IN NIGERIA.

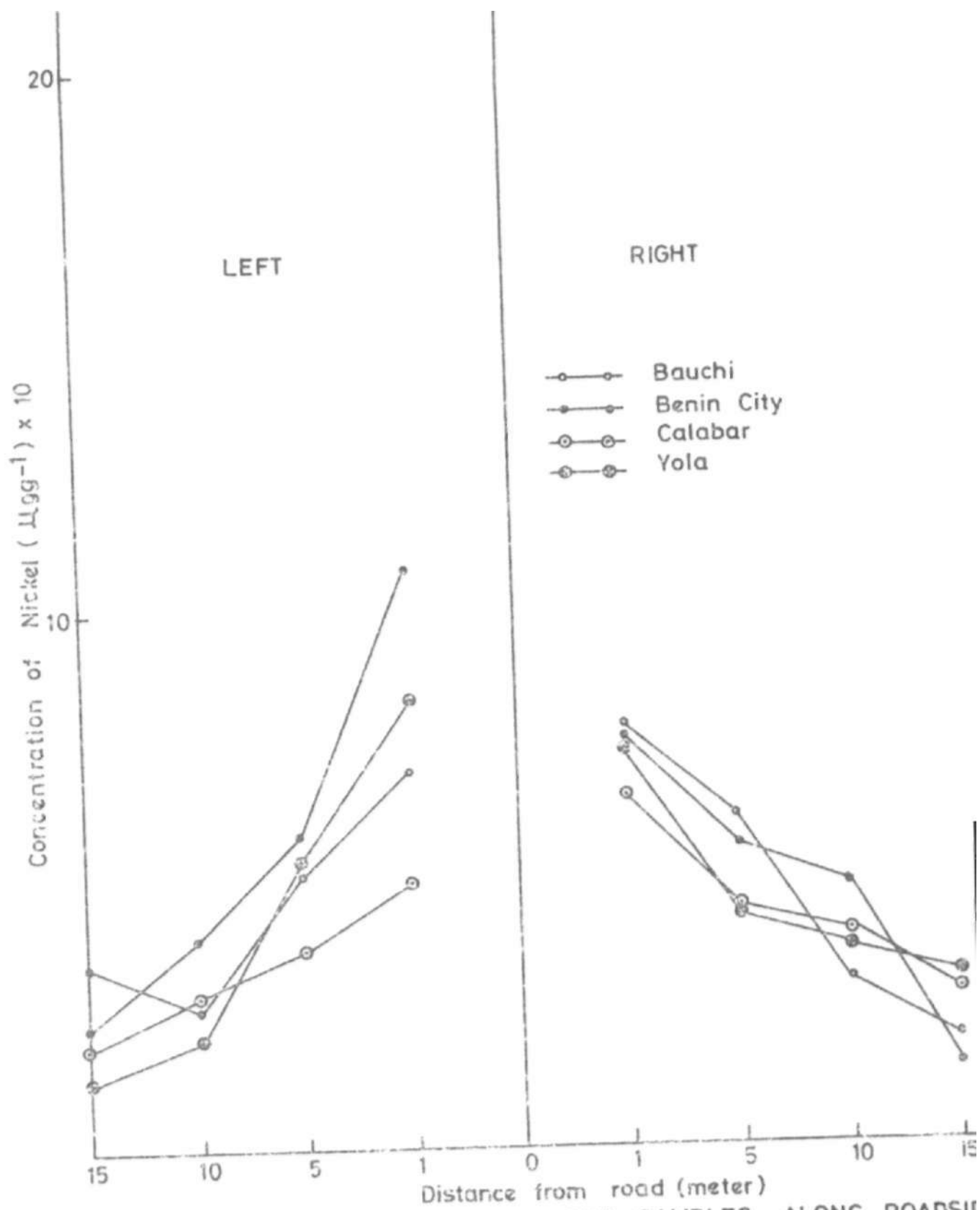


FIG.6. DISTRIBUTION OF NICKEL IN SOIL SAMPLES ALONG ROADSII OF FOUR STATE CAPITALS IN NIGERIA.

