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# Assessment of heavy metals in wastewater obtained from an industrial area in Ibadan, Nigeria

## Ocena težkih kovin v odpadnih vodah industrijske cone v Ibadanu v Nigeriji

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## Abstract

The distribution of heavy metals, namely, Copper (Cu), Chromium (Cr), Lead (Pb), Cadmium (Cd) and Nickel (Ni) in wastewater samples from an industrial area in Ibadan, South-western Nigeria have been evaluated. Wastewater samples were collected from the discharge points of six manufacturing industries and conveyed to the laboratory for chemical analysis. The concentration of heavy metal constituents was determined using Inductively Coupled Plasma (ICP) and Optical Electro Spectrometer (OES) standard methods. The results obtained reveal average concentration in the order of abundance given as Cu>Cr>Ni>Pb>Cd.

This study reveals that the concentration of toxic heavy metals was significantly higher than the permissible limits of WHO which could pose a huge threat to human health and the natural environment. Therefore, the polluting industries have the duty-of-care to manage their wastewater disposal in order to safeguard the aesthetic integrity of the environment and ensure the safety of public health. It is recommended that the manufacturing companies should pre-treat their wastewaters using appropriate green technology prior to disposal in order to improve environmental sustainability.

**Key words:** Heavy metals, wastewater, industrial estate, pollution, health hazard

## Izvleček

Ocenjena je porazdelitev težkih kovin, in sicer bakra (Cu), kroma (Cr), svinca (Pb), kadmija (Cd) in niklja (Ni) v vzorcih odpadne vode iz industrijske cone v Ibadanu v jugozahodni Nigeriji. Odpadne vode so vzorčili v izlivnih točkah šestih proizvodnih industrijskih družb in jih dostavili v analizo v kemijski laboratorij. Koncentracijo težkih kovin so določili s standardnima metodama induktivno vezane plazemske (ICP) in optične emisijske spektrometrije (OES). Iz analiznih rezultatov sledijo povprečne koncentracije kovin v naslednjem zaporedju: Cu>Cr>Ni>Pb>Cd.

Raziskava je razkrila, da je koncentracija toksičnih težkih kovin značilno višja od vrednosti, ki jih dopušča WHO, kar lahko resno ogrozi človekovo zdravje in naravno okolje. Onesnaževalne industrijske panoge so zato obvezane urediti odstranjevanje svojih odpadnih vod tako, da zagotovijo vzdrževanje estetskega videza okolja in varovanje javnega zdravja. Industrijskim podjetjem priporočajo, da zavoljo zagotovitve trajnostnega stanja okolja svoje odpadne vode ob uporabi primerne zelene tehnologije grobo očistijo preden jih odtočijo.

**Ključne besede:** težke prvine, odpadna voda, industrijska cona, onesnaženje, nevarnost za zdravje

## Introduction

Environmental pollution is one of the major concerns of this century. Soil, water and air pollution have attracted continued interventions at a global level regarding remedial approaches to sustainable development due to alarming rates of the associated potential health risks posed to man and the environment. Rapid industrialization and socio-economic development in the 21st century has led to increased growth of the industrial sector in developing countries. As a result, the quantity of wastewater being discharged into the environment has increased over time and has been creating undue environmental degradation and health hazards.

Many researchers have investigated the effect of the prolonged exposure of humans, animals and plants to toxic heavy metals in industrialized cities. Heavy metals such as Arsenic (As), Mercury (Hg), Iron (Fe), Nickel (Ni), Zinc (Zn), Lead (Pb), Copper (Cu), Chromium (Cr) and Cadmium (Cd) are prominent components of industrial wastewaters[1,2]. Some biochemical accumulation risks of heavy metals and uptake effects on the biology of Sitophilus have been studied[3].

The industrial revolution of the 21st century has imposed numerous environmental and health problems to humans in all parts of the world. Mehta et al.[4] reports the effect of industrial growth on the natural environment. Wastewater treatment and disposal problems have increased on a global scale due to increase in production[5]. Khurshid et al.[6] reiterate the effect of wastewater on water quality while Moore and Ramamoorthy[7] report the negative impact of heavy metals on environmental aesthetics. Akinyeye et al.[8] and Adedeji et al.[9] evaluate the status of heavy metal pollutants of the Alaro River at Oluyole industrial area in Ibadan South-western Nigeria while Akinyeye et al.[4] conducted a study on the impact of industrial wastewaters from Oluyole industrial area on Alaro stream and a pond.

