

Evaluation of Heavy Metal Deposits and distribution in Challawa Industrial Area of Kano Metropolis, Nigeria.

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Abstract

This paper reports the evaluation of heavy metal deposits and distribution in Challawa industrial area of Kano metropolis, using atomic absorption spectroscopy (AAS). The results showed that lead (Pb), Cobalt (Co), Zinc (Zn) and Iron (Fe), were present in an increasing order. The comparatively high iron content in both incinerated tannery wastes, and contaminated soils has high implication on plant growth and therefore be of great concern to soil conservationist for agricultural purposes.

Key Words: Incinerated waste, contaminated soils, tannery, and metals.

INTRODUCTION

Heavy metal presence in an environment could be hazardous to plants and animals and as such is a critical reason why soils are analyzed. The sources of such contamination could be conjectured; however, the extent of the contamination can only be ascertained by modern instrumental analytical techniques (Montero et al. 2007). For example, during leather tanning and finishing processes (Geremew and Tekalign, 2017). Heavy metals such as Zinc, Iron, Lead and Cobalt may be involved, and therefore the extent of their contamination to the environment need to be ascertained (Leke et al. 2011; Mohammad and Nwaedozie, 2011; Igwe and Abia, 2007), and mixture of many compounds may complicate the wastewater treatment such as: acids, alkalis, chromium salts, tannins (natural or synthetic), solvents, sulphides, dyes, surfactants, auxiliaries (Mariliz et al. 2014). Not more than 20 % of the chemicals are absorbed by leather; the remainder flows out with the effluent (Muthukkauppan and Parthiban, 2018). Excess of lead in plant is known to inhibit photosynthesis and toxicity to soft tissues, such as liver, kidney and brain (Ogieva, 2003). Similarly, cobalt if found in

excess in animals could inhibit cellular respiration. The tanning industry is known to generate the highest toxic wastes per unit output (Khan et al. 1999). It has been estimated that during tanning at least approximately 300 kg chemicals are used per ton of hides or skins (Verheijin et al. 1996). Tannery effluent and solid wastes constitutes the hazardous pollutants from the industry because of heavy metals, toxic chemicals, chloride and much more. Several analytical techniques such as inductively coupled plasma-atomic emission spectroscopy-ICP-AES, inductively coupled-mass spectroscopy-ICP-MS (Christoph et al. 2001; Montero et al. 2007; Achi et al. 2012). However, in recent time atomic absorption spectroscopy (AAS), has proved to be the most versatile instrument for heavy metal determination due to its high sensitivity, low cost and simple techniques (Gennaro et al. 2007).

The aim of this paper is to report the impact of other heavy metal deposit and distribution in Challawa industrial areas in Kano municipality, by determining these metal pollutants other than chromium and copper in incinerated tannery wastes and contaminated soil samples.

MATERIALS AND METHODS

Description of the Study Area.

Kumbotso Local Government area lies between latitudes 11°56'S to 12°N and longitude 8°24'W to 8°4'E it falls within the Kano State settlement zone bordering the south and west by Madobi local government area in the north-west; Rimingado in the north by Gwale and east by Tarauni local government areas respectively.

Sample Collection

Incinerated tannery wastes, and contaminated soil samples were collected randomly on weekly basis and were stored in plastic bags (Ayodele and Gaya, 1998) labeled $A_1 - Z_1$ and $A_2 - Z_n$ respectively. The soil samples were collected 500 meters away from the dump site at a depth of 15 cm from the surface. Total of 52 samples in each case were collected and analyzed for Zinc (Zn), Iron (Fe), Lead (Pb) and Cobalt (Co) using standard methods (Buckley and Cranston, 1993; Balasubramanian et al. 1997).

