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Health Risk Assessment for safety of soils and vegetables around Isolo dumpsite, City of Lagos

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Abstract

esearch has been on the role of waste on heavy metal contamination in the nvironment and its implications on soil s. Soils were sampled in and around Isolo , Lagos, South-western, Nigeria. Various ere also collected including okro (Hibiscus s), Ewedu (Corchorus Olitorus), Soko Argentea), Water Leaf and African Analysis by Inductively Coupled Plasma mission Spectrometry (ICP-OES) the metals Cd, Cr, Cu, Zn, Ni and Pb. ations of heavy metals in soils decreased ially with distance from the dumpsite due sion by water and topography. Heavy llow the order Zn>Pb>Cr>Cu>Ni>Cd in les.

r of the heavy metal content in the different es was Zn>Cu>Cr>Ni>Pb>Cd except Spinach and okro which had the following : Zn>Ni>Cr>Cu>Pb>Cd and Pb>Cr>Cu>Cd respectively.

der for the heavy metal enrichment coefficients was Zn > Cu > Ni > Cd > Cr for all the vegetables. The calculated PI (Pollution Index) value for Zn, C.., Pb, Cd, Cu and Ni exceeded 1 except Cr which was less than 1 and followed the order of Ni>Cd>Pb>Zn>Cu>Cr. This confirmed the fact that these vegetables are highly polluted and not safe for consumption. It is concluded that the total concentrations of trace elements in soil and pH are the main factors influencing metal contents.

Keywords: Vegetables, Heavy metals, Soil, Pollution, Lagos

Introduction

Lagos is one of the mega cities in Africa with a very large population (about 9.3 millions, Census, 2006). Over 50% of Nigeria's industrial activities including 300 industries in 12 industrial Estates are located in the Lagos area. The continuous increase in population and industrial growth in Lagos persistently cause large volume of waste to be generated (about 10,000 tons per day) (Oresanya, 2000). Disposal of waste in landfills is an integral part of waste management strategies around the world. The production of leachate as a by-product of organic and inorganic decomposition in landfills poses a serious threat if such leachate is released to the environment (Kimmel and Braids 1974; Baedecker and Back 1979; Arneth et al.1989; Jankowski 1997; Odukoya 2007). Because of the increase in human population, polluted soils in the waste disposal sites are still used to produce foods such as vegetables of which consumption can lead to potential negative impacts on the health of the residents. The accumulation of trace elements such as Cd, Pb, Cu, Cr, Ni and Zn through the food chain in soils and vegetables affected by waste disposal sites may ultimately affect human health.

The Isolo waste disposal site is situated at the northern part of Lagos metropolis South western Nigeria and sited very close to a big canal (Isolo) (Fig 1) which normally overflows its banks during rainy season. Also adjacent to this waste dumpsite is Isolo Local Government Primary Health Centre (PHC). A greater percentage of the waste deposited here is domestic wastes. However, the site has been abandoned for more than ten years and therefore no more an active dumpsite.

The purpose of this study is thus to assess the risk of abnormal trace elements concentration in the vegetables around Isolo dumpsites.

Materials and Methods

Samples of soils were taken within the depth of 0-10cm and Vegetables were collected at ten sites (1-10) and different distances from the waste disposal site. The soil and vegetables were collected from the same site. Six edible vegetables (*Corchorus ditorus Celosia Argentea, Talinum Triangulare, Hibiscus Esculentus and African Spinach* were collected within the dumpsite to compare their uptake and accumulation of heavy metals. Soil samples were stored in sample bags and later air dried in the Laboratory. The already air-dried samples were disaggregated in a porcelain mortal and later sieved through a 2.0mm polyethylene sieve to obtain a <63um clay fraction for analysis..

Vegetable samples were harvested at the same stage of growth for comparison. Leaves that were contaminated with dust, damaged by insects or mechanically damaged were removed. Fresh samples were thoroughly washed with de-ionized water and later transferred to the laboratory where they were cut into small pieces and oven dried at 65° C for 48 hours and ground to pass through a 1-mm sieve.

Soil pH was determined using a Beckman pH meter while the following trace elements, Pb, Zn, Cr, Cd, Ni and Cu were determined in both soil and vegetables using Atomic Absorption Spectrometry.

Data Evaluation

The Average Shale Concentration (Turekian and

Wedepohl, 1964 and Wedpohl. 1971)) and the Chinese National Food Sanitation Standards of Heavy Metals (Table 1) were adopted to assess risks of heavy metals in soils and vegetables (Li & Sang 2000; Huang et al. 1999 in J. Li et al., 2006). These standards were used because there was no local standard available.

Results and Discussion

Concentration of trace elements in both soils and vegetables in the study area are shown in Tables 2 and 3 while the Chinese National Food Sanitation Standards of Heavy Metals are shown in Table1.The trace elements followed the following trends (Zn>Pb>Cr>Cu>Ni>Cd and Zn>Cu>Cd>Ni>Cr>Pb) in both soil and vegetables respectively (Fig 3). Concentration of Zn and Cu were higher than others in the vegetables because they are essential for all the vegetables. Ewedu (Corchorus ditorus) had the highest concentrations of Cu, Ni, Cr and Pb while Zn and Cd were highest in Soko (Celosia Argentea) (Fig 4).

Metal concentration in soil samples

Table 2 shows different concentrations of heavy metals in the soil samples according to distance within and away the dumpsite alongside with the Crustal Average (Turekian and Wedepohl, 1964 and Wedepohl, 1971). All the analyzed metals occur in relatively high concentrations compared to the vegetables.

Zn was the most abundant trace elements in soil samples its values ranged from 36 to 558ppm (av 157). The values for the other elements ranged as follows Cr (42-89ppm). Pb (30-379ppm); Cd (0.7-1.8ppm) Ni (13-33ppm) and Cu (16-70ppm). Heavy metals followed the order Zn>Pb>Cr>Cu>Ni>Cd (Table 2 and Fig 3). The concentration of heavy metals in the soil were inversely proportional to the distance from the dumpsite. Since the dumpsite has a long history, due to weathering all the metals in the soil were above Crustal Average (Taylor 1964) for soil except Cr. The concentration of Cu, Pb, Cd and Zn were 40, 10, 5 and 5 times higher than the permitted standard respectively. Therefore the soil is not suitable for farming. The soil samples taken within the dumpsite also show higher concentration for all the metals compared to those taken away from the site.

