

STATUS EVALUATION OF HEAVY METALS IN WASTE DISPOSAL SITES OF CHAMPION BREWERIES AND PLASTO CROWN COMPANY, UYO, AKWA IBOM STATE, NIGERIA

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ABSTRACT

Sludge and soil samples were collected through purposive sampling method within Champion Breweries and Plasto Crown Company waste disposal sites during wet and dry seasons for status evaluation of their heavy metals (Fe, Pb, Zn, Ni, Cr, Cd, Co and Hg) for comparison with the control site and the world threshold standards for tropical soils. The results showed that the sludge pH value of 7.89 during wet season signified alkaline medium (outside the natural range of acidic medium for soils in the Niger Delta region of Nigeria) which was attributed to the high calcium content of the brewery effluent. The 7.42 pH value during wet season for soil in the Plasto Crown Company waste disposal site indicated alkaline medium which was due to the remnants of the wastes which formed lime to neutralize the acidic medium of the soil while the electrical conductivity values (below 4 dSm⁻¹) indicated the non-salinity of the soils. More so, a two way analysis of variance (ANOVA) statistical method used to run the analysis revealed that the soil in terms of heavy metal concentrations did not exceed the world threshold standards.

KEYWORDS: Soil, sludge, heavy metal concentrations, permissible standards.

INTRODUCTION

Environmental contamination by heavy metals such as cadmium, lead, zinc and copper has been of great concern in the last decade to the entire world because they constitute health hazards to man and other organisms when accumulated within the biological systems. According to Sule (2001), plants grown on contaminated soils transfer trace elements into human bodies on consumption of such plants. Heavy metals have relatively high atomic weight. Therefore, problems arise when they are converted by hydrological or biological processes until they become hazardous to natural ecosystems and human health (Martin et al., 1982).

Heavy metals such as lead, mercury, copper, arsenic, chromium, zinc and cadmium discharged into the ecosystems are then picked up by benthic organisms and enter the food

chain. Notably, most of these hazardous wastes are discharged by industries (Asthana and Asthana, 2001). For instance, industrial wastes discharged in the Nkalagu cement factory area, affected agriculture and horticulture as photochemical smog and other heavy metals got into the soil so severely and it became worrisome for people to plant cassava, yam, cocoyam and some other leafy plants (Horsfall and Spiff, 1998).

Therefore, this study is carried out to evaluate the concentration of heavy metals in soils around Champion Breweries and Plasto Crown Company waste disposal sites for comparison with the world permissible standards. This is prompted by the fact that farms and boreholes are located in this area without minding the effects of metal poisoning.

STUDY AREA

The study area which is located in Ak-Offot Industrial Layout, Uyo lies between

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longitudes $7^{\circ} 55'E$ – $7^{\circ}56'E$ and latitudes $5^{\circ}00'N$ – $5^{\circ}01'N$ (Figure 1). Ikot Ayan village in Ediene, Ikono Local Government Area of Akwa Ibom State, chosen as the control site lies between longitudes $7^{\circ}45'E$ – $8^{\circ}00'E$ and latitudes $5^{\circ}05'N$ – $5^{\circ}15'N$. The area is located within a coastal plain that generally has a level to gently undulating

topography with a gradient of less than five per cent (Tahal, 1979; Okoji, 1988). The surface geology is unconsolidated sand formations ranging from coarse to fine sands. The soil is generally very porous and weakly structured with moderate nutrient and water retention capacity.

