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# Determination of Some Metal Contaminants from Textile and Leather Industrial Effluents in Kano, Nigeria Using Neutron Activation Analysis (NAA) Technique

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***Abstract***
*This investigation was made to ascertain the metal contaminants in the effluents collected from textile and leather (tannery) industries in Kano, Nigeria. The chemical analysis of metallic parameters was conducted using Neutron Activation Analysis (NAA) technique. About twenty-eight (28) elements (metals) were determined from eight (8) samples collected from the industries, including soil for background value. The background loading factors of each component were determined by comparison of the elemental concentration with that of a typical soil collected from a non-industrial area within the same city. The values obtained were compared with the Federal Ministry of Environment (FMENV) limitation values to provide insight into the environmental and health implications of the effluents. The result showed that metals; Al, As, Co, Cr, Fe, Mn, and Zn exceeded the standard limit set by FMENV in textile industries while As, Co, Cr, Mn, and Zn for the leather industries.*
***Keywords:*** *Heavy metals, Neutron Activation Analysis (NAA), Textile, leather and effluents,*

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## I. Introduction

It is no secret heavy metals are important for the proper functioning of biological systems. However, their deficiencies or excesses could lead to several disorders[1]. In Nigeria, the major source of heavy metal pollution is industrial effluents discharged from various processing and manufacturing industries. This increases the influx of metals, which can be transported by wind and water, thus become available to plants and animals (including humans). These heavy metals attain higher concentrations, accumulate in dangerous quantities in different plants, and finally pose serious health hazards to human beings and animals through biomagnifications[2]. Heavy metals, including the essential and non-essential elements, have significance in ecotoxicology since they are persistent, and all have the potential to be toxic to living organisms[3]. Heavy metals such as copper, iron, chromium, and nickel are essential metals since they play a crucial role in biological systems.

In contrast, cadmium and lead are non-essential metals, as they are toxic even in trace amounts[4]. Heavy metals pollution is a problem associated with intensive industrial activities from where untreated effluents are introduced into the environment[5]. Industrialization no doubt develops the world and makes life better through the creation of wealth and employment opportunities. Ironically, human lives are being hunted by the massive volume of waste emanating from these industries, especially when discharged into the environment without proper treatment[6]. Local impacts are pronounced because these wastes are generally generated throughout the year, giving no room for the environment to discover. Most of these wastes are discharged directly or indirectly into open gutters, streams, and Rivers (as do the case of Chalawa River). The essential issue is how industrial development can take place without necessarily destroying the environment[7].

Effluents generated by the industries are significant sources of pollution in Nigeria and even worst in industrialized cities[6]. Contaminated air, soil, and water by effluents are associated with a heavy disease burden[8]. This could be part of the reasons for the current shorter life expectancy in Nigeria[9].Some heavy metals contained in these effluents (either in free form or absorbed in the suspended solids) be carcinogenic[10], while other chemicals equally present are poisonous depending on the dose and exposure duration[11].These chemicals are not only deadly to humans but are also found toxic to aquatic life[8], and even dangerous to plants as well, and they may result in food contamination[12]. Industrial effluent: is discharged from the textile, and leather contains high number of metals, especially chromium. These effluents are released on the land and dumped into the surface water, which ultimately leaches to groundwater and leads to groundwater contamination[13]. Hence, industrial effluents offer a broad scope of environmental problems. Their associated health hazards are becoming more complex and critical, especially in regions where little or no attention is given to environmental laws.

Generally, the concentration of heavy metals in the environment occurs due to the continuous disposal of untreated industrial effluents generated during the operational phase of industries[14]. All these metals in these industrial effluents cause a severe health hazard, and their removal is one of the most effective ways of safeguarding our environment. This can be achieved by treating the effluents before discharge[15], but first, the analysis must be done to establish the type and concentration of metals present. In the present context of the study, particular emphasis is placed on the status of metals in effluents of textile and leather (tannery) leather industries. A systematic study was done using Neutron Activation Analysis (NAA) technique. NAA is based on the nuclear activation technique. Challawa industrial layout is one of the industrial areas in Kano city of Kano state. So many industries whose effluents are used for this study are located here. This is obviously due to both raw and human resources and water[15].

