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DETERMINATION OF CHROMIUM AND NICKEL CONCENTRATIONS IN CHALAWA TANNERY EFFLUENT

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Abstract

Some tanneries release their effluents into drainages that ultimately move into streams whose water is used for irrigation in the nearby farm lands. Hence, there is the possibility of the vegetables and other crops watered with the remains of the effluent to contain some of the chemicals used in the tanneries. Samples of tannery effluent from Chalawa tannery were collected at the source and some points away, with intervals of 20m from each other. The liquid parts of the samples were digested and analysed for chromium and nickel by the use of ALPHA-4 model Atomic Absorption Spectrophotometer (AAS). The average concentrations of chromium at the sampling points, 0.0, 20.0, 40.0, 60.0 and 80m away from the outlet of the effluent were 4.31 ± 0.40, 3.10 ± 0.21, 2.30 ± 0.34, 1.21 ± 0.12 *and* 0.24 ± 0.06*ppm respectively, while those of nickel from the same distances as above were respectively,* 2.51 ± 0.32, 2.12 ± 0.50, 1.44 ± 0.30, 0.62 ± 0.22 *and* 0.13 ± 0.04*ppm. These showed decrease in concentrations of the two metals with increase in distance from the outlet, hence possibly only the nearby farm lands and ultimately the crops would be affected.*

Keywords: chromium, nickel, tannery, Chalawa, Kano, Nigeria

INTRODUCTION

Industrial effluent discharged from leather tanneries contains high amount of metals especially chromium. These effluents released into rivers or canals as well as dump into ground water and lead to chromium contamination due to accumulation. It has been reported that only about 20% of the large number of chemicals used in the tanning process is absorbed by leather and the rest is released as waste (Javaid et al., 2008). Hence maximum concentration of this waste material is absorbed by bioaccumulation process in cultivated crops irrigated by tannery effluent. The toxicity of chromium through drinking water is the major problem of human health (Javaid et al., 2008).

Tanneries have been found to discharge not only chromium which is inherent product of the tanning process but also significant amounts of zinc, manganese, copper and lead have been observed at the main range in soils. It was also reported that the waste from leather industries consists of tanned and untanned solids, waste water, (effluents) including the sludge and waste gases. The sludge derived from treatment of tannery effluent varies in composition but usually contains water (65 – 98%), lime, chromium, hydrate oxide, residual sulphides and organic matter (protein, hair and grease) (Hug, 1998). The common elements such as aluminum, iron, calcium, sodium, potassium and silicon are present in significant quantities in sludge and may also contain trace element and heavy metals such as chromium, cadmium, lead, mercury, astatine, nickel, zinc, boron, selenium as well as nitrogen and phosphorus in both organic and inorganic form (Hug, 1998).

Chromium is an environmentally significant metal used in various industrial processes (Lambe et el., 1994). Chromium compound enter natural water mainly through the effluents from sanitary and water cooling towers. It can also enter the drinking water distribution system from the corrosion inhibitors used in water pipes (Sparling et el., 1992). Chromium is the most commonly used tanning agent; nearly 90% of all leather produced is tanned using chromium (Stain and Schwatt, 1994). The determination of trace chromium in environmental samples is of great importance due to its toxicity (Stain and Schwatt, 1994). The two mainly oxidation states of chromium, Cr(III) and Cr(VI) present in natural waters significantly differ in biological, geo–chemical and toxicological properties. Cr(III), over a narrow concentration range is considered to be essential for mammals for the maintenance of glucose, lipid and protein metabolism, but Cr(VI) is reported to have a toxic effect in humans (Cotton et el., 1999). Chromium being essential element for humans, its daily ingestion of 0.5g to 2g is required for adults, though this daily requirement for the metal is under discussion (Micheal, 1987).

Deficiency of chromium level in the body causes a disease known as diabetes in which some old people have been found to have difficulty in breaking the glucose concentration in their blood back to normal, this is due to the facts that they absorb chromium less efficiently than normal people and their disability is due to the shortage of chromium (Magnus, 1975). However, excess chromium leads to growth retardation, damage to kidney and cancer of the liver (Stain and Schwatt, 1994). Numerous cancers of the nose and other tissues are being reported in industrial workers (Robert, 1986). Recent research has found that even low levels of chromium, lead, mercury, cadmium, aluminum and arsenic can cause a wide variety of health problems (Robert, 1986).