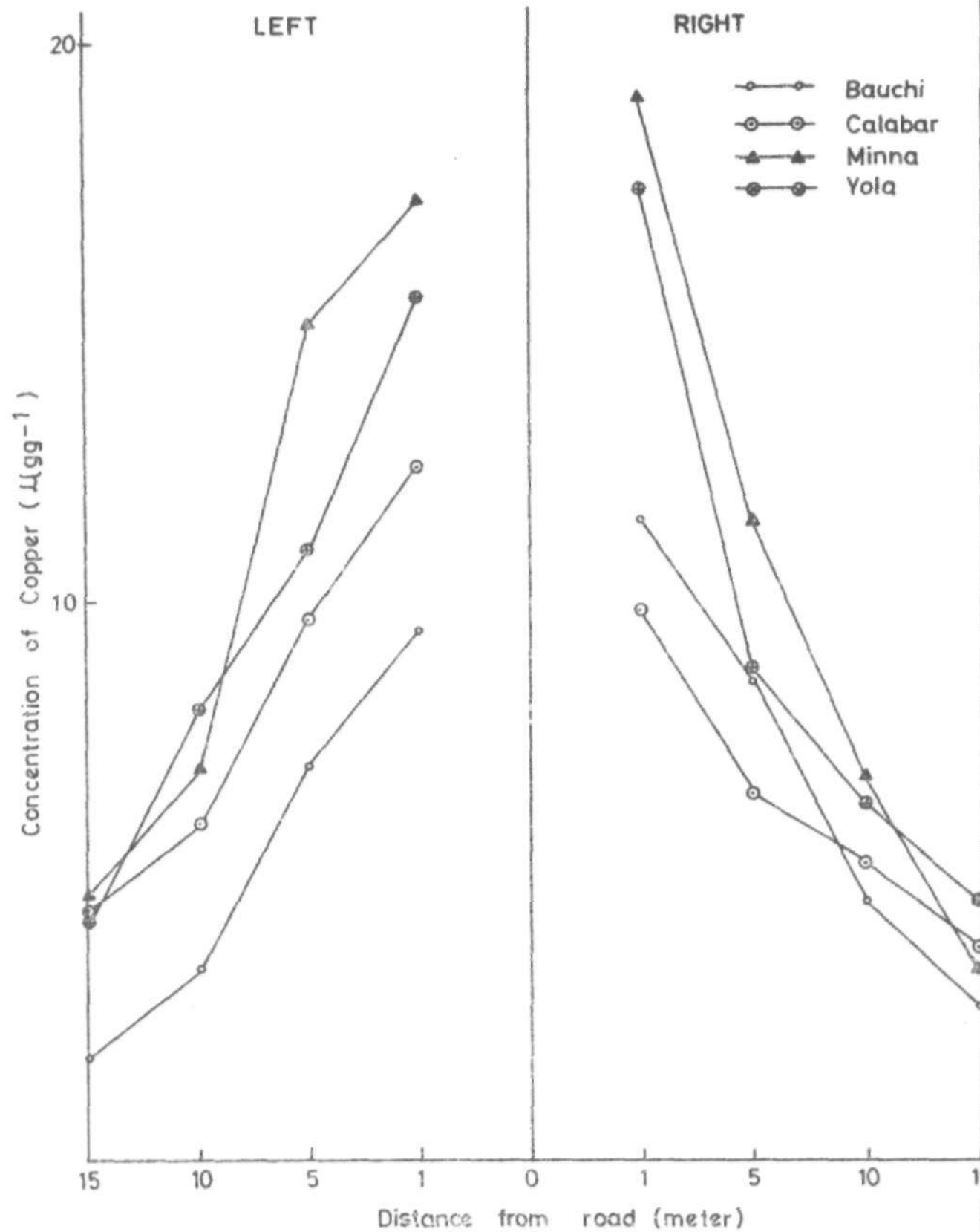


FIG.7. DISTRIBUTION OF COPPER IN SOIL SAMPLES ALONG ROADSIDE IN FOUR STATE IN NIGERIA.