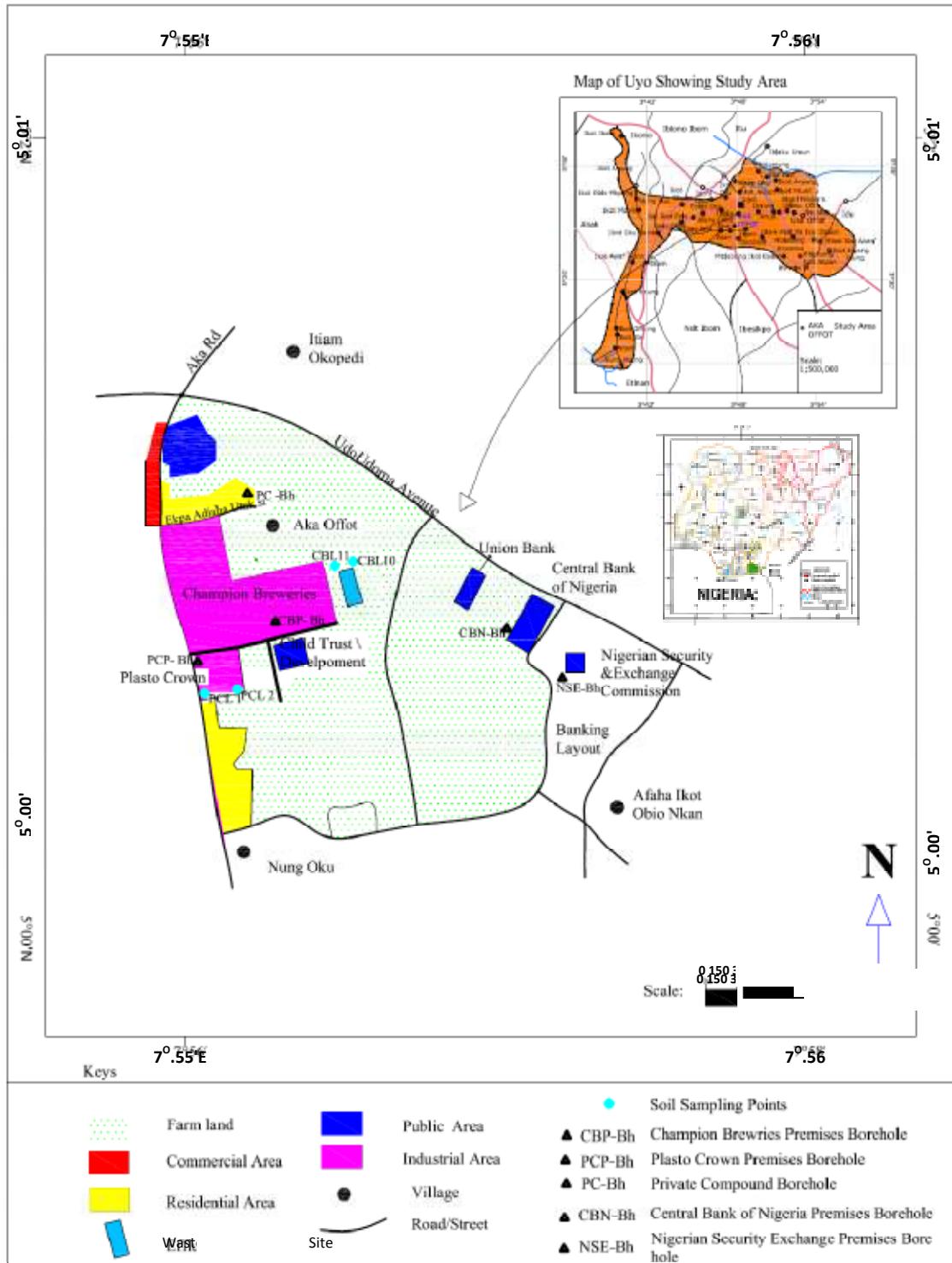


FIGURE 1: Aka Offot Industrial Layout, Uyo showing Champion Breweries Plc and Plasto Crown Company (study area) and sampling points
Source: Agate Geographic Services (2008)

METHOD OF STUDY

Soil and sludge samples were collected within the Champion Breweries and Plasto Crown Company waste disposal sites during wet and dry seasons. Sludge samples were collected at nine locations in Champion Breweries wastewater disposal site through purposive sampling method as well as the control site with the aid of a soil auger and put in sterilized bags while two depths: 0-15cm (surface) and 15-30cm (subsurface) soil samples were also collected through purposive sampling method within the Champion Breweries and Plasto Crown Company waste dump sites (Figure 1) with the aid of a soil auger and put separately in labeled sterilized containers. The same samples in the control site were equally collected. They were transported to the laboratory for digestion. The soil and sludge samples were air dried (at room temperature); grinded with a wooden roller and sieved via a 2mm mesh. The soil pH was determined using the routine method of International Institute for Tropical Agriculture (1979). Heavy metals of the soil/sludge were extracted by digestion of the samples with a mixture of concentrated HNO_3 and HCL. The content of each metal was determined from the samples after due calibration runs using appropriate salts investigated. They were analyzed using a computerized atomic absorption spectrophotometer (AAS) UNICAM model 939, using Whitehead (1979) method.