Determination of Metals in Soil Samples

About 0.25 g of sample was digested with 10 cm³ hydrofluoric acid and 1.0 cm³ aqua regia, which is hydrochloric acid and nitric acid (3:1) in a flask. Thereafter, 5.0 cm³ perchloric acid was added and again heated to dryness on a hot plate; distilled water was added, filtered through Whatman, no 42-filter paper and made up to 100 cm³. Digested soil samples were analyzed in triplicates including the blank for Zinc, Iron, Lead and Cobalt concentrations using Atomic Absorption Spectrophotometer Alpha 4 Model (Deepali and Gangwar, 2010).

Determination of Metals in Incinerated Tannery Wastes

Burnt tanneries wastes from the sampling site were collected, crushed, mixed and sieved using 0.4 mm mesh for homogeneity. One gram of each sample was weighed into platinum crucible and ashed at 400 °C (Gary, 2004) to a constant weight. The ash was quantitatively transferred from the platinum crucible using

spatula into a 250 cm³ conical flask. A mixture of concentrated oxidizing acids of nitric (5 cm³), sulphuric (3.5 cm³) and perchloric (11.5 cm³) were transferred into conical flask containing the ash (John, 2003) antibumping granules and funnel was introduced into the conical flask. The mixture was heated on a hot plate in a fume cupboard. The initial colour of the solution varied from dirty green to orange (SLTC, 1996; Balasubramanian et al. 1997). The digestion was completed after 1½ hours and the heating stopped and cooled at room temperature. 100 cm³ of distilled water was added into the solution and further boiled for 10 minutes, cooled and filtered through a Whatman filter paper no (1) 90 mm into a 250 cm³ volumetric flask and was made up to the mark with water. The resultant solutions were analyzed in triplicates including the reagent blank for Zinc, Iron Lead and Cobalt concentrations using Atomic Absorption Spectrophotometer (Buckley and Cranston, 1993; Deepali and Gangwar, 2010).

Preparation of Standard Solution

The following were prepared independently for their standard stock solutions as follows: Zinc nitrate (1.1375 g); Iron nitrate (1.8085 g); Lead (II) nitrate (0.3998 g); Cobalt nitrate (1.0082 g), transferred into a beaker containing 2.5 cm³ of 10 % nitric acid and made up to 250 cm³ with distilled water respectively. 2.5 cm³ of 250 mg/dm³ (standard stock solution) were prepared and made up to 25 cm³ mark with distilled water from the resultant solution 2.0, 4.0, 6.0, 8.0, 10.0. were pipetted and made up to 25 cm³ mark with distilled water each with new concentrations of 2.0, 4.0, 6.0, 8.0 and 10.0 mg/dm³ (Chemiasoft, 2011) for Zinc; Iron; Lead and Cobalt salts respectively (John, 2003). The absorbance of these serial dilutions was recorded. Average reading of both standards and samples were corrected from the blank readings. Calibration curves were plotted for their standards. The concentrations of each element under investigation in mg/dm³ or mg/kg were determined from the calibration curve of its standard as presented in Figures 1.0 - 4.0.