## II. Methodology

Eight (8) samples, including soil for background value of elements, were collected using plastic containers. The soil for background value was collected from a non-industrial area at a considerable distance away from the textile companies. The collected samples vary in composition and color depending on the industry and the stage of production. The sludge was collected right from the effluent discharge point within the neighborhood of the plant just before they flow into the drainage canal and then empty into the Challawa River in Kano.

The samples were air/oven-dried within 55oC to 75oC for approximately four hours. Furthermore, they were grinded to fine dust and regimented with mortar and pestle. The grinded samples were sieved with sieving cloth to obtain fine particle size, packaged, and taken to the Centre for Energy Research and Training (CERT) Ahmadu Bello University, Zaria, Kaduna state for analysis. The samples were analyzed for twenty-nine (29) elements (metals), but ten (10) elements (metals) of interest were selected for this study. A thorough description of the laboratory procedures for NIRR-1 irradiation and gamma-ray counting protocols adopted is available[16].

The environmental impact of element levels from effluents on the background soil was assessed using a background loading factor defined as

Background loading factor (BLF) = $\frac{[\mathrm{Ci}]\mathrm{eff}}{[\mathrm{Ci}]\mathrm{soil}}$

Where :

$[Ci]_{eff}$ = concentration of the ith element in the industrial effluent

$[Ci]_{soil}$ = concentration of the ith element in the soil (assumed to be the background level for the environment).

## III. Result And Discussion

This study revealed some metals had high elevated concentration or background loading values (see table 1), which could be attributed to industrial activities in the place The highest metal concentration in the textile industries was cobalt and chromium for leather industries (see table 2). This high concentration value of chromium could be explained as due to the chemical processing stage of leather products involving tanning with chrome.

**Table 1**: Analytical result for elements in the industrial effluent in mg/kg (ppm)

| | Africa textile mill ATM1 | African textile mill ATM2 | Ayafa concert ltd, Kano AY | Fata tanning limited, Kano F | Multitan limited, Kano MA | Mario-jose enterprise ltd, Kano MJ | w Mahaza company ltd, Kano NM | Background soil G |
|---|---|---|---|---|---|---|---|---|
| Al | 35630 ±326 | 35760 ± 358 | 16140 ± 45 | 31470 ± 220 | 11950 ± 179 | 11450 ± 103 | 11930 ± 143 | 64410 ±580 |
| As | 10.4 ± 0.2 | 7.27 ± 0.27 | BDL | 1.16 ± 0.21 | BDL | 0.63 ± 0.08 | 0.88 ± 0.09 | 2.77 ± 0.15 |
| Ba | 539 ± 46 | 893 ± 51 | 301 ± 26 | 642 ± 31 | 626 ± 38 | 201 ± 22 | 165 ± 21 | 1166 ± 0.42 |
| Ca | 27450 ± 244 | 29710 ± 2168 | BDL | 30560 ± 1956 | 77140 ± 3548 | 4272 ± 679 | 22780 ± 1709 | 2590 ± 660 |
| Co | 57.9 ± 0.6 | 2881 ± 1 | 1.90 ± 0.21 | 2.06 ± 0.22 | 2.41 ± 0.22 | 1.36 ± 0.15 | 1.43 ± 0.15 | 4.77 ± 0.33 |
| Cr | 371 ± 5 | 880 ± 6 | 19300± 19 | 2794 ± 11 | 42400±42 | 1279 ± 6 | 2177 ± 9 | 271 ± 4 |
| Fe | 301400 ± 904 | 95080± 570 | 5257± 152 | 15840 ± 238 | 6264 ± 169 | 7701 ± 162 | 6438 ± 161 | 29940 ± 299 |
| Mg | 1450 ± 480 | BDL | BDL | 1515 ± 186 | 1381 ± 144 | BDL | 591 ± 118 | 1610 ± 137 |
| Mn | 220 ± 11 | 839 ± 7 | 156 ± 3 | 213 ± 2.57 | 155 ± 4 | 309 ± 4 | 108 ± 3 | 193 ± 3 |
| Zn | 627 ± 15 | 352 ± 14 | 2.44 ± 0.24 | 76.6 ± 5.4 | 143 ± 6 | 25.3 ± 3.6 | 30.6 ± 3.9 | 37.0 ± 4.8 |