RESULTS AND DISCUSSION

The results of the physical properties and heavy metal concentrations in soil and sludge samples of the study area and the control site are presented in Tables 1, 2, 3 and 4 (wet and dry seasons). They are hereby summarized in mean values for both seasons for comparison with the world threshold standards for discussion.

Sludge Sample Analyses - Sludge in this context refers to the semi-solid residue deposited at the bottom of the Champion Breweries wastewater disposal site and the one deposited in a dug well at the control site through surface water.

The sludge pH mean values for wet and dry seasons are 7.89 and 5.93 while the control site has 6.54 and 5.26 for wet and dry seasons. The pH value of 7.89 during wet season which signifies alkaline medium is outside the natural range of acidic medium for soils in the Niger

Delta region of Nigeria. The alkaline medium in pH is attributed to the high calcium content of the brewery effluent thereby forming lime to neutralize the acidic medium of the soil (Orhue et al, 2005). The mean values of electrical conductivity (EC) are 0.21 dSm^{-1} and 0.251 dSm^{-1} for wet and dry seasons. The EC values for the control site are 0.04 dSm^{-1} , 0.251 dSm^{-1} for wet and dry seasons. This indicates the high values of EC in the industrial complex.

In terms of heavy metals, the Iron (Fe) mean values for wet and dry seasons are 1848.1mg/kg and 2092.3mg/kg (Tables 1 and 2). The control site is 876mg/kg for wet season and 907mg/kg for dry season. The values are below the world threshold standards. Mean zinc value is 17.44mg/kg for wet and 22.25mg/kg for dry seasons. The control site value is 1.47mg/kg for wet season and 2.94mg/kg for dry season, indicating higher concentrations in the industrial area. Equally, manganese mean values for wet and dry seasons are 19.17mg/kg and 23.07mg/kg (Tables 1 and 2), and 2.68mg/kg and 4.15mg/kg for wet and dry seasons in the control site. The lead mean value is 11.95mg/kg for wet season and 15.67mg/kg for dry season. The control site is 0.329mg/kg for wet and 0.825mg/kg for dry seasons, indicating higher concentrations in the industrial area though below the world threshold standards.

However, despite the fact that all the analyses carried out on sludge and soil in the study area fell within the tolerable levels in terms of heavy metal concentrations, there is need for adequate waste disposal method as well as periodical assessment to avoid unpleasant consequences. This would guide against any negative development in this area as Umana (2010) observed during his reconnaissance survey that Champion Breweries and Plasto Crown Company disposed their wastes into the larger environment without proper treatment. This is in line with Martins (1978) as he observed that some industrial establishments in Nigeria dispose non-processed solid wastes indiscriminately within their premises.

Furthermore, Asia et al. (2007) collected soil and water samples from four locations for analyses of their heavy metals around an oil well head, flare site, waste pit and effluent discharge point in exploration areas in the Niger Delta area. The results showed that lead, copper, cadmium, iron and chromium were higher than the

permissible limits for heavy metals in the tropical soils signifying pollution of the soil. Equally, analyses carried out by Adediran et al. (2004) on water, soil and plants due to effluent discharge from a brewery industry to the territory of three rural communities in Ibadan showed higher concentrations of cadmium, chromium, copper and nickel in most of the water samples than the World Health Organization permissible standards while some elements such as copper, iron and manganese in soil and plant analyses were higher than the permissible standards.

Also, the mean chromium value for wet season is 6.29mg/kg and 9.57mg/kg for dry season (Tables 1 and 2). The cr value in the sludge from the control site is 0.063mg/kg for wet season and 0.095mg/kg for dry season. Accordingly, the mean cadmium value during wet season is 1.89mg/kg and 2.51mg/kg for dry season as well as 0.023mg/kg and 0.078mg/kg

for wet and dry seasons in the control site recording higher concentrations in the industrial area. One of the major sources of chromium into the environment is industrial discharge although contamination occasionally arises from the use of sewage sludge when added to land. Exposure to it can bring about cancer and malignant growth in the respiratory tract and painless perforation of the nasal spectrum (WHO, 1984). More so, cobalt mean value is 0.07mg/kg for wet season and 1.63mg/kg for dry season. The control site cobalt concentrations are 0.033mg/kg and 0.043mg/kg for wet and dry seasons, indicating higher concentrations in the industrial area (Tables 1 and 2). According to Wills (1966) effects of excess intake of cobalt include vomiting, diarrhoea and damaged nerves. Incidence of goiter is higher in regions with higher levels of cobalt in water and soil.