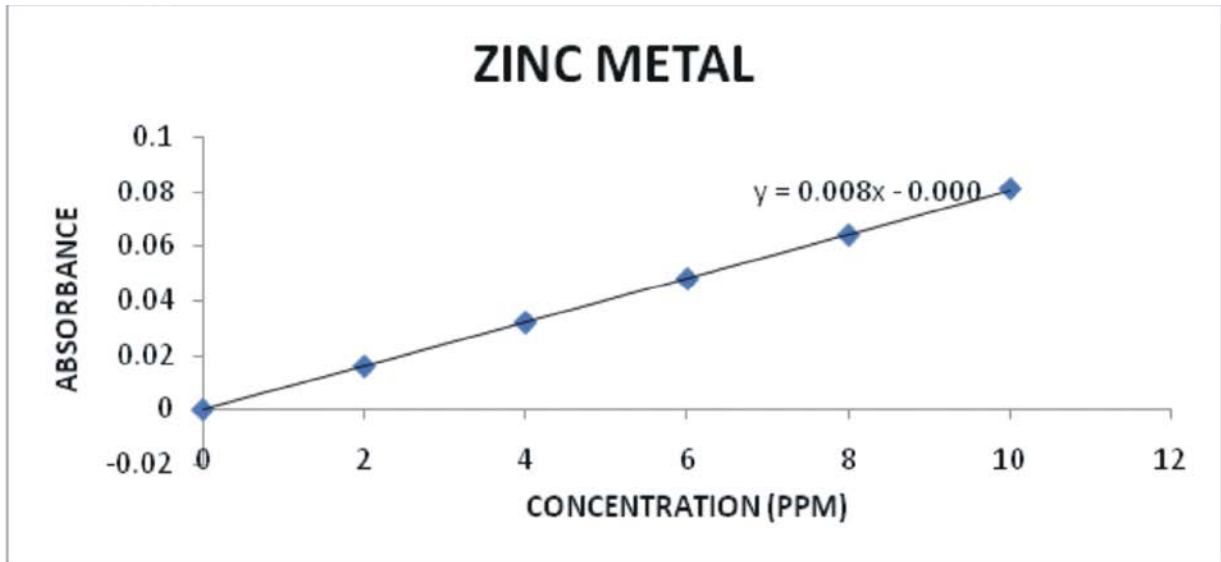


Figure 1: Calibration Curve for Zinc Standard Solution

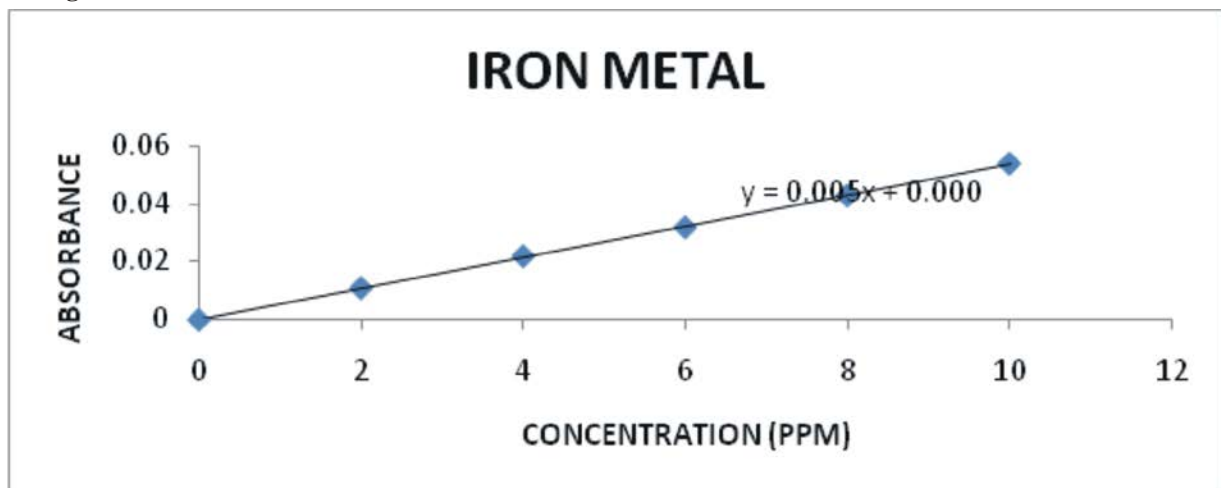


Figure 2: Calibration Curve for Iron Standard Solution

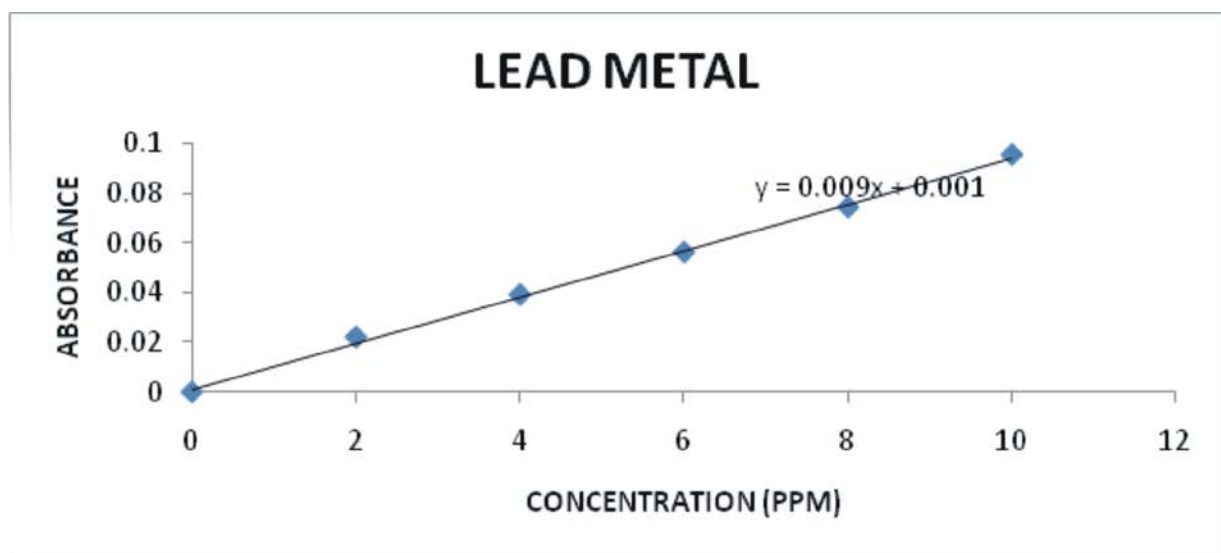


Figure 3: Calibration Curve for Lead Standard Solution

