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HEAVY METALS CONTENT IN LABORATORY WASTEWATER: A CASE STUDY OF SELECTED UNITS OF BAYERO UNIVERSITY, KANO-NIGERIA.

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ABSTRACT

Heavy metals are well-known environmental pollutants due to their toxicity, persistence in the environment and bio-accumulative in nature. They contribute immensely in the environmental pollution and their sources include weathering of metal bearing rocks, mining, industrial and agricultural activities. Laboratory is a major point of research activities. This study is aimed at accessing the level of heavy metals in some laboratories wastewater in Bayero University, Kano. Four different laboratories where selected (Biochemistry, Chemistry, Microbiology and Central Laboratory complex) from Bayero University Old Campus. The wastewater samples were collected four times with one week interval and some heavy metals were determined using microwave plasma atomic emission spectrometry (MP-AES). The average mean concentrations of Cd, Cr, Co, Mn, Ni and Pb in each laboratory were compared with WHO standard in wastewater. The Results obtained from Biochemistry Laboratory for Cd, Cr, Co, Mn, Ni and Pb are 0.0067±0.0001, 0.0000±0.0000, 0.000±0.0000, 0.010±0.001, 0.027±0.0001 and 0.106±0.0001 mg/L respectively. Similarly Central laboratory with 0.07±0.001, 0.47±0.002, 0.00±0.00, 0.31±0.003, 0.10±0.002 and 0.20±0.001 mg/L. While Microbiology Laboratory with 0.00±0.00, 0.00±0.00, 0.00±0.00, 0.063±0.001, 0.027±0.001 and 0.093±0.0001 mg/L respectively. And Chemistry laboratory with 0.000±0.00, 0.607±0.0001, 0.053±0.002, 2.183±0.001, 0.127±0.0001 and 0.263±0.0002 respectively. Among all the laboratories, chemistry laboratory was found to have higher average mean concentrations of Mn, Ni and Pb and are above WHO Standard. However some heavy metals like Cr and Cd were found to be lower compared to WHO Standard. Therefore the wastewater studied contained some heavy metals which contribute to the environmental pollution and measures should be taken by the management concerned to ensure good laboratory waste management.

Keywords: Heavy metals, Laboratory, waste, Management.

INTRODUCTION

The wastewater from chemical laboratory was discharged from various laboratory activities, such as washing of glass ware and chemical waste from research and educational experimental activities. Discharged chemical liquid contains toxic chemicals, organic compounds and heavy metals which are harmful to living organism and the environment (Putra *et al*., 2017).

In order to reduce combined environmental impact and the risk of discharging harmful substances from laboratory activities, it is very important that everyone contributes to reducing emissions of chemicals to the sewer network as far as possible. Therefore wastewater from university laboratories should be channeled to a central treatment plant. Environmentally hazardous and harmful substances, such as heavy metals and certain organic substances which are degradable with difficulty, toxic, bioaccumulative (are stored in living organisms) or inhibit nitrification/denitrification (interfere with nitrogen separation) must on no account before discharged into the sewer network. All chemical solutions which differ in their chemical content from normal household waste shall be collected in waste containers and sent for destruction as hazardous waste (*https//medarbetarpartalen.gu.se*).

Environmental impact of heavy metals was earlier mostly attributed to industrial sources and agricultural activities. There has been growing concern over the diverse effects of heavy metals on humans and aquatic ecosystems. A significant part of the anthropogenic emissions of heavy metals ends up in wastewater. Major industrial sources include surface treatment processes with elements such as Cd, Pb, Mn, Cu, Zn, Cr, Hg, As, Fe and Ni, as well as industrial products that are discharged in waste. Major urban inputs to sewage water include household effluents, drainage water, business effluents (e.g. car washes, dental uses, other enterprises, etc.), atmospheric deposition, and traffic related emissions (vehicle exhaust, brake linings, tires, asphalt wear, gasoline/oil leakage, etc.) transported with storm water into the sewerage system. For most applications of heavy metals, they are estimated to be the same in nearly all countries, but the consumption pattern may be different. For some applications which during the last decade has been phased out in some countries, there may, however, today be significant differences in uses (Hui, *et al*., 2005), (Ahluwalia, *et al*., 2007). Most common sources of heavy metals to waste and/or wastewater are European Commission (2002); (i) Mining and extraction; by mining and extraction a part of the heavy metals will end up in tailing and other waste products. A significant part of the turnover of the four heavy metals with mining waste actually concerns the presence of the heavy metals in waste from extraction of other metals like zinc, copper and nickel. It should, however, be kept in mind that mining waste is generated in-dependent of the subsequent application of the heavy metal. (ii) Primary smelting and processing; a minor part of the heavy metals will end up in waste from the further processing of the metals. (iii) Use phase; a small part of the heavy metals may be lost from the products during use by corrosion and wear. The lost material may be discharged to the environment or end up in solid waste either as dust or indirectly via sewage sludge. (iv) Waste disposal; the main part of the heavy metals will still be present when the discarded products are disposed. The heavy metals will either be collected for recycling or disposed to municipal solid waste incinerators (MSWI) or landfills or liquid waste. (v) Volcanic eruptions (vi) fossil fuel combustion. (vii) Agriculture (viii) erosion (ix) metallurgical industries. Actually metal pollutants are neither generated nor completely eliminated; they are only transferred from one source to another. Their chemical forms may be changed or they are collected and immobilized not to reach the human, animals or plants.