TABLE 1: pH, electrical conductivity and heavy metal concentrations in sludge of Champion Breweries waste water disposal and control sites for wet season.

Wet Season

Parameters	Range	Mean	SD	CV(%)	SE	Control site
A. physical properties						
pH	7.67-8.20	7.89	0.1477	1.8712	0.0492±7.8933	6.54
Electrical conductivity (dSm ⁻¹)	0.111-0.518	0.21	0.1278	60.3399	0.0426±0.2118	0.040
B) Heavy metals						
Iron (Fe) (mg/kg)	1800–1984	1848.11	56.642	3.0648	18.881±1848.111	876
Zinc (Zn) (mg/kg)	0.73–31.60	17.44	10.3958	59.5976	3.4652±17.4433	1.47
Manganese (Mn) (mg/kg)	14.18–22.27	19.17	3.1965	16.6755	1.0655±19.1688	2.68
Lead (Pb) (mg/kg)	5.451–16.32	11.95	4.8495	40.5666	1.6165±11.9544	0.329
Chromium (Cr) (mg/kg)	2.942–8.466	6.29	2.2683	36.0734	0.7561±6.2880	0.063
Cadmium (Cr) (mg/kg)	1.163–2.905	1.89	0.7351	38.8531	0.2450±1.8920	0.023
Cobalt (Co) (mg/kg)	0.047–0.094	0.07	0.0176	23.6877	0.0058±0.0743	0.033

Note: SD = standard deviation; CV = coefficient of variability and SE= standard error.

Source: Author's Fieldwork.

TABLE 2: pH, electrical conductivity and heavy metal concentrations in sludge of Champion Breweries wastewater disposal and control sites for dry season.

Dry Season

Parameters	Range	Mean	SD	CV(%)	SE	Control site
A. physical properties						
pH	5.30-6.43	5.93	0.4920	8.296	0.1564±5.93	5.26
Electrical conductivity (dsm^{-1})	0.059 – 0.931	0.52	0.4236	81.46	0.1441±0.52	0.251
B) Heavy metals						
Iron (Fe) (mg/kg)	2008-2180	2092.33	55.959	2.674	18.65±2092.33	907
Zinc (Zn) (mg/kg)	5.03 -35.19	22.25	12.783	62.91	4.261±20.32	2.94
Manganese (Mn) (mg/kg)	15.36 – 29.86	23.07	5.7565	24.95	1.9188±23.07	4.15
Lead (Pb) (mg/kg)	8.112 – 21.94	15.67	5.7896	36.947	1.9298±15.67	0.825
Chromium (Cr) (mg/kg)	6.312 – 12.06	9.57	1.4912	15.58	0.497± 9.57	0.095
Cadmium (Cr) (mg/kg)	1.854 – 3.409	2.51	0.6673	26.59	0.222±2.51	0.078
Cobalt (Co) (mg/kg)	1.075 – 2.016	1.63	0.3931	24.12	0.131±1.63	0.043

Note: SD = Standard deviation; CV = coefficient of variability and SE=standard error.

Source: Author's Fieldwork.

Soil Sample Analyses - The soil pH mean values close to Champion Breweries wastewater disposal site are 5.92 and 5.30 for wet and dry seasons; 7.42 (wet season) and 6.25 (dry season) for Plasto Crown waste disposal site while the control site has 5.25 and 5.65 for wet and dry seasons. 7.42 pH value which is alkaline is outside the natural range of acidic medium for soils in the Niger Delta region of Nigeria (Orhue et al, 2005). This means that the remnants of the wastes have formed lime to neutralize the acidic medium of the soil.

The mean electrical conductivity for samples near Champion Breweries is 1.066 dSm^{-1} (wet season) and 1.062 dSm^{-1} (dry season); 0.665 dSm^{-1} (wet season) and 1.040 dSm^{-1} (dry season) for Plasto Crown waste disposal site while the control site has 0.089 dSm^{-1} and 0.075 dSm^{-1} for wet and dry seasons. These values are below 4 dSm^{-1} permissible level, which indicate that the soils are non-saline (Miller and Donahue, 1995). Heavy metals, iron mean values near Champion Breweries wastewater disposal site for wet and dry seasons are 1898.25 mg/kg and 2014.5 mg/kg ; 2211.75 mg/kg and 2316.75 mg/kg wet and dry seasons for Plasto Crown waste

disposal site as well as 1125.5 mg/kg and 1099.5 mg/kg (wet and dry seasons) for the control site. These values are within the permissible limits for iron of $10,000\text{-}100,000 \text{ mg/kg}$ (Brady and Weil, 1996).