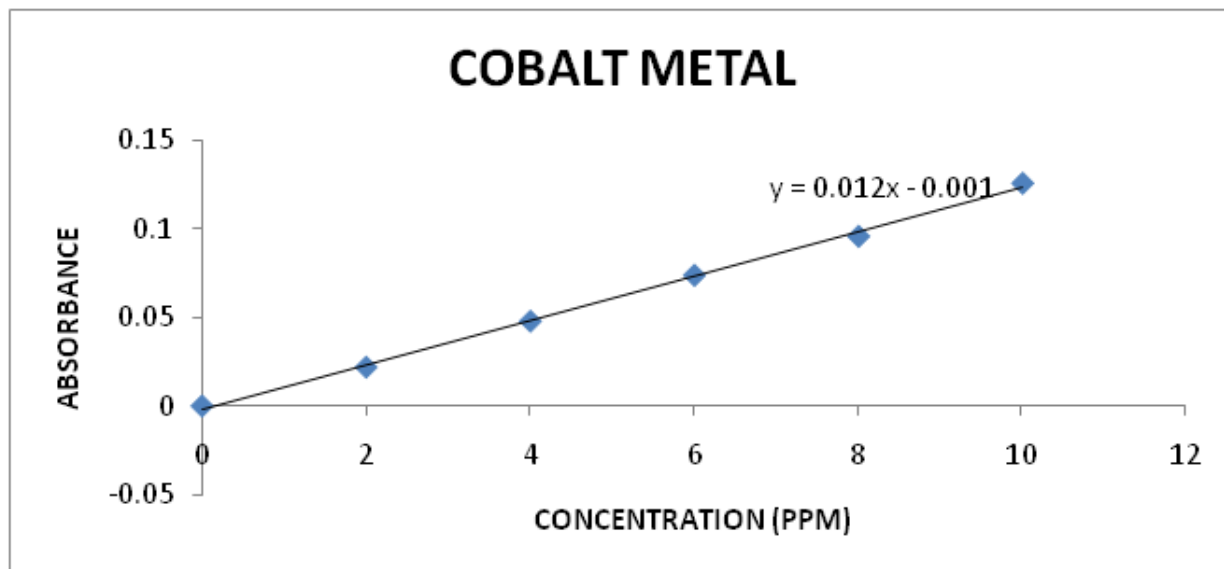


Figure 4: Calibration Curve for Cobalt Standard Solution

RESULTS AND DISCUSSION

The results from this work are presented in Figures 5 and 6, highlighting the metal Concentrations of Zn, Fe, Pb and Co in Tannery Incinerated Wastes and Contaminated Tannery Soil Sample (mg/kg).

