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Spectroscopic investigation of heavy metals in waste water from University students' halls of residence

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ABSTRACT: Although there is increased global concern on sustainable environmental and human health management, the African countries are still unserious which should not be the case considering the potential consequences of harmful chemicals discharge into our environment from domestic and other anthropogenic activities. We are therefore reporting in this paper a spectroscopic assessment of heavy metals in wastewater generated from students' halls of Usmanu Danfodiyo University Sokoto, Nigeria. The analysed samples showed mean concentrations (ppm) range of 6.40-14.80, 0.40-1.83, 0.001-0.005, 0.001-0.005 and 0.55-2.09 for Fe, Cr, Cd, Ni and Pb respectively. When compared with the maximum allowed limits set by World Health Organisation (WHO) for drinking water, the samples are heavily contaminated with Fe, Cr and Pb. This accounts for potential pollution risks, requiring attention from appropriate agencies.

Key words: Students' hall, Wastewater, Heavy metals, Pollution.

Introduction

Heavy metals are elements with specific gravity of atleast 5.0 recognised as health and environmental threats since many decades due to associated pollution risks (Ademoroti, 1996). In the recent years much environmental concern has been focused on the contamination of soils and water by these species (Leharne and Xio, 1987), which may occur in a number of ways simply classified as geochemical processes and human activities such as metal smelting industries, coal combustion, auto emissions and application of commercial fertilizers, liming materials, sewage sludge, animal waste and irrigation water (Cunningham *et al*., 1975).

Some of these heavy metals have no essentials biological function and are highly toxic to plants and animals, for example accumulation of cadmium in the kidney cortex can cause malfunction of the kidney cortex (Alloway, 1990). Generally, environmental pollution has its source mainly from industries either as solid, gas and most especially liquids in the form of waste water or effluents allowed to drain into water ways. Therefore, it became necessary to adopt a method through which heavy metals and other parameters in wastewater can be determined and removed.

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In most Nigerian cities today, roadside sellers contribute immensely to the deplorable conditions caused by dirtiness resulting from cans of soft drinks, banana, orange peels, and wrappers of sweets disposed on the streets. Similarly, a considerable number of food items such as kolanuts, eba, moi-moi and agidi are wrapped in thick layers of leaves, usually disposed off on the streets. In most cases these wastes find their way to gutters and later into lakes, dams, streams and other water bodies (Sada, 1988).

In addition to that, domestic and industrial wastewater containing large quantities of chemical substances are discharged into rivers without proper treatment, causing serious water pollution. The major concern has been how to ensure sustainable development and utilization of water resources.

On the other hand, heavy metals, present serious danger to human health because of their ability to be accumulated in different organs as well as their inability to neither be rapidly removed nor readily detoxified through metabolic activities (Schlatter, 1994). These substances find their way into humans either by direct absorption via the air or drinking water, or the food chain. An indispensable link in the chain is plant life (marine or terrestrial); from which human receive their allocation of heavy metals either directly or indirectly by feeding upon herbivorous animals which depend on plants for their nutrition (Ademoroti, 1996; Bockris, 1977).

In terms of potential adverse health effects, cadmium, lead and arsenic are amongst the elements that have caused most concerns. This is because they are readily transferred through food chains and are not known to serve any essential biological function (Friberg *et al*., 1979). While the effect of chronic exposure to trace amount of some metals is not well understood, a legacy of incidents revealed the seriousness of high level of exposure to some metals, especially cadmium and methyl mercury. In the 50's chronic cadmium poisoning from rice, coupled with dietary deficiencies, caused an epidemic of kidney damage and a painful skeletal disease among middle aged women in Japan (Nagase *et al*., 1994). Also in Japan mercury poisoning from fish in a polluted rivers had been reported. Minamata incident is one of these industrial disasters where several deaths had been documented. Overall, the major risks associated with heavy metals exposure include irritation of the eyes and respiratory passages, damage to brain, liver, bones and kidney, bronchitis, dermatitis, emphysema, hypertension, rickets and asthma. Others are mutagenic, carcinogenic and tetragenic (Ademoroti, 1996; Su and Wong, 2003).