The mean zinc values near Champion Breweries wastewater disposal site are 13.33 mg/kg and 22.39 mg/kg for wet and dry seasons; 58.53 mg/kg and 63.05 mg/kg (wet and dry seasons) for Plasto Crown waste disposal site while the control site has 2.42 mg/kg (wet) and 2.52 mg/kg for dry season. The results show that zn concentrations in the Plasto Crown waste disposal site were higher than that of the Champion Breweries site but within the $10\text{-}300 \text{ mg/kg}$ permissible level of Brady & Weil (1996). In terms of lead, the mean values near Champion Breweries site is 9.10 mg/kg (wet season) and 14.96 mg/kg (dry season); Plasto Crown waste disposal site are 21.32 mg/kg , 31.20 mg/kg (wet and dry seasons) while 1.109 mg/kg and 1.541 mg/kg (wet and dry seasons) are for the control site. The nickel mean values near Champion Breweries waste disposal site is 7.86 mg/kg and 9.745 mg/kg (wet and dry seasons; 34.19 mg/kg and 25.32 mg/kg (wet and

dry seasons) for Plasto Crown waste disposal site while the control site has 1.035mg/kg and 1.302mg/kg for wet and dry seasons (Tables 3 & 4). These ranges are within the nickel permissible limits of 10-1000mg/kg for tropical soils (Line et al, 1987).

According to Ademoroti (1996), most industrial activities lead to enrichment of heavy metals in water, air and land. This conforms with the submission of Gulson et al. (1981) that trace metals most commonly associated with man-made pollution of soils are boron, cadmium, cobalt, chromium, copper, nickel, lead and zinc. These elements constitute essential micronutrients to plants as well as components of vitamins, the enzyme system, hormones to human but, in higher concentrations than normal, they affect man through food chain.

Chromium mean values near Champion Breweries wastewater disposal site for wet and dry seasons are 1.99mg/kg and 2.44mg/kg; 14.14mg/kg and 9.5914mg/kg (wet and dry seasons) for Plasto Crown waste disposal site while the control site has 0.763mg/kg (wet season) and 0.759mg/kg (dry season); Plasto Crown waste disposal site has higher values than the Champion Breweries wastewater disposal site but within permissible limits of 10-1000mg/kg (Bohn et al., 1985). Cadmium mean value near

Champion Breweries wastewater disposal site are 0.309 mg/kg and 0.512 mg/kg (wet and dry seasons); 0.76 mg/kg and 0.87 mg/kg (wet and dry seasons) for Plasto Crown waste disposal site whereas the control site has 0.016 mg/kg and 0.025 mg/kg (wet and dry seasons). These values fall within cadmium permissible limits of 0.1 - 7 mg/kg (Brady and Weil, 1996).

Equally, mercury mean values near Champion Breweries wastewater disposal site for wet and dry seasons are 0.058 mg/kg and 0.061 mg/kg; 0.152 mg/kg and 0.124 mg/kg for Plasto Crown waste disposal site (wet and dry seasons) as well as 0.005 mg/kg and 0.047 mg/kg (wet and dry seasons) for the control site (Tables 3 & 4). The Plasto Crown waste disposal site records higher concentrations than Champion Breweries wastewater disposal site. There is need to avoid excess accumulation of this metal in soils of this area because of its health implications such as impaired vision, muscular convulsion, madness and paralysis (Goldwater, 1972). Subsequently, a two-way analysis of variance (ANOVA) statistical method used in running the test shows that the soil in terms of heavy metal concentrations, do not significantly exceed the world permissible standards ($F\text{-ratio}=1.01798$; $F\text{-critical}=3.48103$; $p>0.05$) (Table 5).

TABLE 3: pH, electrical conductivity (EC) and heavy metal concentrations in soil sampled in Champion Breweries, Plasto Crown Company waste disposal and control sites for wet season.