The term "heavy metals" refers to any metal and metalloid element that has a relatively high density ranging from 3.5 to 7 g/cm3 and is toxic or poisonous at low concentration and include mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), Nickel (Ni), Zinc (Zn), Copper (Cu) and lead (Pb). Although "heavy metals" is a general term defined in the literature, it is widely documented and frequently applied in the widespread pollutants of soil and water bodies (Gautam *et al*., 2014). These metals are found widely in the earth crust and are non-biodegradable in nature. They enter into the human body via air, water and food (Gautam *et al*., 2014).

The analysis of waste-water for trace and heavy metal contamination is an important step in ensuring human and environmental health. Wastewater is regulated differently in different countries, but the goal is to minimize the pollution introduced into natural waterways. In recent years, metal production emissions have decreased in many countries due to heavy legislation, improved production and cleaning technology. A variety of inorganic techniques can be used to measure trace elements in waste water including flame atomic absorption spectrometry (FAAS) and graphite furnace (or electro-thermal) atomic absorption spectrometer (GFAAS or ETAAS), microwave plasma atomic emission spectrometer (MP-AES), inductively coupled plasma optical emission spectrometer (ICP-OES) and inductively coupled plasma mass spectrometer (ICP-MS). Depending upon the element and/or its concentration, the most suitable technique for business requirements or sensitivity can be chosen. Information and or literature on the levels of heavy metals pollution from laboratory wastewater is scanty, therefore this study is aimed to determine the heavy metal content from various research laboratories: a case study of Bayero University old Campus.

MATERIALS AND METHODS

Chemicals/Equipment

All solvents were purchased from Merck. Standards and reagents used were purchased from Sigma-Aldrich. All chemicals used in the study were of analytical grade. The Equipment used are MP-AES (AGILENT 4210) Agilent Technologies and Advanced Microwave Digestion System, (.Model: EHOS EASY)

Sample Collection

The wastewater samples were collected four times weekly from the four different research laboratories in a clean plastic containers and directly transported to the laboratory for the sample digestion and heavy metal analysis.

Sample Digestion (Using Advanced Microwave Digestion System, Model: EHOS EASY)

The samples were prepared as programmed by the equipment; briefly: Ten milliliter (10ml) of samples were measured and transferred into 90ml microwave digestion vessels. Ten millilitres (10ml) mixture of 15.9N trace metal grade Nitric acid, hydrogen peroxide and perchloric acid (7:2:1) was added to each vessel. After standing for one hour (1h), the samples were processed by microwave digestion system as follows: ramp temperature from ambient to 200^{o}C over 20min, then hold at 200^{o}C for 20min, after digesting, they were allowed cool to approximately 50^{o}C or lower before handling. The digestion was transferred to 50ml volumetric flask, the solution volume was adjusted to 50ml with deionised water and filtered for instrumental analysis.

Heavy Metals Analyses

The Heavy Metals content was determined using Agilent Microwave Plasma Atomic Emission Spectrometer (MP-AES Model: AGILENT 4210) as described by (Li *et al*., 2013), at Central Instrumentation Laboratory, Centre for Dryland Agriculture, Bayero University, Kano.