Most nickel compounds are blue or green. Nickel dissolves slowly in dilute acid but, like iron, becomes passive when treated with nitric acid. Finely divided nickel adsorbs hydrogen (Derek, 2005). Food stuffs naturally contain small amounts of nickel. Chocolates and fats are known to contain severally high quantities (Lenntech, 2011). Plants are known to accumulate nickel and its uptake in vegetables is eminent. Smokers have a higher nickel uptake through their lungs. Nickel can also be found in detergents (Petrucci, 2002). Humans may be exposed to nickel by breathing air, drinking water, eating food or smoking cigarettes. Skin contact with nickel – contaminated soil or water may also result in nickel exposure. In small quantities nickel is beneficial, that about 170ug eaten every day, but when the uptake is high it is dangerous to human health; EPA recommends 0.1mg/L in drinkingg water (ATSDR, 2005). Nickel is not only favourable as an essential element, but is also dangerous when the maximum tolerable amounts are exceeded. It causes various kinds of cancer on different sites within the bodies of animals, mainly of those that live near refineries (Thornalley, 2003 and El-Shafei, 2011). An uptake of large quantities of nickel has many consequences such as higher chances of development of lung cancer, nose cancer, larynx cancer and prostate cancer, lung embolism, respiratory failure, sickness and dizziness after exposure to nickel gas (Zhao et al., 2009). Other effects include birth defects, asthma and chronic bronchitis, allergic reactions such as skin rashes (mainly from jewelry), heart disorders etc (Lenntech, 2011). Nickel has also been identified as a toxin that severely damages reproductive health and can lead to infertility , miscarriage, birth defects and nervous system defects (Apostoli and Catalani, 2011; Forgacs et al., 2012). Nickel fumes are respiratory irritants and may cause pneumonitis. Nickel is released in to the air by power plants and trash incinerators (Lenntech, 2011). On earth, nickel occurs most often in combination of sulfur and iron; in pentlandite with sulfur, in millerite with the arsenic and sulfur and, in nickel galena (NPI, 2012).

The large part of all nickel compounds that are released into the environment will be adsorb to sediments and on soil particles, and become immobile as a result. In acidic ground however, nickel is bound to become more mobile and it will often rinse out to the ground water. There is not much information available on the effects of nickel upon organisms other than humans (Jaouen, 2006). It is known that high nickel concentrations on sandy soils can clearly damage plants and high nickel concentrations on the surface water can diminish the growth rate of algae (Greig, 2005).

Afiza et al, (2013) reported that fish can accumulate some certain elements such as chromium, copper, nickel, lead etc. from surrounding water or food which in turn affect human health on eating the fish. Heavy metal toxicity is an uncommon medical condition. However, it is a clinically significant condition when it does occur. If unrecognized or inappropriately treated, toxicity can result in significant illness and reduced quality of life (Ferner, 2001). For persons who are suspected that they or someone in their household might have heavy metal toxicity, testing is essential, so that appropriate conventional and natural medical procedures may need to be pursued (Dupler, 2001).

This work is aimed at analyzing the liquid part of the effluent that comes out of a tannery for chromium and nickel. This is because the effluent drains directly into a stream that is used in the irrigation of some crops and vegetables at the farm lands some meters away from the tannery.

MATERIALS AND METHOD

The samples were collected from Chalawa tanneries waste water drainage at five different points, at a distance of 20 metres from each other, beginning with the outlet from the tannery. The samples were taken in one litre plastic bottles at each point and then filtered through filter paper to remove solid undissolved materials in the effluent.

Fifty ($50cm^3$) of the filtrate was taken and mixed with$10cm^3$ of a mixture of concentrated sulphuric acid (H_2SO_4) and concentrated nitric acid (HNO_3) 1:1. The solution was boiled on a hot plate at 120^0C until dense white fumes of SO_3 just appeared. Then $10cm^3$ of concentrated nitric acid were added and boiled. The heating was continued until the solution was near dryness and $15cm^3$ of 10% HNO_3 was added and boiled to dissolve the soluble salts. After cooling, the solution was transferred into $100cm^3$ volumetric flask and the volume was made up to the mark with deionized water.

ALPHA-4 model of atomic absorption spectrophotometer (AAS) machine was used to determine the absorbance of the metals in the standards and samples using appropriate lamps for the metals. The lamps were attached and left on for some time to warm up. The blank was introduced into nebulizer capillary and set the gain and auto-zero controls to bring the meter reading to zero, then a top standard was aspirated and the acetylene flow was adjusted to give maximum absorbency on the meter. The standard solutions were tested for serially before the samples for each of the metals and before each reading blank solution had to be used for zeroing the absorbance readout. The appropriate lamp, wavelength, gain, slit width and lamp current had to be selected on the machine for each metal. However, air/acetylene gas mixture was used throughout this determination. Standard curves of concentration against absorbance were plotted. From the standards curves, the concentration of the metals in the samples were read out using the absorbance obtained (Ayodele and Yalwa, 2005).

SPSS 16.20 was used in analyzing all the data obtained statistically.

RESULTS AND DISCUSSION

The chromium concentrations in the sample solutions collected from five different points away from the outlet of the effluent were as shown in the Table 1 below. The concentrations were obtained from the standard curve constructed using standard solutions, where the concentration and absorbance for standard chromium solutions have obeyed Beer Lambert's law which in turn indicated that, the technique is reliable for the chromium metal determination.