Champion Breweries							
Parameters	Range	Mean	SD	CV(%)	SE	Control site (mean)	Maximum permissible limits
pH	5.76- 6.06	5.92	0.14975	2.5295	0.074875 ± 5.9175	5.25	5.1-6.5*
EC (dSm ⁻¹)	1.003- 1.148	1.066	0.071267	6.6854	0.035634 ± 1.0655	0.089	2-4 dSm ⁻¹ *
Iron (Fe) (mg/kg)	1673- 2103	1898.25	7894.31	4.1587	3947.155 ± 5898.25	1125.5	10,000- 100,000* mg/kg
Zinc (Zn) (mg/kg)	11.41- 16.44	13.33	2.203096	16.5273	1.101548 ± 13.325	2.43	10-300* mg/kg
Lead (Pb) (mg/kg)	6.98- 12.85	9.10	2.603626	28.6112	1.301813 ± 9.100	1.109	2-200mg/kg*
Nickel (Ni) (mg/kg)	6.44- 8.81	7.86	1.105712	14.0675	0.552856 ± 7.86	1.035	10- 1000mg/kg***
Chromium(Cr)(mg/kg)	1.82- 2.16	1.99	0.147196	7.3967	0.0737598 ± 1.99	0.763	10- 1000mg/kg**
Cadmium (Cd) (mg/kg)	0.219- 0.402	0.309	0.074999	24.2715	0.0375 ± 0.30975	0.016	0.1-7mg/kg*
Mercury (Hg) (mg/kg)	0.041- 0.072	0.058	0.01372	23.6551	0.00686 ± 0.05825	0.005	

Plasto Crown Company							
Parameters	Range	Mean	SD	CV(%)	SE	Control site (mean)	Maximum permissible limits
Ph	7.04- 7.92	7.42	0.408932	5.5112	0.204466 ± 7.4225	5.25	5.1-6.5 *
EC (dSm ⁻¹)	0.010- 0.011	0.665	0.544394	81.8637	0.272197 ± 0.665	0.089	2-4 dSm ⁻¹ *
Iron (Fe) (mg/kg)	2014- 2043	2211.75	275.1925	12.4422	137.5963 ± 2211.75	1125.5	10,000- 100,000* mg/kg
Zinc (Zn) (mg/kg)	52.10- 60.97	58.53	4.299992	7.3466	2.14996 ± 58.53	2.43	10-300* mg/kg
Lead (Pb) (mg/kg)	18.08- 24.91	21.32	2.914543	13.6704	1.457271 ± 21.3225	1.109	2-200* mg/kg
Nickel (Ni) (mg/kg)	30.19- 38.16	34.19	3.254499	9.5188	1.62725 ± 34.185	1.035	10-1000*** mg/kg
Chromium(Cr)(mg/kg)	10.40- 19.00	14.14	4.112355	29.0831	2.056178 ± 14.14	0.763	10-1000** mg/kg
Cadmium (Cd) (mg/kg)	0.296- 0.927	0.76	0.30903	40.6618	0.154515 ± 0.75925	0.016	0.1-7 mg/kg*
Mercury (Hg) (mg/kg)	0.108- 0.214	0.152	0.046869	30.8348	0.023434 ± 0.152	0.005	

Note: *Brady and Weil (1996) ** Bohn et al, (1985); *** Line et al. (1987).

SD = standard deviation; CV% = coefficient of variability; SE = standard error.

Source: Author's Field work.

TABLE 4: pH, electrical conductivity (EC) and heavy metal concentrations in soil sampled in Champion Breweries, Plasto Crown Company waste disposal and control sites for dry season.