The current study reports a determination of the presence and concentration levels of some heavy metals such as Iron (Fe), Chromium (Cr), Cadmium (Cd), Nickel (Ni) and Lead (Pb) in wastewater generated from Usmanu Danfodiyo University students' halls.

Materials and Methods

Sampling

Wastewater samples were collected from the outlets of six different blocks (A-F) of students' halls in the permanent site of Usmanu Danfodiyo University Sokoto, Nigeria between 29th May and 3rd June, 2009. After coding according to respective blocks, the samples were stored in pre-cleaned and dried plastic containers under laboratory conditions before subsequent analysis on 4th June, 2009.

Sample Digestion and Analysis

Sample digestion was carried out according to standard analytical methods using Nitric acid ($HN0_3$), Hydrochloric acid (HCl) and Sulphuric acid (H_2SO_4) at relatively low temperature as reported by Tinsely (1979) and Walinga *et al*. (1989). Stock solutions were prepared based on standard analytical methods adopted in Walinga *et al*. (1989). For the analysis, the Spectrophotometer (Pye Unicam Model) was calibrated with with standard solutions and the digested samples analysed for the presence and concentrations Fe, Cr, Cd, Ni and Pb at their respective detection wavelengths.

Results and Discussion

The results of the Atomic Absorption Spectrometric analysis (determination) of some heavy metals in domestic wastewater samples generated from Usmanu Danfodio University, Sokoto residence hall showed the presence of various metals namely; Iron (Fe), Chromium (Cr), Cadmium (Cd), Nickel (Ni) and Lead (Pb). A summary of the mean concentration of these metals in wastewater samples collected from six different sampling points are shown in Table 1.

Table 1: Mean concentration of heavy metals in domestic wastewater.

SAMPLE	**CONCENTRATION OF ELEMENTS (PPM)**				
	Fe	**Cr**	**Cd**	**Ni**	**Pb**
A	10.105±3.821	1.834±0.779	0.003±0.002	0.005±006	1.201±0.193
B	6.401±1.776	0.402±0.386	0.003±0.004	0.005±0.006	0.548±0.473
C	6.766±1.776	1.347±0.795	0.003±0.003	ND	2.096±0.743
D	28.380±10.321	1.474±1.391	0.005±0.003	0.004±0.008	1.402±0.926
E	11.203±1.382	0.967±0.852	0.001±0.002	0.001±0.018	0.561±0.921
F	14.775±10.898	0.887±0.912	0.002±0.002	0.011±0.019	0.703±0.831

The results are expressed as Mean±Standard deviation, ND = Not detected

Table 2: WHO's tolerance limits of heavy metals.

METAL	**UPPER LIMIT OF CONCENTRATION (ppm)**
Lead (Pb)	0.05
Cadmium (Cd)	0.01
Chromium (Cr)	0.05
Nickel (Ni)	0.05
Iron (Fe)	0.3

Source: Ademoroti, (1996)

Fe have larger levels in all the samples analysed with block D recording the highest concentration (>28ppm). When compared with the maximum permissible limit of 0.3ppm reported in WHO guidelines (Table 2) all the samples are heavily contaminated with Fe, accounting to a multiple factor of atleast 20 (Figure 1). Although this could be related to Fe concentration in the sampling site soils, frequent disposal of carrier wastes in the outlets may be the main factor. In addition to soil contamination due to accumulation, acute toxicity, to the aquatic species of Kwalkwalawa River (the major recipient of wastewater from the area), the plants of the neighboring irrigation areas could be polluted and therefore the inhabitants who solely rely on these farms for their daily vegetables are at serious risk. Studies from other parts of the world documented Fe to have considerable effects on alveolar epithelial cells (Riley *et al*., 2003). Even though allowed limit is necessary for normal human health, higher concentrations are associated with stomach and intestinal corrosion, leading to bleeding and shock development.