Heavy metal concentration in different vegetables

The content of heavy metals in the Ewedu, Soko, Okro and Spinach grown in the polluted soils are listed in Table 3. The order of the heavy metal content in the different vegetables was Zn>Cu>Cr>Ni>Pb>Cd except African Spinach and okro which has the following order Zn>Ni>Cr>Cu>Pb>Cd and Zn>Ni>Pb>Cr>Cu>Cd respectively.

The result showed that different plant genotypes have different cumulative capacity of heavy metals. Most of the heavy metals showed highest concentration in Ewedu except Zn and Cd which showed highest concentration in Seko while the lowest concentrations were seen in Okro for (Cu, Cr), African Spinach (Zn, Ni, Pb) and water leaf (Cd) (Fig 4).

The concentrations of heavy metals in the vegetables were positively proportional to the content of heavy metal in the soil and inversely proportional to the distance from the dumpsite (Fig 6)

Enrichment Coefficient of heavy metals in vegetables

Heavy metals have different accumulation and enrichment capacities in different vegetable species. Enrichment coefficients (Wang & Bai 1994) were calculated to determine the quality of the soil and vegetables within and around the dumpsite. The metal enrichment coefficients were calculated as follows;

Coefficient from soil to the vegetable = vegetable concentration / soil concentration x 100%.

All the vegetable species accumulatec Zn easily with the least enrichment of 45% found in African Spinach. Generally all the vegetables accumulated other heavy metals lower than 30% except for *Hibiscus Esculentus* and *Celosia Argentea* with the enrichment of Cd and Cu slightly higher than 30% respectively. The order for the heavy metal enrichment coefficients was as follows for all the vegetables:

Zn > Cu > Ni > Cd > Cr > Pb (Fig 5).

Quality assessment for soils and vegetables in the study area

Vegetables are very important to human health and there is a need to take serious the quality of food that we eat. Heavy metals can be accumulated in the body through the dietary intake of foods such as vegetables. Long term daily intake of these vegetables may be hazardous to human health; it is therefore pertinent to monitor the concentration of these metals in the vegetable.

To access the quality of soil in the study area as regards its suitability for agricultural uses Pollution Index (PI) which assess the environmental risk caused by the contaminated soils was used. Pollution index can be calculated using the following formula (Li et al., 2003):

$$Pi = Ci / Si$$

Where Pi = environmental quality index for heavy metal i

Ci = heavy metal content in a soil sample (ppm) and

Si = Maximum Permissible concentration of the same metal in soil

The calculated Pi value for Zn, Cu, Pb, Cd, Cu, Ni in Fig 6 exceeded 1 except Cr which was less than 1 for some samples far away from the dumpsite and followed the order of Ni>Cd>Pb>Zn>Cu>Cr. Fig 7.This shows that the soil were highly polluted and are not safe for farming.

The PI was also calculated for vegetables using the same formula above where

Pi = environmental quality index for heavy metal i

Ci = heavy metal content in Vegetable (ppm)

and

Si = Maximum Permissible concentration of the same metal in vegeta

The calculated PI values were above 1 for all the metals in the vegetables (Fig 8) which shows that they are highly polluted and not fit for consumption.

Conclusion

In this study area, both soils and plants have been contaminated by wastes from the dumpsite. Elevated concentrations of metals were found in surface soils around the dumpsite. Metal concentration in vegetables varied between plant species. Thus the regular consumptions of these vegetables could pose a potential health problem from long term metal exposure though health data have not yet been collected. The main factor responsible for the metal uptake into the vegetables studied is the total metal concentration in the surface soils which correlated positively with the metal concentrations in plants. It is concluded that high levels of heavy metals in soils around the dumpsite from the wastes will continuously migrate and disperse into lower land. As a consequence, soils and plants in the vicinity of dumpsite will be contaminated except there is introduction of environmental reclamation techniques to reduce heavy metal concentrations.

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Table 1: Chinese National Food Sanitation Standards for Heavy metals (Dry weight ppm (China National Standards Management Department GB documents.

Element	Standard Limit (ppm)	Standard Origin
Cd	? 0.05	Food sanitation standard of Cd (GB15201-94)
Cr	? 0.5	Food sanitation standard of Cr (GB14961-94)
Cu	? 10.0	Food sanitation standard of Cu (GB15199-94)
Pb	? 0.2	Food sanitation standard of Pb (GB14935-94)
Zn	? 20.0	Food sanitation standard of Zn (GB13106-94)

Table 2: Concentration of Heavy Metals in Soil Samples within Isolo Dumpsite

Soil Samples	Zn	Cr	Cu	Ni	Pb	Cd
	ppm	ppm	Ppm	ppm	ppm	ppm
S1	558	89	86	33	379	25.8
S2	139	81	55	24	223	8.06
S3	191	63	70	20	162	3.56
S4	145	42	49	22	88	12.4
S5	139	64	26	18	126	18.5
S6	151	78	43	24	102	8.6
S7	132	67	39	24	33	10.2
S8	105	59	25	24	23	3.65
S9	78.5	59	16	13	30	10.2
Range	36-558	42-89	16-70	13-33	30-379	0.7-1.8
Mean	157.33	66.56	45.44	22.44	130.11	1.22
St.dev.	159.08	14.16	22.53	5.43	114.05	0.36
*Crustal Average	70	100	50	75	12.5	0.15