An industrial area in Ibadan, south-western Nigeria, was mapped out for geo-environmental assessment as a result of the indiscriminate disposal of untreated wastewater into the environment from point source discharge. The objective of this study was to investigate the nature of the composition of the untreated wastewater with respect to heavy metals and to highlight the potential environmental damage and health risks that could arise as a result of the disposal of raw wastewater into the environment.

## Materials and methods

The study area is located North-east of Ibadan in the South-western part of Nigeria and is underlain by homogeneous resistant rock which is characteristic of a basement complex setting. The Basement complex forms part of the African Crystalline Shield[11], while[12] classifies the rocks of the Basement complex of Nigeria into five main groups which are: Migmatite gneiss complex, Charnokitic rocks, Schist, Older granites and Unmetamorphosed dolerite dykes which are presented in Figure 1. The topographical map of Ibadan (sheet 261 N.E.) on a scale of 1:25,000 was utilised as a base map. A mobile Global Positioning System (GPS) was used to determine the coordinates of the study area which lies within Longitude 3°50'E and 3°52'E, and Latitude 7°21'N and 7°23'N as shown in Figure 2.

The wastewater samples were collected from the points of discharge of the pharmaceutical, agrochemical, confectionery, textile, paint and bottling companies in the study area. The pharmaceutical company was producing a wide range of prescription medicines, vaccines and some healthcare products. Some of the chemicals used for production were albumin, phenols, glycine and aluminum gels. The agrochemical company was producing pesticides and herbicides, while the chemicals and materials used were sulphur, epoxiconazole, fenpropidin and dimethylamine salt. The confectionery company was producing chocolates, sweets and biscuits whilst the materials used were mainly cocoa, sugar, wheat and sweeteners. The textile company manufactured clothes and the raw materials used were cotton, dye, polyacrylamide, Na and Ca lignosulphonate, NaOH and anionic polymer. The paint company was producing emulsion and coating for interior usage and the chemicals used were mainly