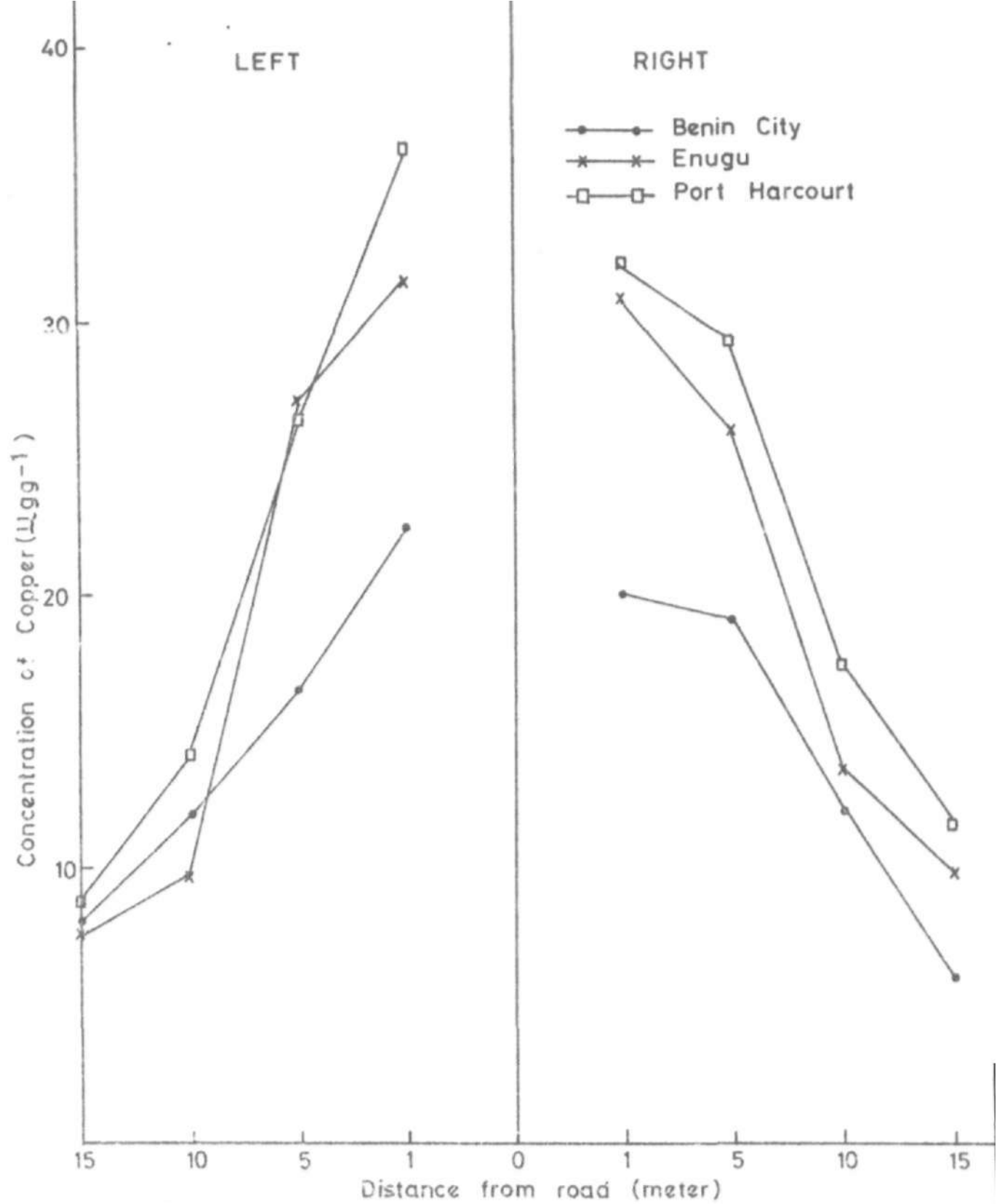


FIG.8. DISTRIBUTION OF COPPER IN SOIL SAMPLES ALONG ROADSIDE IN THREE STATE CAPITALS IN NIGERIA.