* Turekian and Wedepohl 1964

Table 3: Concentration of Heavy metals in Vegetables within Isolo Dumpsite

Vegetable samples	pH	Cu	Zn	Ni	Cr	Cd	Pb
		ppm	Ppm	ppm	ppm	ppm	ppm
Corchorus ditorus (Ewedu)	5.11	39.63	123.5	6.5	8.26	1.2	4.23
Corchorus ditorus (Ewedu)	4.86	38.94	120.4	6.4	6.81	1.5	4.33
Celosia Argentea (Soko)	5.01	23.45	130.9	3.74	3.83	1.8	3.96
Celosia Argentea (Soko)	5.12	15.24	102.4	5.6	4.2	1.3	2.34
Talinum Triangulare (Water leaf)	5.14	17.12	65.4	4.47	5.2	0.7	3.92
Talinum Triangulare (Water leaf)	4.76	12.34	98.6	4.6	3.6	0.7	3.46
Hibiscus Esculentus (Okro)	4.88	1.47	54.6	3.7	4.6	1.2	1.21
Hibiscus Esculentus (Okro)	5.21	2.04	98.6	4.8	2.6	1.5	2.78
African Spinach	4.98	2.34	36	3.65	3.4	1.1	1.12
Range	4.76-5.21	2.34-39.63	54.6-130.9	3.65-6.5	2.6-8.26	3.65-25.8	1.12-4.33
Mean	5.01	18.06	93.6	4.83	4.77	11.22	3.03
std dev	0.15	15.18	28.06	1.11	1.8	7.09	1.26