Champion Breweries								
Parameters	Range	Mean	SD	CV(%)	SE	Control site (mean)	Maximum permissible limits	
pH	5.42-5.59	5.50	0.075277	1.3698	0.038 ±	5.65	5.1-6.5*	
EC (dSm ⁻¹)	1.005-1.120	1.062	0.064407	6.0646	0.032 ±	0.075	2-4 dSm ⁻¹ *	
Iron (Fe) (mg/kg)	1189-2116	2014.5	93.81009	4.567	46.90505 ±	1099.5	10,000-100,000 mg/kg*	
Zinc (Zn) (mg/kg)	16.11-27.63	22.39	5.747373	25.6693	2.873687 ±	2.52	10-300 mg/kg**	
Lead (Pb) (mg/kg)	6.98-19.64	14.96	4.574895	30.5808	2.287448 ±	1.541	2-200mg/kg*	
Nickel (Ni) (mg/kg)	8.73 – 10.85	9.745	0.934398	9.5679	0.4462 ±	1.302	10-1000mg/kg***	
Chromium(Cr)(mg/kg)	1.98-3.02	2.44	0.495042	20.2886	0.247521 ±	0.759	10-1000mg/kg**	
Cadmium (Cd) (mg/kg)	0.416-0.603	0.512	0.077037	15.0462	0.03851 ±	0.025	0.1-7mg/kg*	
Mercury (Hg) (mg/kg)	0.037-0.088	0.061	0.024663	40.4311	0.012331 ±	0.047		
Plasto Crown Company								
Parameters	Range	Mean	SD	CV(%)	SE	Control site (mean)	Maximum permissible limits	
pH	5.95-6.95	6.25	0.464283	7.4285	0.232141 ±	5.65	5.1-6.5*	
EC (dSm ⁻¹)	0.918-1.315	1.040	0.190566	18.32236	0.095283 ±	0.075	2-4 dSm ⁻¹ *	
Iron (Fe) (mg/kg)	2106-2811	2316.75	335.8605	14.4970	167.9302 ±	1099.5	10,000-100,000 mg/kg*	
Zinc (Zn) (mg/kg)	61.35-62.69	63.05	3.555475	5.6391	1.777737 ±	2.52	10-300 mg/kg*	
Lead (Pb) (mg/kg)	31.14-36.18	31.20	4.722936	15.1376	2.361468 ±	1.541	2-200 mg/kg*	
Nickel (Ni) (mg/kg)	20.01-28.97	25.32	4.127722	16.3022	2.063861 ±	1.302	10-1000 mg/kg***	
Chromium(Cr)(mg/kg)	9.11-11.02	9.59	0.954624	9.9543	0.477312 ±	0.759	10-1000mg/kg**	
Cadmium (Cd) (mg/kg)	0.813-0.917	0.87	0.060047	6.9019	0.030024 ±	0.025	0.1-7mg/kg*	
Mercury (Hg) (mg/kg)	0.040-0.217	0.124	0.072629	58.5717	0.036315 ±	0.047		

Note*: Brady and Weil (1996);** Bohn et.al., (1985);*** Line et al., (1987);

SD = standard deviation, CV(%) = coefficient of variability;

SE = standard error.

Source: Author's Fieldwork.

TABLE 5: Variations in heavy metals in soils from Champion Breweries and Plasto Company waste disposal sites.

Source of variations	Sum of square	Degree of freedom	Mean sum of square	F-ratio	P- value	F-critical
Heavy metal concentrations	1.14E+11	8	1.43E+10	1.017981	0.490255	3.48103
Treatment	1.42E+10	1	1.42E+10	1.013004ns	0.34653	5.31764 5
Error (within)	1.12E+11	8	1.4E+10			
Total	2.41E11	17				

Note: ns= not significant

SUMMARY/CONCLUSION

The reconnaissance survey carried out within the premises of Champion Breweries and Plasto Crown Company reveals that the two industries did not have any formal waste treatment method before disposal into the larger environment at the time of this study. This contributes to the alkaline soil pH in this area.

This study reveals that the soils of their waste disposal sites only exceed the control site but do not significantly exceed the world permissible standards in terms of heavy metal concentrations. The results further draw a distinction between the study area and the control site justifying the study area as an industrial complex. However, though the study reveals that heavy metal concentrations in the study area do not significantly exceed the world permissible standards, there is that concern that if these industries continue to dump wastes in this area without prior treatment, a time will come when the concentration of most of these metals will be so high in the soil, so that they become deleterious to this ecosystem thereby bringing adverse effects to the inhabitants of this area, hence the following suggestions for a sustainable environment:

1. Major stakeholders such as the Ministries of Health and Environment should come up with a position by telling people to discontinue farming in this industrial area so as to avoid any form of metal poisoning.
2. The Ministry of Environment should make it mandatory for Champion Breweries and Plasto Crown Company to engage experts in environmental management to come out with measures in ameliorating the effects of wastes already dumped in this area.
3. The management of Champion Breweries should as a matter of urgency install anti-pollution equipment for the treatment of their effluent in line with FEPA ACT (CAP 131) of 1991.
4. The installation of such equipment shall be based on the Best Available Technology (BAT), the Best Practical Technology (BPT) or the Uniform Effluent Standards (UES).
5. The management of Champion Breweries and Plasto Crown Company should as a matter of urgency establish "waste management" units in their industries and equip them with functional machines and qualified personnel with good background in waste management.

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