Table 1: Chromium concentration at five different sampling points away from the outlet of the effluent

S/N	Sampling Points	Distance from the tannery	Mean Concentration (ppm)
1	A	0.0	4.31 ± 0.40
2	B	20.0	3.10 ± 0.21
3	C	40.0	2.30 ± 0.34
4	D	60.0	1.21 ± 0.12
5	E	80.0	0.24 ± 0.06

From the result obtained, the immediate effluent discharged from the tannery has the highest concentration of the metal, which is in line with Javaid et al, (2008). The concentration of the metal decreases with increase in distance away from the source and this is most probably due to the surface absorption by the soil and other materials as the effluent is flowing away from its source, which may also lead to soil pollution. The metal may be leaching down to drinking water table. According to Javaid et al, (2008), the toxicity of chromium through drinking water is one of the major problems of human health. The permissible limit of chromium in any industrial waste is 1mg/L or 1ppm and 0.05mg/L in drinking water (WHO, 2003). Hence, even at the distance of 80m away from the source may be considered to be high, since the daily chromium requirement of absorbable chromium III is 0.2-2µg and if a fractional absorption value of 25% for biologically incorporated chromium III in food is assumed, this provided by a daily dietary intake of 2-8µg of chromium III, equivalent 0.03-0.13µg of chromium per kg of body weight per day for a 60kg adult (WHO, 2003).

The concentration of chromium in Table 1 above shows that, the people living in the area may suffer from various kinds of diseases due to the high contamination of the metal. The determination of trace chromium in environmental samples is of great importance due to its toxicity (Stain and Schwatt, 1994). Hence, care must therefore be seriously taken to avoidcontaminating drinking water with the metal. Irrigated crops are also possibly contaminated with the metal as well. Hence, farmers must also take serious care while cultivating crops in the area, although the concentration decreases as one moves away from the tannery. The danger here is that the effluent drains directly into the river used in irrigating the crops.

Table 2: Nickel concentration at five different sampling points away from the outlet of the effluent

S/N	Sampling Points	Distance from the tannery	Mean Concentration (ppm)
1	A	0.0	2.51 ± 0.32
2	B	20.0	2.12 ± 0.50
3	C	40.0	1.44 ± 0.30
4	D	60.0	0.62 ± 0.22
5	E	80.0	0.13 ± 0.04

The standard curve was constructed from standard concentrations and the corresponding concentrations of the metal in the samples were then extrapolated from the curve.

The results in the Table 2 above indicate that the effluent discharged from the tannery is highly contaminated with nickel. The concentration of the metal reduces with distance from the source as chromium above. This might be due to surface absorption by the soil and other materials which also leads to the pollution of the soil as well. Humans may be exposed to nickel by drinking water and skin contact with nickel; contaminated soil or water may also result in nickel exposure according to Lascelles et al, (2005). As the results in the table above shows the concentration of nickel in the area is high particularly from the source, since the permissible limit of nickel in any industrial waste is 0.2mg/L.

Observing the way the two metals concentrations are decreasing with distance, it may mean that the effluent can be safe at a distance of about 100m away from the outlet as far as these metals are concerned. It is therefore not safe to be used for irrigation and other activities in farm lands close to the industry.

Although chromium is the most commonly used tanning agent; nearly 90% of all leather produced is tanned using chromium compounds as according to Stain and Schwatt, (1994), from the results, in the samples collected nickel also generally has high concentration. This possibly shows that some other nickel containing compounds are also used in the tanning processes of the leather or the nickel source was not among the tanning chemicals in the industry or the deconcentration treatment process carried out by the industry is directed more or selective to chromium and pays less attention to other heavy metals like nickel.

CONCLUSION

Environmental pollution being a major hazard facing the world today, there is an increasing awareness of the facts that a clean environment is necessary for smooth living and for better health of human beings and their animals.

The concentration of each of the metals was determined to be lower than many others, which show some extent of treatment. However, the wastewater released from Challawa industrial area of Kano state is still polluted with the two heavy metals; chromium and nickel, despite the treatment by the industry. The nickel concentration in the liquid part of the effluent was found to be high as compared to other tannery effluents. This may be due to some other sources in the industry apart from the normal chemicals used in the tannery. The results obtained also showed that concentrations of the metals decrease with distance from the source; the effluent is becoming safer and safer with distance from its source. From the trend of the decrease in concentration of the two metals it can be concluded that the water from the tannery can be used for irrigation at a distance of about 100m from the source as far as the metals are concerned. This shows that there is still the need for the industries to further improve their effluent treatment so that it will come out in to the immediate land safe.

The diminishing quality of water seriously delimits its use for human consumption and for aquatic life. Tanneries generally accelerate the deterioration of water quality especially by heavy metals pollution. Hence, there is the possibility of serious water quality deterioration few years from now and this will be a serious threat to aquatic and human life.

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