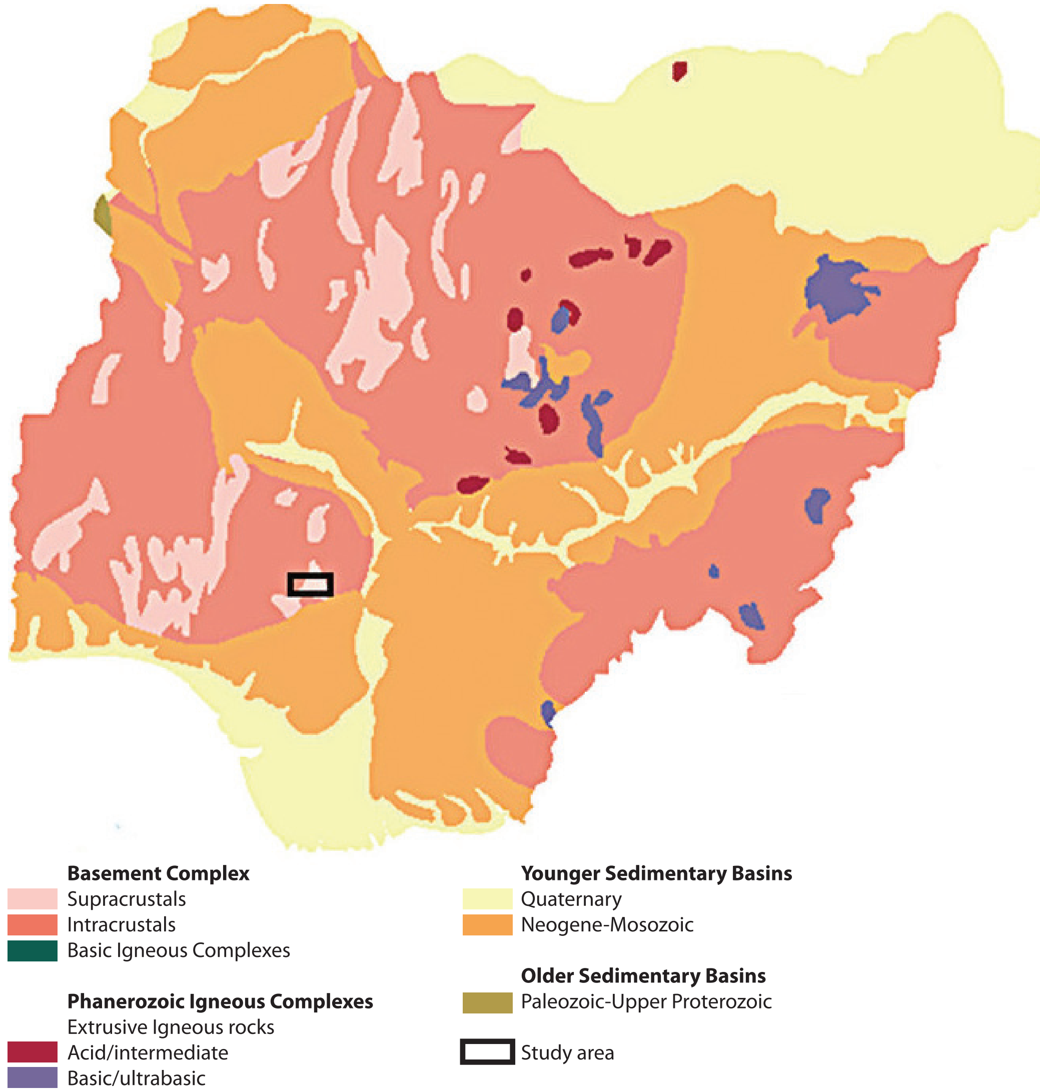


**Figure 1:** *Geological map of Nigeria showing the study area (Adapted from NGSA, 2006)*[13].

Titanium dioxide, Cu monoxide, Al triolyphosphate, Fe oxide and pigment powder whilst the bottling company was producing non-alcoholic drinks and the materials used were mainly water, flavours and sugar.

The sites were denoted with IB-01 to IB-06 as shown in Figure 2 and Table 1 respectively while the concentration of heavy metals in the wastewater samples varied considerably from one site to another. The wastewater samples were collected in plastic containers; these were pre-washed and rinsed with tap water and later soaked in 10 % $HNO_3$ for 24 h before they were rinsed with distilled water prior to usage. The wastewater samples were labeled appropriately and conveyed to the laboratory for chemical analysis using the standard ICP and OES chemical procedures proposed by[14] and the American Environmental Protection Agency EPA[15]. Accuracy and instrument detection limits for measured heavy metals were estimated by taking replicate measurements of the calibrated blank (1 % nitric acid) in accordance with 85–115 % of EPA[15] set limit and accuracy of 0.1 for Cd, 1.5 for Pb, 0.5 for Ni and 0.3 for Cr and Cu respectively.