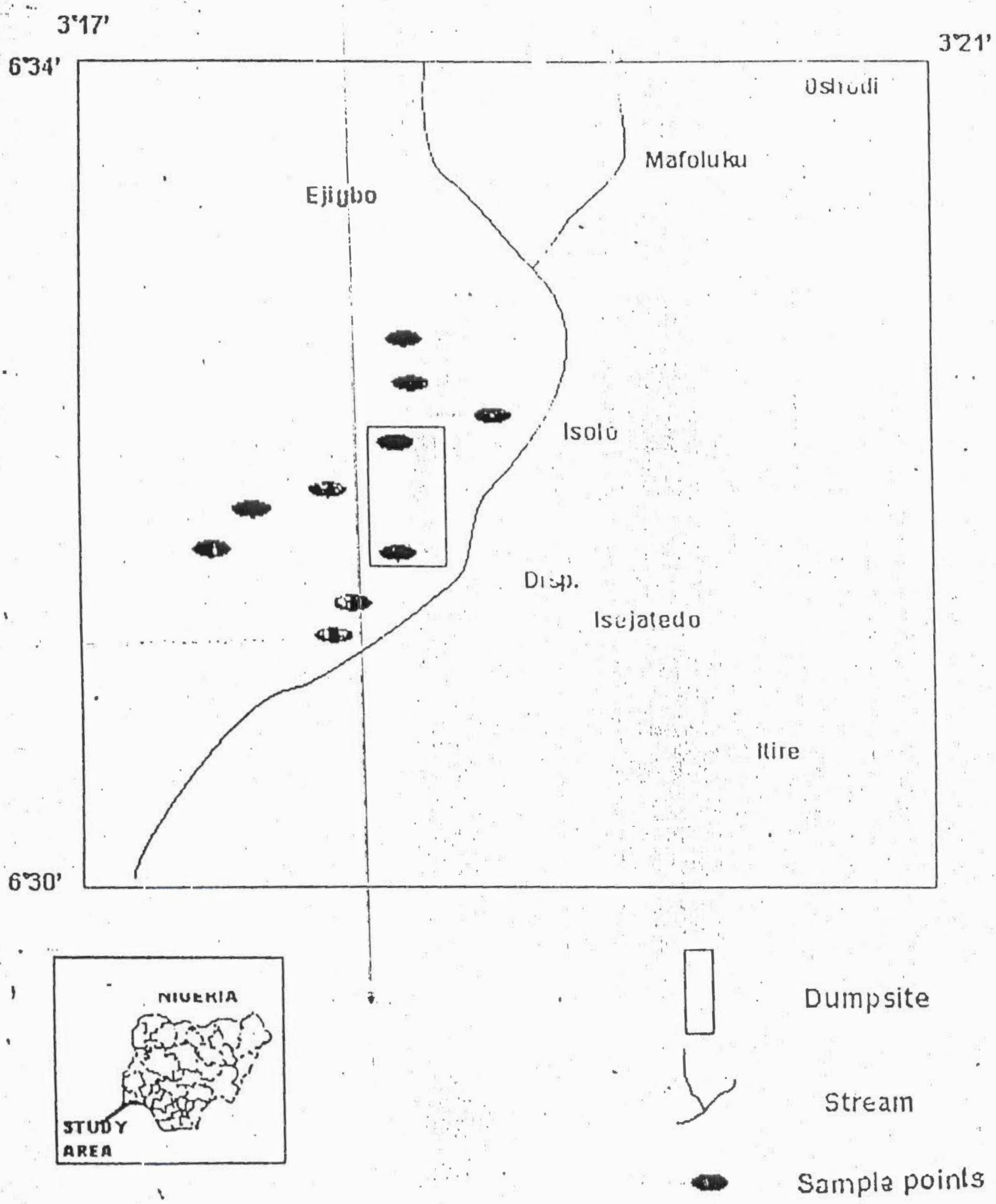


Fig 1: Map showing the study area and the sample points

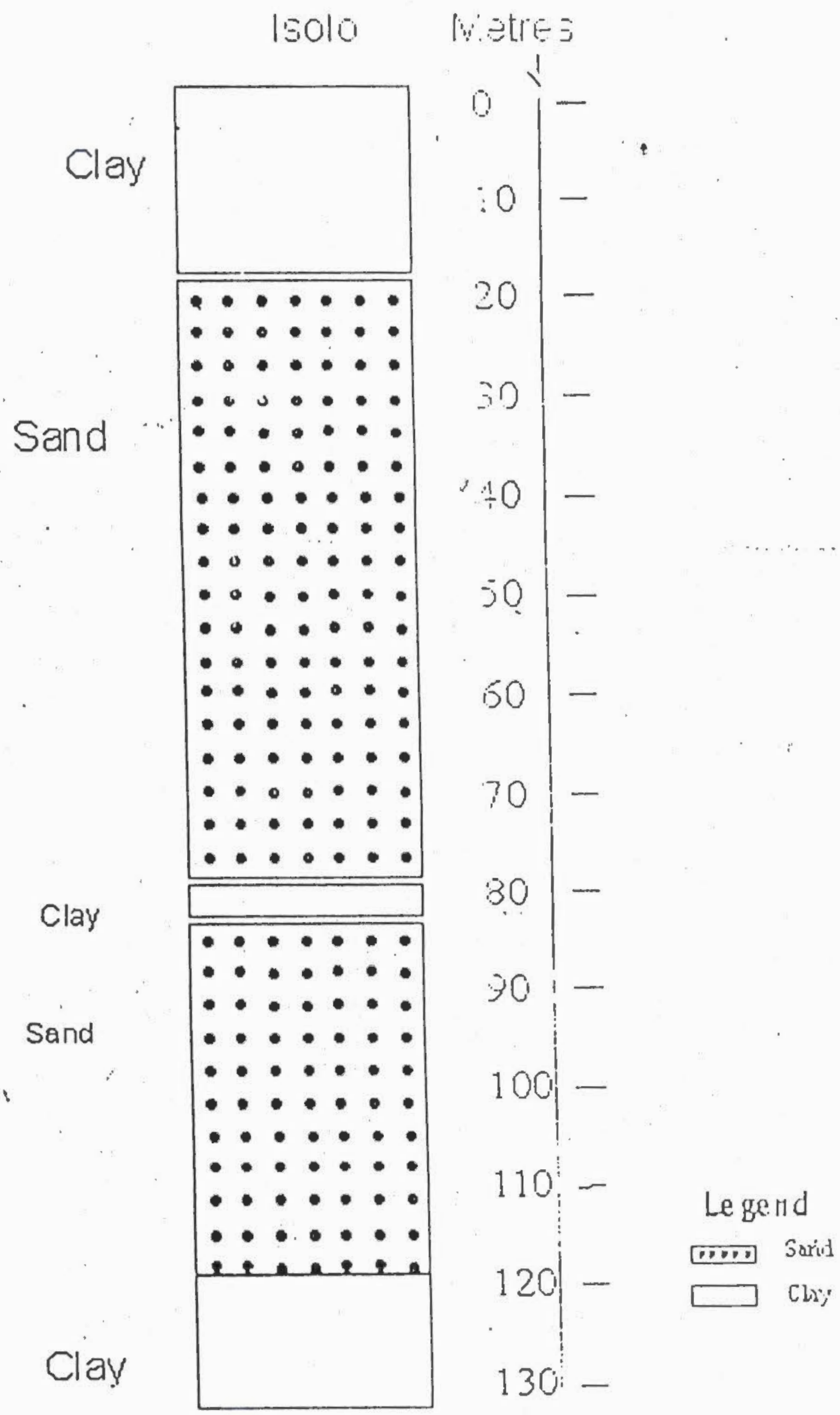


Fig 2: Stratigraphic log of the study area