Like Fe, all the samples are contaminated with elevated levels of Cr and a multiple factor of atleast 16 (Figure 2) when compared with WHO guidelines for drinking water (Table 2) and with block A having the highest concentration. International findings indicated Cr to be a major environmental contaminant. Health consequences include respiratory cancer, mutations, chromosomal aberrations, and cultured mammalian cells transformation (Usman, 2000; Li *et al.*, 2001). In addition to potential decrease in oxidant defense system ability, chromium exposure causes reduction in sperm quality and consequently reproduction potentials of both human and exposed animals (Li *et al.*, 2001). The actual sources of the Cr contamination in the study site should therefore be quickly identified and addressed by the inhabitants or their appropriate authorities on time.

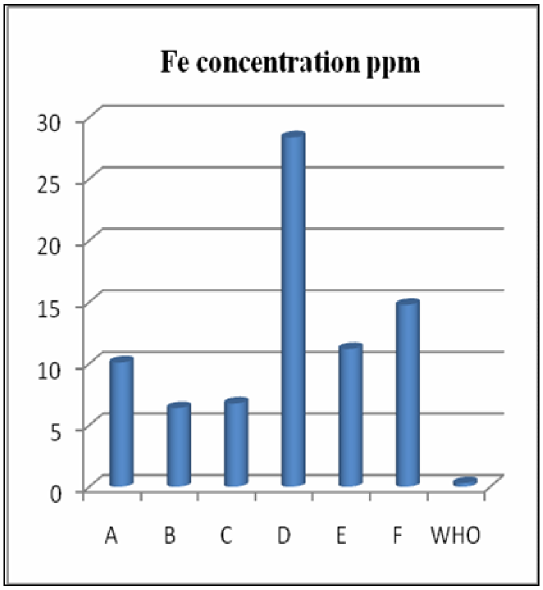

Figure 1: Fe level in samples.

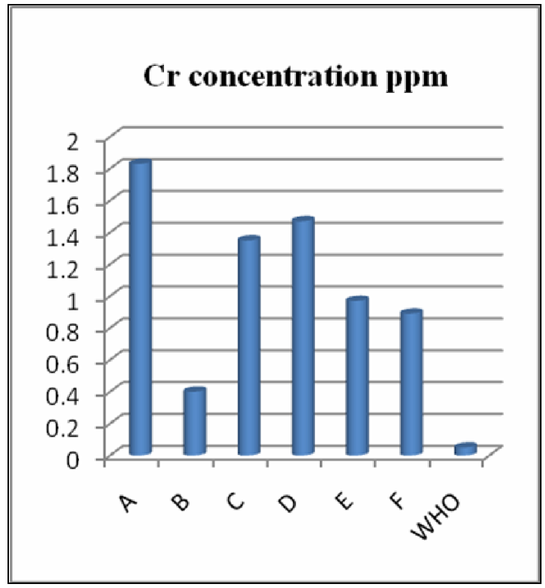

Figure 2: Cr level in the samples

In each case the area label WHO represents the maximum level accepted by World Health Organisation for drinking water.

Another seriously hazardous specie found in high concentrations from the study site is Pb. As seen from Figure 3, the lowest level obtained with block B is about eleven times the upper permissible limit of Pb concentration in drinking water reported in Table 2. We have attributed the elevated levels to continuous used and disposal of lead batteries by the students and scratched leaded paints. Similarly, tailpipe emission from students' cars constantly passing the sampling area is a major contributing factor because similar cases had been reported globally. For example, Blokker (1972) documented up to 3000ppm of Pb in samples from heavily transported high ways. Johansson *et al.* (2009) have also reported high concentrations in massively traffic areas of Stockholm, Sweden. According to them combustion of leaded gasoline is a serious risk to water, air and soil contamination. The major problems of lead exposure include several neurotoxicities, especially in young children and gestation and lactation mortalities.