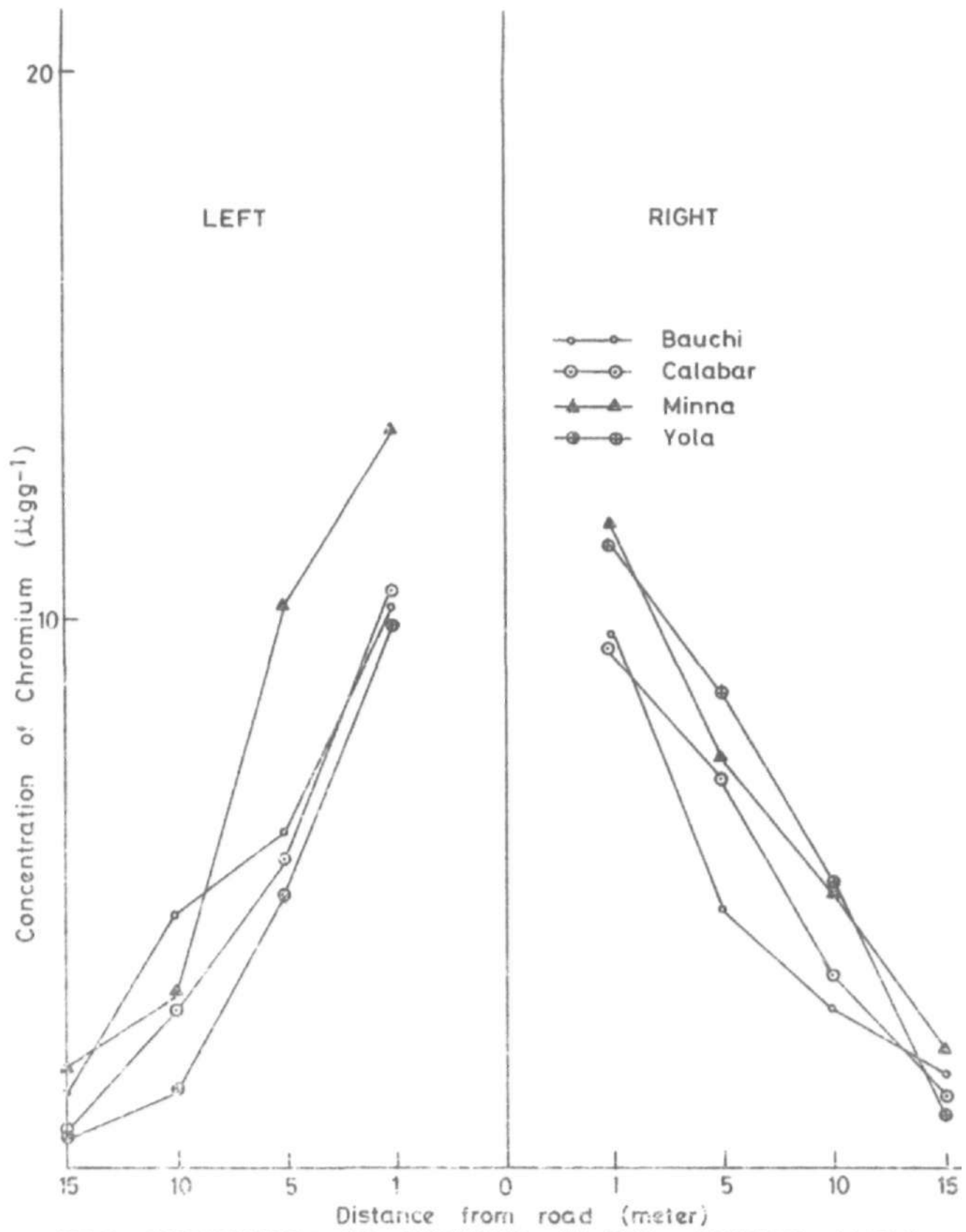


FIG. 9. DISTRIBUTION OF CHROMIUM IN SOIL SAMPLES ALONG ROADSIDE IN FOUR STATE CAPITALS IN NIGERIA