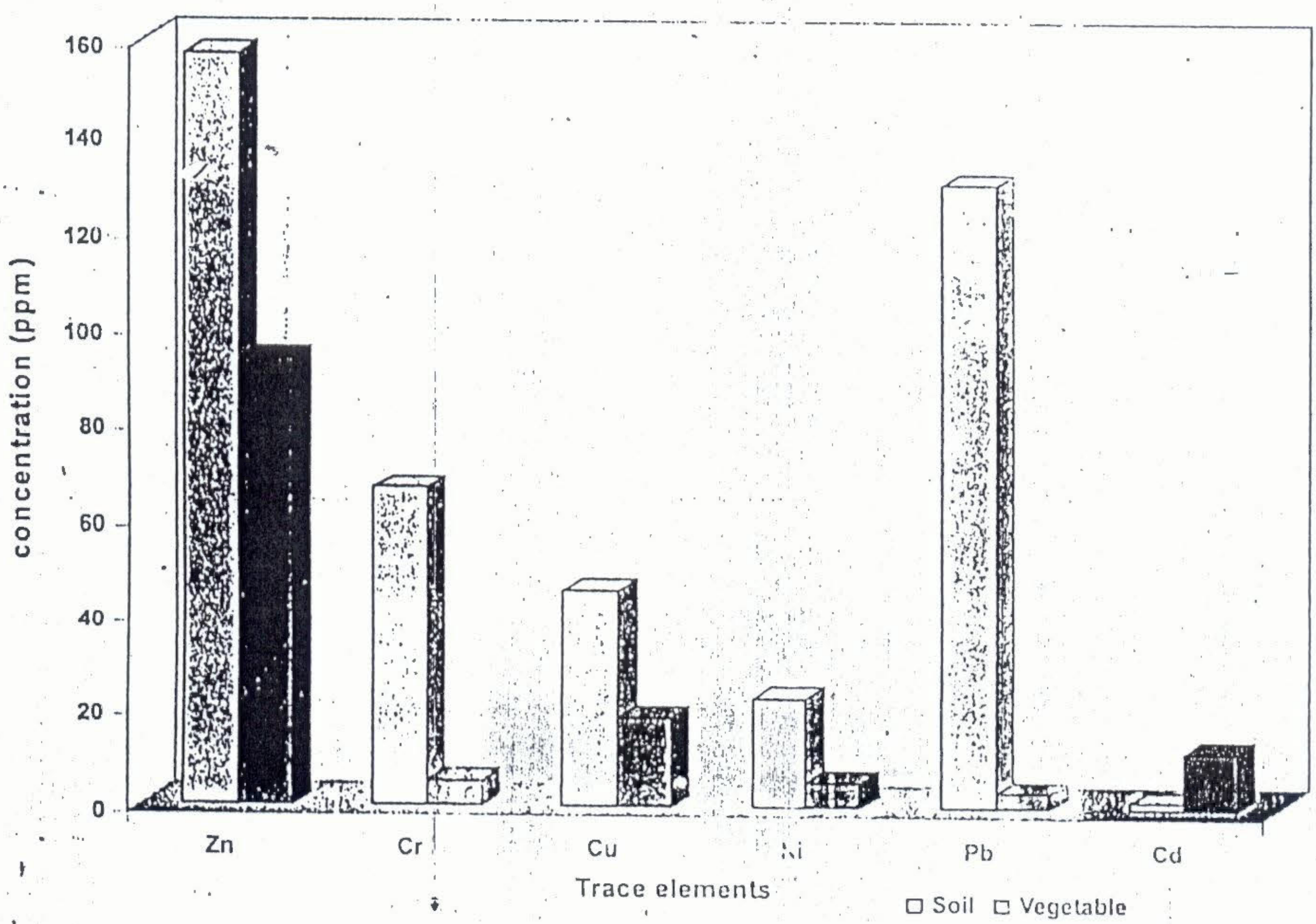


Fig 3: Average concentration of trace elements in both soil and vegetables

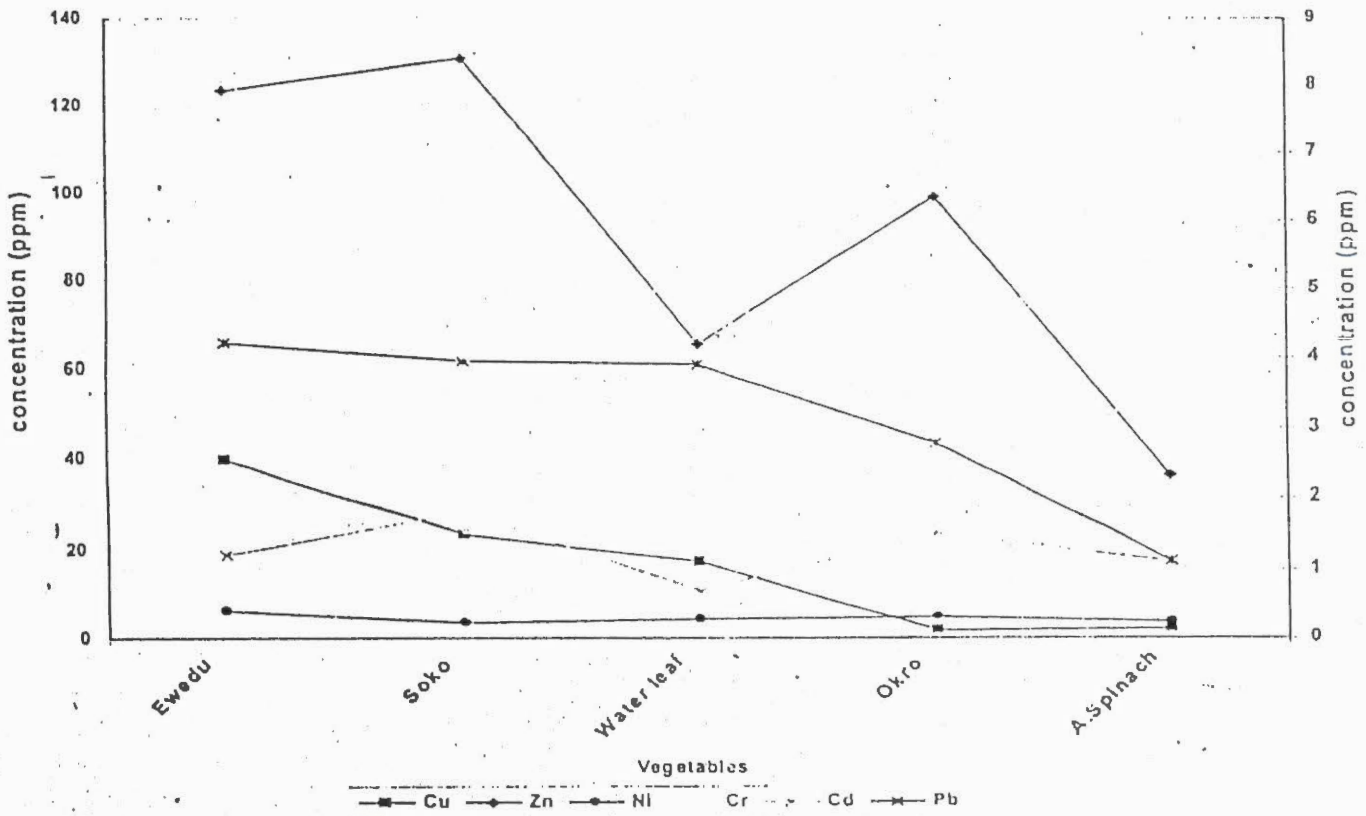