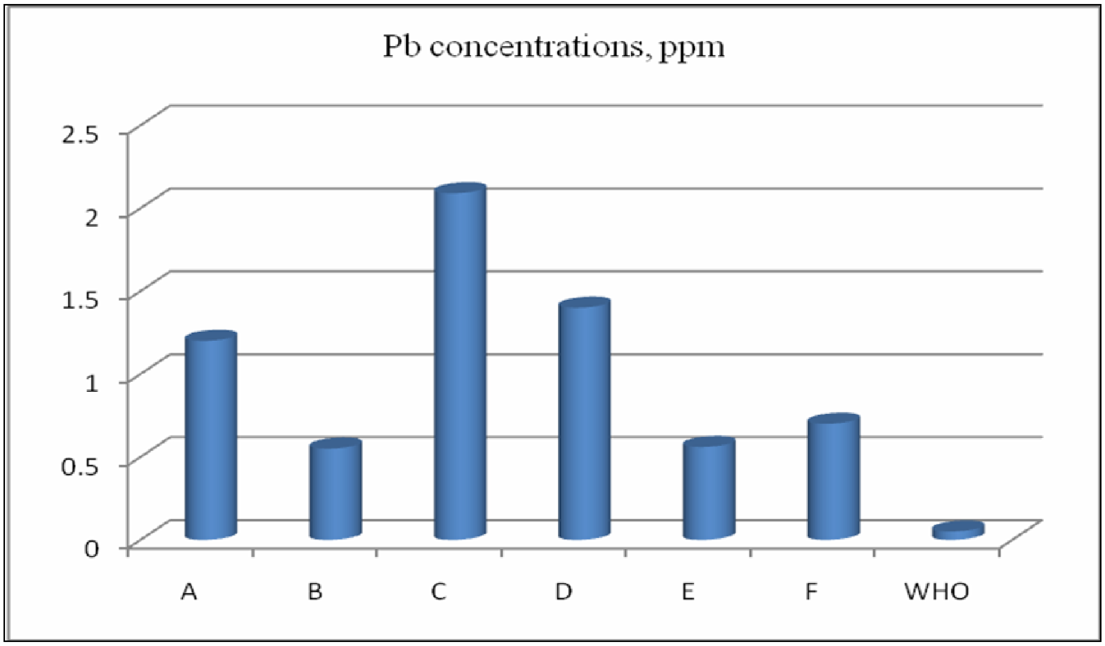

Figure 3: Pb concentrations in the samples compared with permissible WHO limit.

The remaining heavy metals (Ni, Cd) detected were found to exhibit very low concentrations within the recommended limits reported in Table 2. This provides an indication that there is low usage of Cd and/or Ni containing materials and potential contamination by these species within the sampling site is absent. However, regular monitoring is required to avoid unforeseen consequences because large concentration carrier waste water or products may be disposed in future. Since Cd is usually coupled to Ni to form Cd-Ni battery, we assume that these batteries are either not in circulation or only used to a very low extent in the halls. Cd can also be found in pigments and plastic and therefore should be noted. This metal is not essential to animal like Fe but can cause severe diseases like the itai-itai disease documented in Japan. Generally, the levels of the metals analysed increased in the order Fe> Cr> Pb >Ni > Cd in most of the samples. This could be clue for assigning mitigation priority by the concerned authorities.

Conclusion

The elevated levels of Fe, Pb and Cr in the analysed samples showed that there is heavy metals contamination at the sampling sites. This could be attributed to continuous usage of containing products by the students and the disposal of carrier wastes by the sellers of different items in the residence premises. The higher concentration of Fe may also be associated with its content in the soil of the sampling sites. High lead level on the other hand can be due to anthropogenic emissions from the combustion of leaded gasoline (i.e tailpipe emissions) by the numerous number of students' cars loitering in the sampling area. Use of leaded batteries and renovation paints is another important factor to be considered. Sources of Cr in the samples had been attributed to reasons similar to Fe. Cd and Ni showed low concentrations accounting for low usage and disposal of carrier materials. Overall, the area is at potential risk of severe heavy metals pollution requiring immediate action by appropriate authorities.

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