BDL – Below Detection Limit

**Table 2**: Average metal concentration in industrial effluents textile and leather industries and the background spoil in mg/kg (ppm).

| Elements | Textile industries | Leather industries | Background soil |
|---|---|---|---|
| Aluminum (Al) | 36569 | 16588 | 64410 |
| Arsenic (As) | 8.84 | 0.53 | 2.79 |
| Barium (Ba) | 716 | 387 | 1166 |
| Calcium (Ca) | 28580 | 26950.4 | 2590 |

| | | | |
|---|---|---|---|
| Cobalt (Co) | 172.95 | 1.83 | 4.77 |
| Chromium (Cr) | 623 | 13590 | 271 |
| Iron (Fe) | 198240 | 8300 | 29940 |
| Magnesium (Mg) | 725 | 697.4 | 1610 |
| Manganese | 529.5 | 188.3 | 193 |
| Zinc (Zn) | 489.5 | 55.6 | 37 |

The high concentration of chromium (350mg/l), 48.95mg/l) is associated with the tanning process. In this process, only 50- 70% of chrome is taken up by the skin collagen, allowing about 30-50% to be discharged directly into effluents; in this tanning process, the chromium (III) is also converted to chromium (VI) which is hazardous to the ecosystem [17].

The background loading of aluminum values for textile industries (0.55mg/kg) is higher than the FMENV limitation value, while that of leather industries (0.22mg/kg) is lower than the FMENV limitation value (see table 3 and 4). A similar study conducted in some textile industries in Kaduna, Nigeria, reported a lower value of (0.61mg/l) (0.22mg/kg), which is significantly lower than the value obtained from this study[15]. However, this could be attributed to the increased industries activities in the textile industries for the past 11years (since their studies in 2004). Traces of aluminum may be allied with Alzheimer's disease, and excessive intake of drinking water could result in anemia [18].

**Table 3**: Background loading factor (BLF) for metal concentration in industrial effluents of textile and leather industries in mg/kg (ppm)

| Element | Textile industries | Leather industries |
|---|---|---|
| Aluminium (Al) | 0.55 | 0.26 |
| Arsenic (As) | 3.17 | 0.19 |
| Barium (Ba) | 0.61 | 0.33 |
| Calcium (Ca) | 11.03 | 10.41 |
| Cobalt (Co) | 36.26 | 0.38 |
| Chromium (Cr) | 2.30 | 50.15 |
| Iron (Fe) | 6.62 | 0.28 |
| Magnesium (Mg) | 0.45 | 0.43 |
| Manganese (Mn) | 2.74 | 0.98 |
| Zinc (Zn) | 13.23 | 1.50 |

Arsenic showed values higher than the FMENV limitation value, with the values being much higher in the textile industries (3.17mg/kg) than the leather industries (0.19mg/kg). It is no secret arsenic is a toxic element with apparently little or no beneficial health effect on humans. Several diseases have been associated with excessive arsenic intake: lung and bladder cancer, skin changes, disease of the blood vessels of the legs and feet, and possibly also diabetes, HBP, and reproductive disorder[19]. Barium and iron, on the other hand, showed lower values in both textile (0.61mg/kg) and leather (0.33mg/kg), and for barium, 6.62mg/kg for textile industries and 0.28mg/kg for leather industries. These values are lower than the limit value set by FMENV (1.39mg/kg). This is clearly stating the little use of chemicals containing barium and iron by these industries.