Fig 4 Concentration of heavy metals in different vegetable species

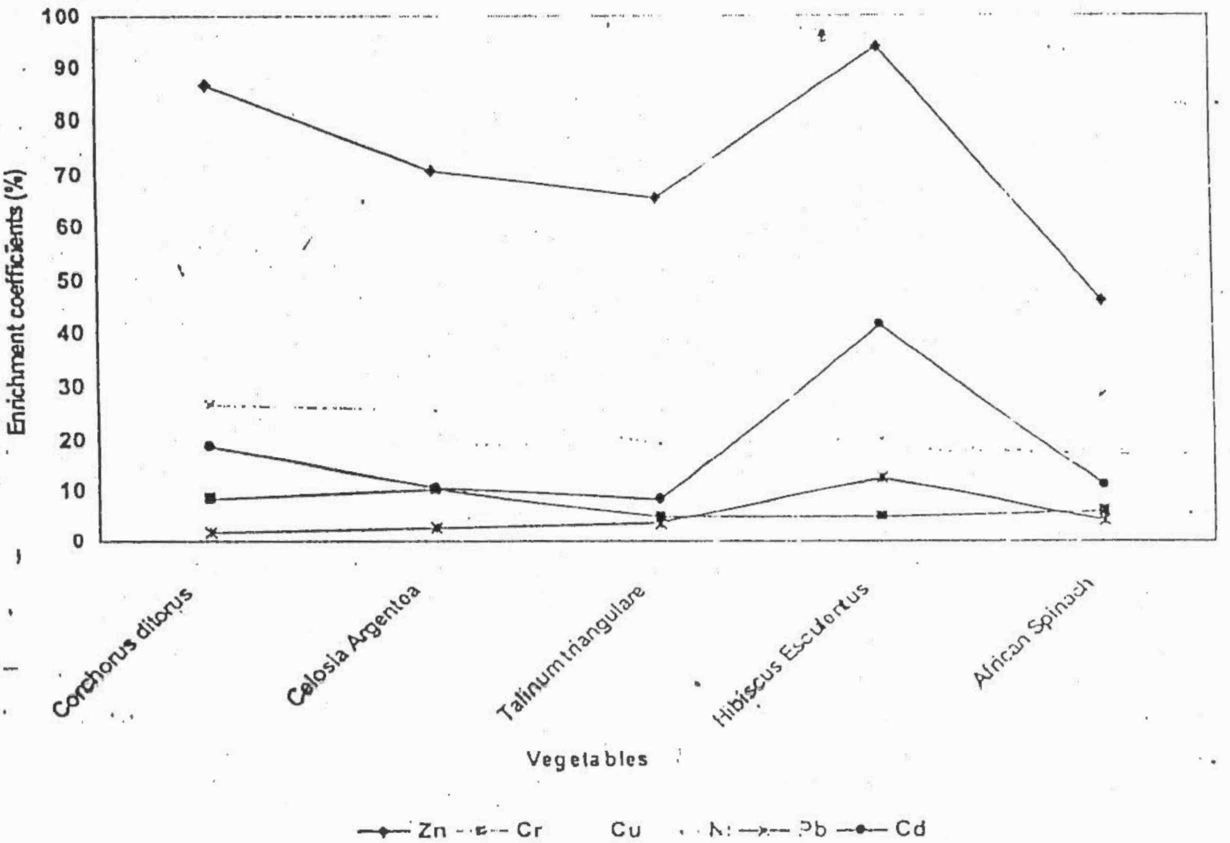


Fig 5 Enrichment Coefficients of heavy metals in vegetables

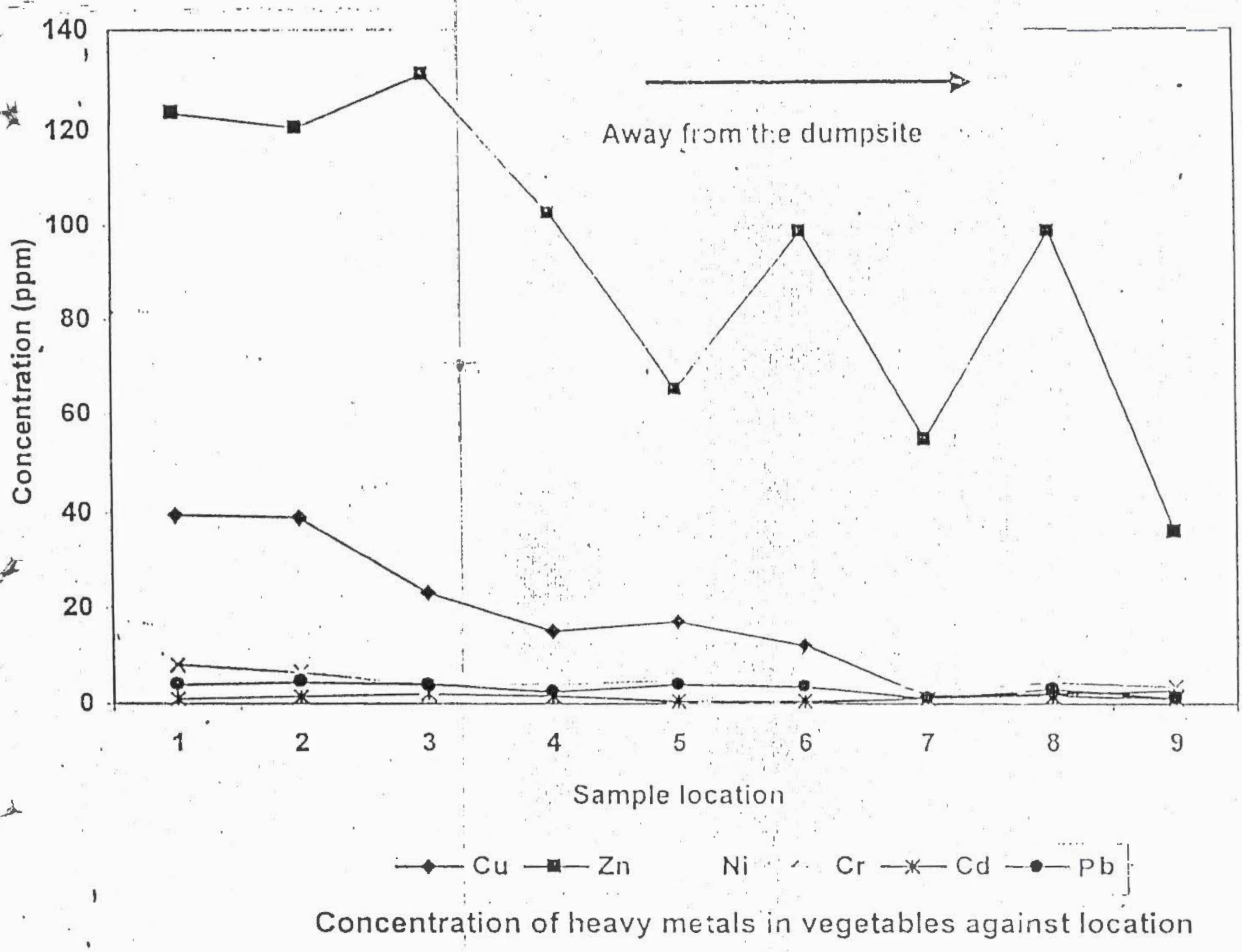