Experimental Procedure (using MP-AES Model: AGILENT 4210)

All measurements were performed using Agilent 4210 MP-AES. The sample introduction system consisted of PVC peristatic pump tubing (white/white and blue/blue), a single pass cyclonic spray chamber and the oneNeb nebulizer. The Agilent MP Expert software was used to automatically subtract the background signal from the analytical signal. A background spectrum from a blank solution was recorded and automatically subtracted from each standard and sample solution that was analysed. The software was also used to optimize the nebulization pressure and the viewing position for each wavelength selected to maximize sensitivity. Because of this optimization, and considering that all determinations were carried out sequentially, each analyte was determined under optimized conditions. A standard reference solution was used to quickly and easily optimize the parameters (Li *et al*., 2013).

Table 1: Agilent 4210 MP-AES operating parameters for determination of macro and micro-nutrients in plants samples

Parameter	Value
Pump speed	15
Sample uptake delay (s)	15
Stabilization time (s)	15
Read time (s)	5
Replicate	3
Rinse time (s)	25
Sample pump tubing	Orange/green solvaflex
Waste pump tubing	Blue/blue solvaflex
Background correction	Auto
Gas source	V350 Alliance Nitrogen generator

Table 2: Agilent 4210 MP-AES Settings condition for each analyte

Element	Emission wavelength (nm)	Nebulizer gas flow rate (L/min)
Pb	405.781	0.75
Cd	228.802	0.50
Cr	425.433	0.90
Mn	403.076	0.65
Co	340.512	0.75
Ni	352.454	0.70

RESULTS AND DISCUSSION

The results obtained from this study were statistically analyse and the average mean concentrations for the four different weeks and different laboratories were presented in Table 3. It was observed that the mean concentrations of Pb from each laboratory found to be significantly higher (P>0.005) when compared to the other elements. When comparing the mean concentrations of Pb among the four laboratories, the samples collected from the chemistry laboratory was higher than other laboratories and this could be as a result of many activities with respect to bio-remediation and phyto-remediation research using synthetic pollutant and other synthesis that involve the use of Pb salt.

The mean concentrations of Mn. Co and Ni from Chemistry laboratory are significantly higher than those recorded in the other laboratories studied and could also be attributed to the much use of inorganic salt in the chemistry laboratory than other laboratories. However the mean concentration of chromium from the central laboratory waste was much higher compared to the other laboratories may be as a result of waste that come out from their atomic absorption spectrometer machine. The cadmium contents from all laboratories is lower than other elements analysed, this could be as a result of low or non-usage of cadmium salts in most of biochemical or physical researches, because unlike other heavy metals, cadmium is not essential for biological system, therefore it has no benefit to the ecosystem and only harmful effect have been reported in literature (Gautam *et al.*, 2014).

Table 3: The average mean concentrations of the heavy metals in the laboratories and WHO Standard.

Lab. / Elements	Cd (mg/L)	Ni (mg/L)	Co (mg/L)	Pb (mg/L)	Mn (mg/L)	Cr (mg/L)
BCH	0.0067 ±0.0001	0.0200 ±0.0001	0.000 ±0.000	0.1060 ±0.0001	0.010 ±0.001	0.0000 ±0.0000
MCB	0.0000 ±0.0000	0.0270 ±0.0010	0.000 ±0.000	0.0930 ±0.0001	0.063 ±0.001	0.0000 ±0.0000
CHM	BDL	0.1270 ±0.0001	0.053 ±0.002	0.2630 ±0.0002	2.183 ±0.001	0.6070 ±0.0001
C LABS	0.0700 ±0.0010	0.1000 ±0.0020	0.000 ±0.000	0.2000 ±0.0020	0.310 ±0.003	0.4700 ±0.0020
WHO	0.0100	0.2000	0.010	0.0500	0.050	0.0500

Note: BCH=Biochemisrty, MCB=Microbiology, CHM= Chemistry, CLABS= Central Laboratory, WHO= World Health Organization (2011)

A proper arrangement should be made in order to treat laboratory wastewater before discharge to water bodies or absorb by the environment, Additionally, involvement of scientific techniques such as precipitation and coagulation, ion exchange, membrane filtration, bioremediation, adsorption and heterogeneous photocatalyst in the laboratory waste management will drastically reduce the effect of heavy metal pollution and provide knowledge to many environmental scientist.

CONCLUSION

The concentrations of heavy metals in the biochemistry, microbiology, chemistry and central laboratories were determined and then compared among the laboratories, chemistry laboratory was found to have higher average mean concentration of heavy metals analysed. Therefore concentration of heavy metals (Co, Pb, Mn, and Ni) measured were above the permissible limit set by WHO (2011) and this can contribute to environmental pollution when discharged to environment or waterways and ultimately cause a deleterious effect to humans and animals health.

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