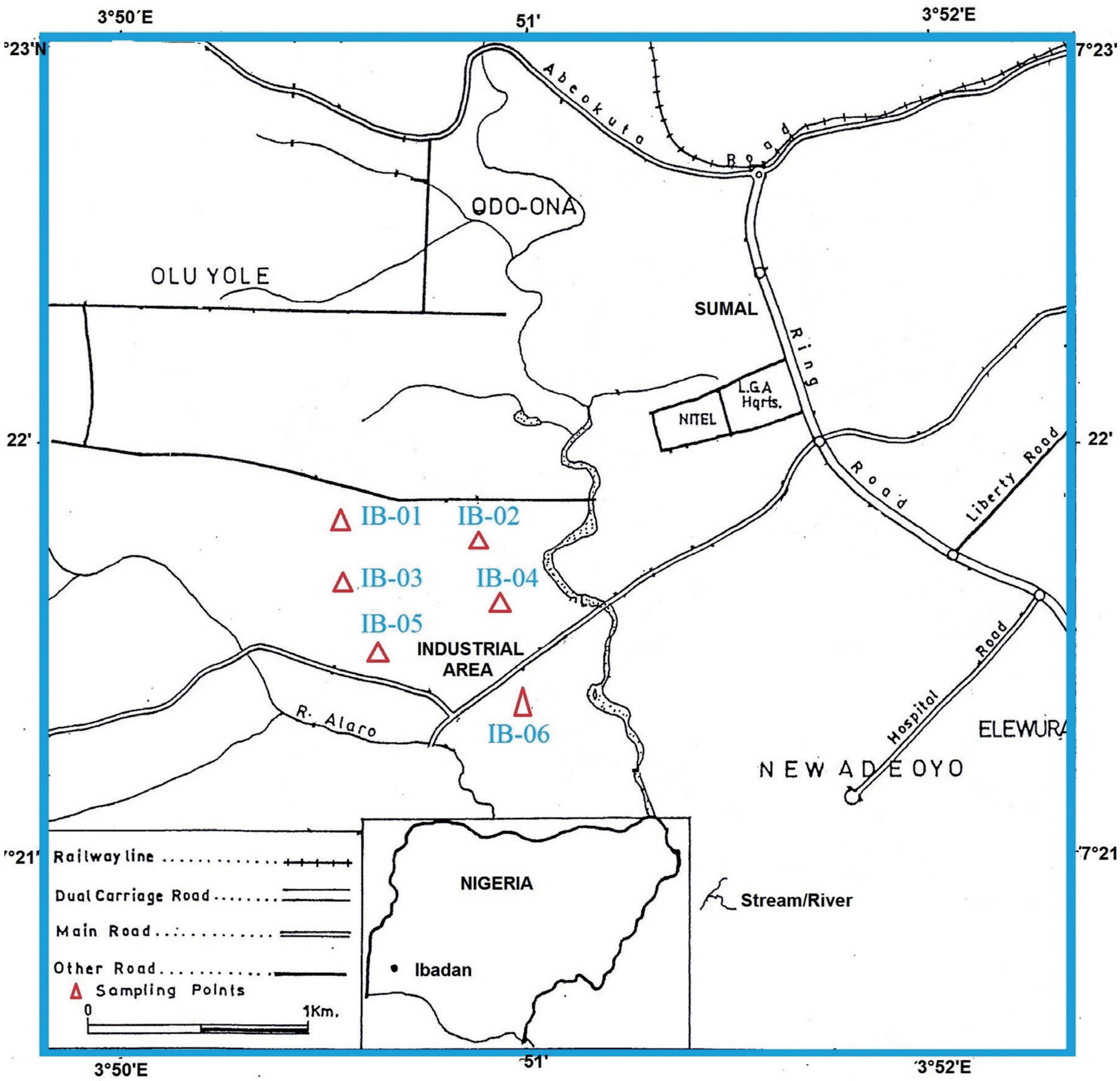


**Figure 2:** *Map of study area showing sampling points.*

## Results and discussions

The results obtained from the chemical analysis of wastewater samples are reported in Tables 1 and 2 and depicted graphically in Figures 3 and 4 respectively.

Table 2 presents the comparison between the average concentration of heavy metals in wastewater samples and the WHO standards in mg/L. The average concentration of heavy metals is given in the order of abundance as Cu>Cr>Ni>Pb>Cd.

**Table 1:** *Heavy metal concentrations in wastewater samples at various sampling points* (mg/L)

| Sample points | Cu | Ni | Pb | Cr | Cd |
|---|---|---|---|---|---|
| IB-01 | 5.5 | 2.3 | 0.5 | 2.4 | 0.6 |
| IB-02 | 4.1 | 3.6 | 0.6 | 3.2 | 0.5 |
| IB-03 | 6.7 | 4.4 | 0.9 | 3.9 | 0.9 |
| IB-04 | 3.8 | 1.7 | 0.4 | 2.7 | 0.4 |
| IB-05 | 1.9 | 2.2 | 0.7 | 3.8 | 0.2 |
| IB-06 | 2.2 | 1.4 | 0.3 | 1.9 | 0.1 |