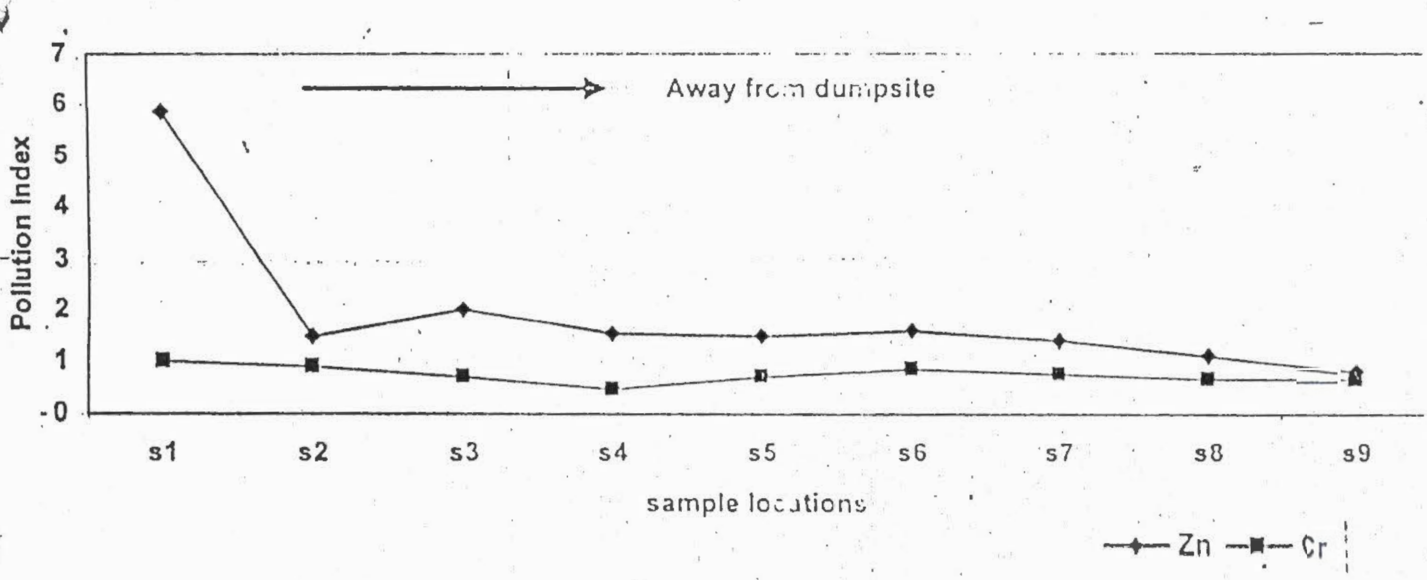
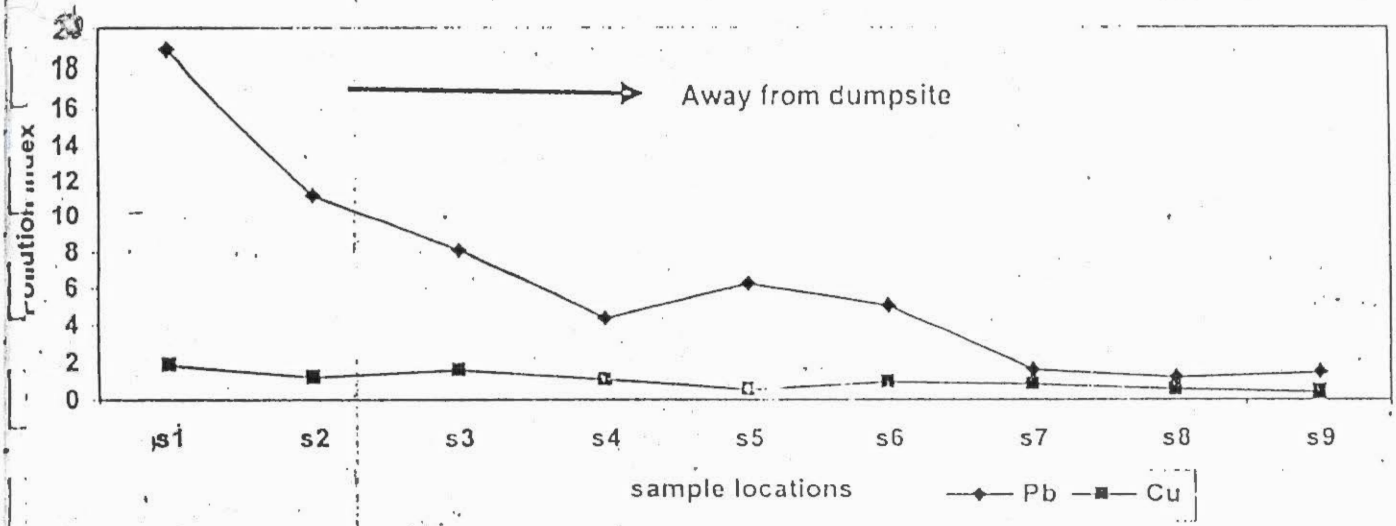


Fig 6: Concentration of Heavy metals in Vegetables against concentration in soil and locations.