Calcium and magnesium values are both lower in textile and leather than the FMENV limitation value of 129.87mg/kg and 115.07mg/kg, respectively (see tables 3 and 4). Calcium is the most abundant metal in the human body; it is the main constituent of bones and teeth. Lack of calcium causes osteoporosis, a disease in which bones become extremely porous and could be subject to fracture[18]. Cobalt has a value of 36.26mg/kg in textiles industries and 0.38mg/kg in leather industries, values which are much higher than the limit value of FMENV of 0.06mg/kg. One may be exposed to cobalt by breathing air, drinking water, and eating contaminated foods through skin contact with water or soil. However, it contains vitamin B12 and could be used in the treatment of asthma. However, exposure to a high concentration of cobalt may cause pneumonia[18]. Magnesium in balance and deficiencies can cause coronary heart disease, neuromuscular disorder, kidney disease, asthma preeclampsia and eclampsia, menopausal bone problems, premenstrual syndrome, and even obesity[18].

**Table 4**: comparison of the background loading factor (BLF) values of metal concentration of this work with the FEMNV limitation values

| Element | Textile industries | Leather industries | FMENV/NEPA (1991) | |
|---|---|---|---|---|
| | | | mg/l | mg/kg |
| Aluminium | 0.55 | 0.26 | <1.0 | 0.37 |
| Arsenic | 3.17 | 0.19 | 1.0 | 0.19 |
| Barium | 0.61 | 0.33 | 5.0 | 1.39 |
| Calcium | 11.03 | 10.41 | 200 | 129.87 |

| | | | | |
|---|---|---|---|---|
| Cobalt | 36.26 | 0.38 | 0.5 | 0.06 |
| Chromium | 2.30 | 50.15 | <1.0 | 0.14 |
| Iron | 6.62 | 0.28 | 20 | 2.54 |
| Magnesium | 0.45 | 0.43 | 200 | 115.07 |
| Manganese | 2.74 | 0.98 | 5.0 | 0.67 |
| Zinc | 13.23 | 1.50 | <1.0 | 0.14 |

The BLF concentration values of chromium for textile and leather industries were 2.30mg/kg and 50.15mg/kg, respectively, which are higher than the FMENV values (0.14mg/kg), especially in leather industries. Similar study documented chromium value of 0.036mg/kg (0.255mg/l) for textile industrial effluents in Lagos metropolis, Nigeria[20], also chromium value of 0.07mg/kg (0.5mg/l) for textile industries within Kaduna metropolis in Nigeria was reporeted[15]. Their value much lower values could suggest partial treatment of effluent before final discharge or relatively passive textile industrial activities in 2004 compared to textile industries in the commercial city of Kano. Health implication of this high chromium concentration in drinking water includes allergic reactions in the skin, several lung diseases and possible asthma attack[21].

The concentration values of manganese for textile and leather industries were 2.74mg/kg and 0,98mg/kg, respectively, which were much higher than the FMENV limitation value of 0.67mg/kg, especially in textile industries. Depending on the exposure mechanism, manganese may be among the least toxic trace elements if ingested[22]. Still, if inhaled, it could cause damages to brain tissue and lung[23]. Zinc BLF concentration values for textile and leather industries are13.23mg/kg and 1.50mg/kg respectively which are above FMENV limitation value of 0.14mg/kg. Zinc is a trace element that is essential for human health. Less absorption of zinc causes loss of appetite, decreased sense of taste, and small slow wound healing and skin sore and congenital disability. Also, too much zinc can cause stomach cramps, skin irritation, vomiting, nausea, anemia, and arteriosclerosis [18].

## IV. Conclusion

Sludge from the textile and leather industries in Challawa industrial area in Kano showed a high level of metal contamination. Most of the observed metals exceeded the FMENV limitation values and are therefore dangerous, not only to the workers in the industries and those living near the industrial area but also to all those who depend on the Challawa River for domestic or irrigational purposes. Furthermore, Kano is characterized by high evaporation during the long dry season. During this dry season, the occasional dust re-suspension could introduce these heavy metals into the atmosphere along with the particulates and may constitute airborne diseases or could result in volatilization of chemicals in the effluents and the release of heavy metals as particulates due to their absorption on the effluents' solids, also resulting to air pollution. This research, therefore, calls for proper treatment of effluents and chemical re-evaluation before final disposal. Also, incorporating appropriate heavy metal recovery in the proposed central effluent treatment[24], could go a long way in assuring environmental protection and sustainability.

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