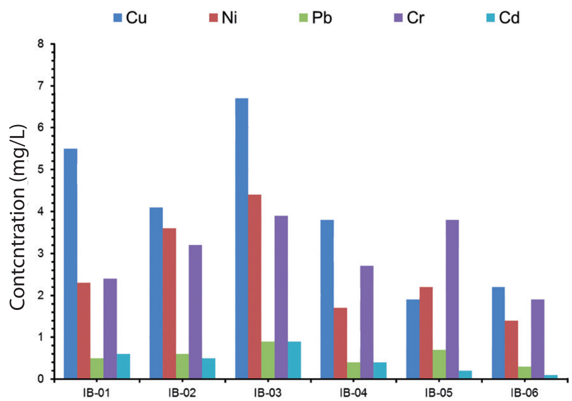


**Figure 3:** *Distribution of heavy metals in wastewater samples.*

**Table 2:** *Average concentration of heavy metals in wastewater samples and WHO standards (mg/L)*

| Parameter | Cu | Ni | Pb | Cr | Cd |
|---|---|---|---|---|---|
| **Concentration** | 4.00 | 2.60 | 0.60 | 3.00 | 0.50 |
| **W.H.O. standards** | 1.20 | 0.02 | 0.01 | 0.05 | 0.003 |

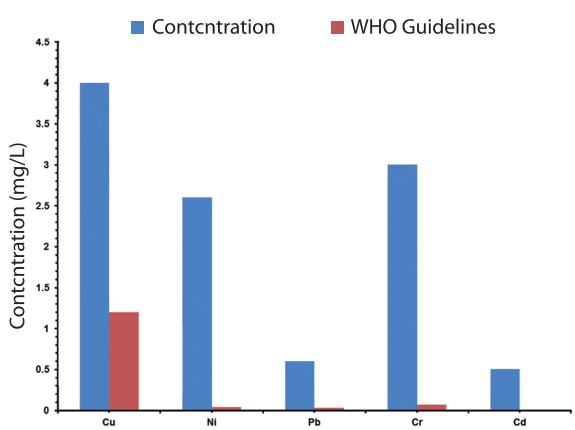


**Figure 4:** *Average concentration of heavy metals in wastewater samples versus WHO Guidelines values* (mg/L).

The chemical concentration of heavy metals analysed revealed significant variability across the geographic spread of the sample points in the study area. The order of relative abundance of heavy metals in wastewater samples is given as Cu>Cr>Ni>Pb>Cd indicating a higher concentration of Cu as 6.7 mg/L while Cd has the least value, which is 0.1 mg/L. Higher values obtained for Cu in the wastewater could have been due to the correspondingly high Cu content of chemical additives used in the production chain. Ayedun et al.[16] confirms that groundwater pollution by toxic heavy metals has inherent health risks.

This study reveals there is a generally high concentration of toxic heavy metals higher than the permissible contaminant levels established by WHO[17,18] as shown in Table 2 and Figure 4 respectively. Sharma et al.[19] confirms that Cu plays an important role in chemical and biological processes in the environment and that excessive exposure could lead to health hazards. In the same vein increased concentration and long term exposure of humans to Ni can lead to decreased body weight, liver and heart damage and skin irritation as reported by James et al.[20]. Cr has been reported to increase lean body mass and cause a reduction in the percentage of body fat, which may result into weight loss in humans[21]. Pb can cause acute and chronic symptoms of poisoning depending on the level and duration of exposure[22] and it can also affect mental development such as impaired intelligence. James et al.[20] affirms that Cd has been reported to be associated with renal dysfunction and obstructive lung disease which has been linked to lung cancer, skin irritation and ulceration.

## Conclusions

The higher concentration of toxic heavy metals in the wastewater samples indicate indiscriminate disposal and negligence of the manufacturing industries towards duty-of-care as a result of untreated wastewater prior to disposal into the environment. The discharge of these raw wastewaters into the natural environment may have also contributed significantly to the bioaccumulation of heavy metals in the ecosystem. Therefore, it is expedient that the polluting industries should endeavour to treat raw wastewaters using state-of-the-art technologies before disposal in order to keep the environment safe and reduce the potential health risks in the area.

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