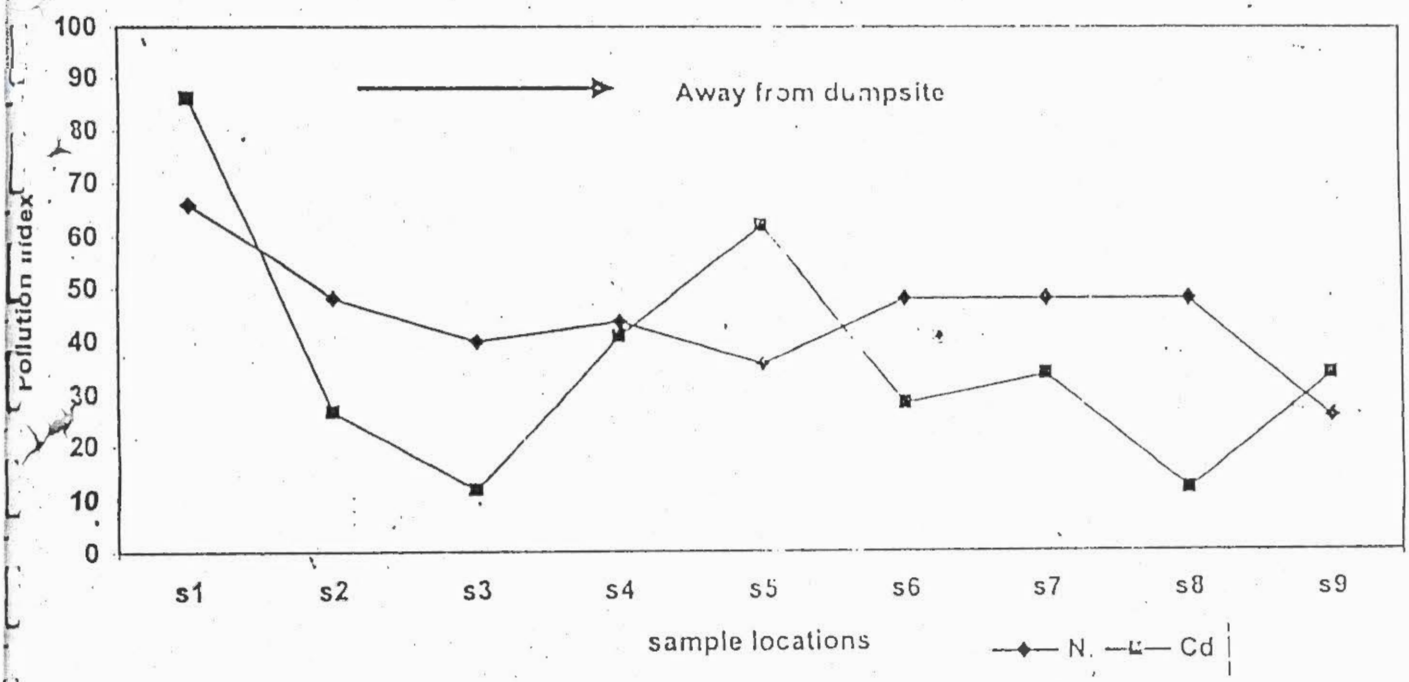


Fig 7 Environmental pollution index in soil

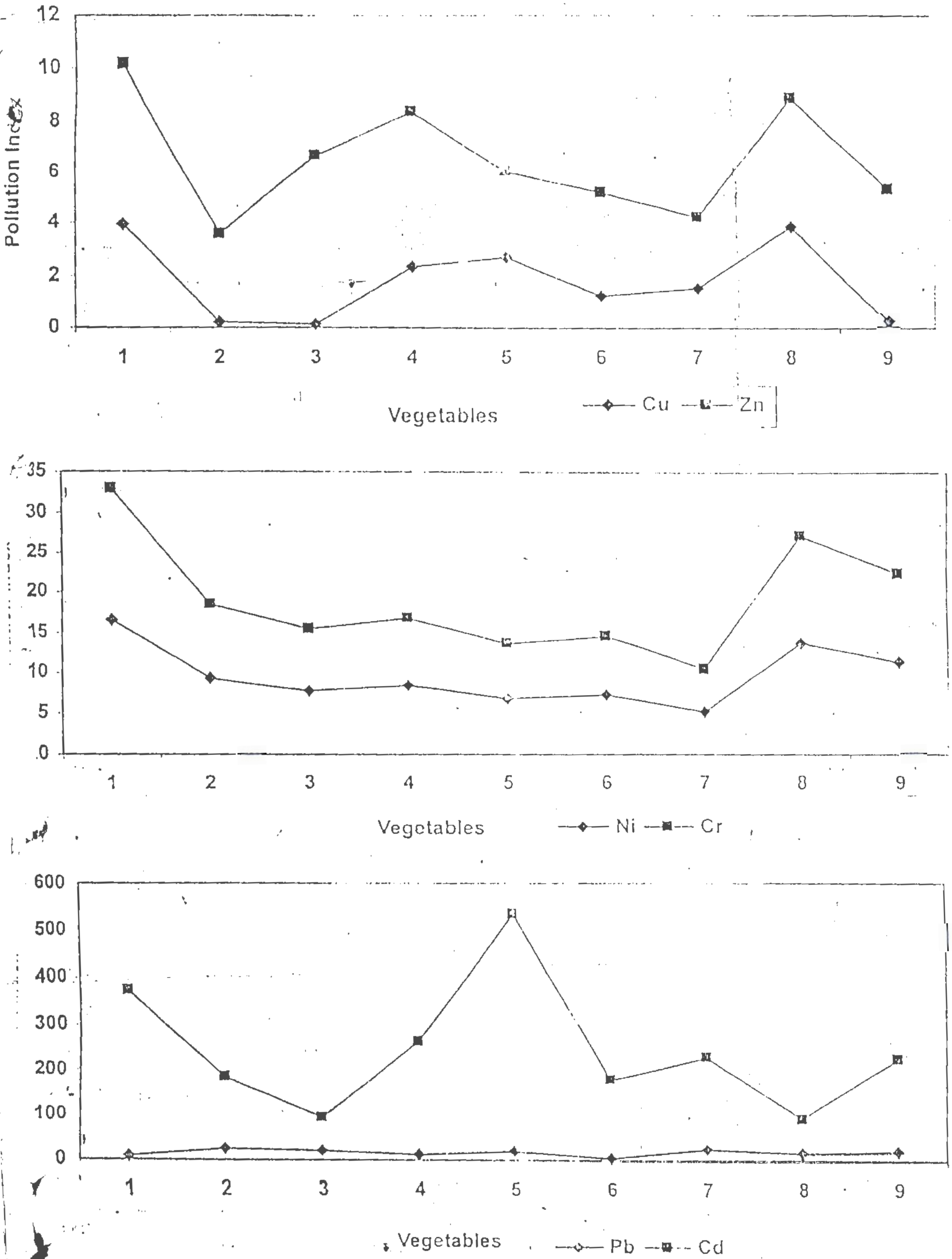


Fig 8: Environmental quality index in the different vegetables.