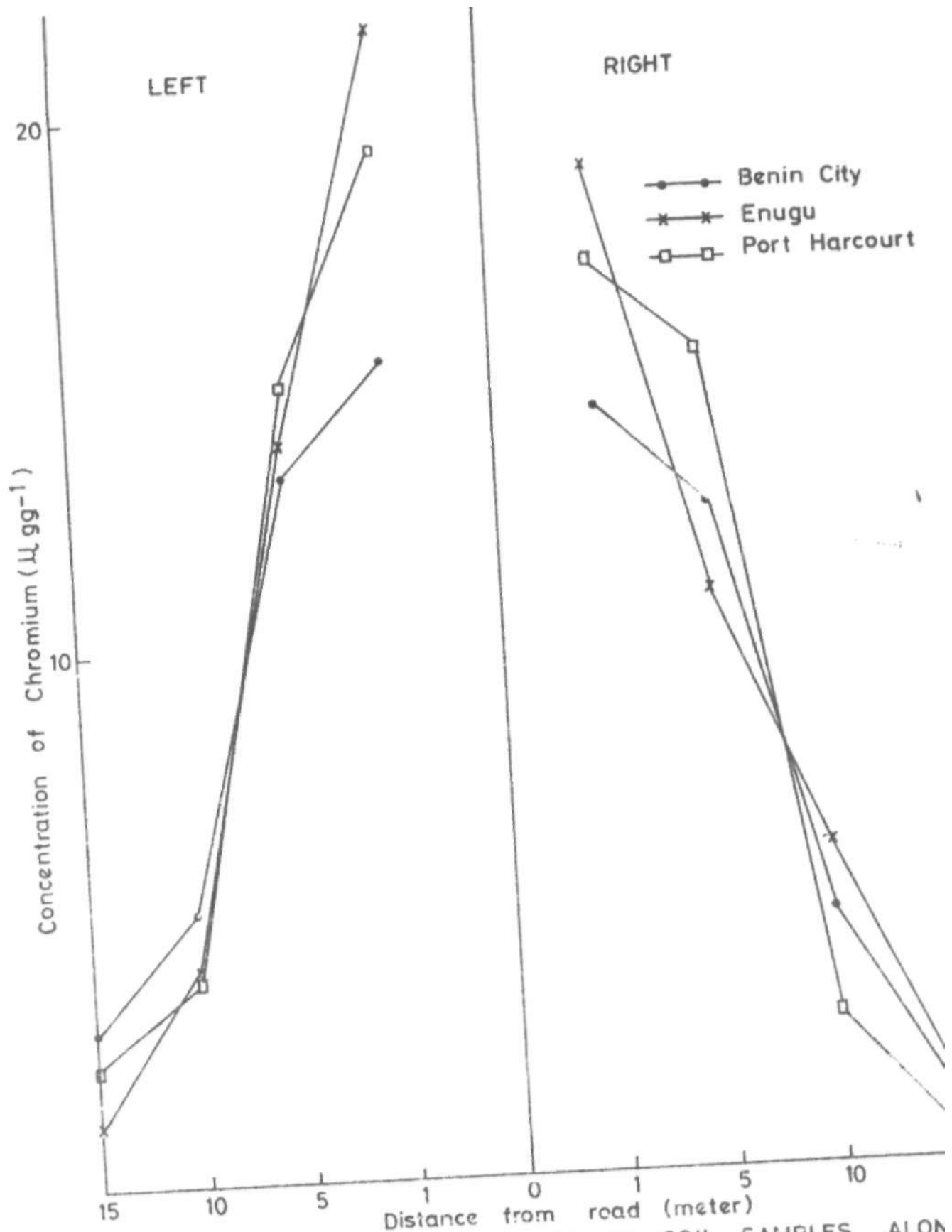


FIG. 10. DISTRIBUTION OF CHROMIUM IN SOIL SAMPLES ALONG ROADSIDE IN THREE STATE CAPITALS IN NIGERIA.