Zinc

The concentrations for Zinc in the tannery wastes and farm soils were found to be 565.07 ± 225.71 and 251.20 ± 157.28 mg/kg respectively. These values were below the set standard for sludge and soil contaminated with tannery waste (Corning, 1979). Sources of Zinc are: Animal skins 0.20 % on dry basis (Adegboye and Agina, 1983) tanning salts, galvanized materials or containers and pigments (Daintith, 2004). The low concentration of Zinc could lead to the formation of chlorophyll in plants because ligand exchange processes in Zn^{2+} are usually rapid and does not disturb the genetic heredity and biosynthesis of enzymes (Sindhu, 2002) and activates of some enzymes and hormones to enhance reproduction growth and development (Ogiera, 2003). Although Zinc is important in the body it becomes toxic above 15 mg/day concentration due to bioaccumulation of the fumes from the burnt tannery waste the body through inhalation could lead to nausea and disorder of the immune system (John, 1986; Ohnersorge and Wilhelm, 1991; Milacic et al.

1998; Sindhu, 2002) and consequent accumulation of the ingested fruits such as carrots from farmland contaminated with tannery waste could increase health risk.

Iron

The concentration for iron was found to be 1823.33 ± 364.23 and 362.73 ± 130.08 mg/kg for incinerated waste and farm soil respectively. The incinerated waste was above the standard limit for waste disposal but lower in the case of farm soils. These values were below 4,837-6,311 mg/kg range obtained from affected soils in Mexico as reported by Alvarez-Bernal et al. (2006) Sources of iron in tannery waste are the tanning agents because of their complexing power with other substances such as (mineral tannage), dyes other sources may include, natural geochemical processes and machineries used which may include fleshing, setting out, shaving, staking and buffing (machines) in their production (Thinkaivelan et al. 2000; Lorede et al. 2003). Iron in high concentration could lead to poor growth and development in plants (Ogieva, 2003). Although iron is needed in haemoglobin and several enzymes, its bioaccumulation in the body in excess of 200 mg/day is considered toxic for human (Butler, 1979; Bowen, 1979; John, 1986; Milacic et al. 1998; Sindhu, 2002). Consequently, iron may be harmful to the body cells when it catalyses the production of

hydroxyl radicals (Hueber, 1991) during the dry season when the leather wastes are burnt resulting in fumes causing poor visibility (Sezgin et al., 2004) with other related health problems. This is because iron bioaccumulates and does not degrade naturally even when organic iron complexes breakdown by hydrolysis, fresh unreactive inorganic complexes are formed (Corning, 1984; Shen et al. 1986).

Lead

The data for lead concentrations in both incinerated waste and contaminated soil samples were found to be 77.88 ± 25.23 and 29.19 ± 14.61 mg/kg respectively. These values were found to be below the set standards (Corning, 1979). The presence of lead could be attributed to the use of pigment such as lead chromes and basic lead carbonate (white lead) the later has been curtailed for toxicity consideration. Other sources could be from domestic effluent surface water run offs lubricating oil, grease (Hodel and Chang, 2004). Lead toxic effect on plant is the inhibition of photosynthesis due to direct interference with the synthesis of carbohydrate which results in flaccidity of stomata guard cells and impaired transpiration and CO₂ exchange. Furthermore, lead gets into man through his diet

by inhalation and accumulates to cause toxicity in soft tissues such as the liver, kidney and brain (Ademoroti, 1991).

Cobalt

The concentration of cobalt in the incinerated waste and farm soils are 116.23 ± 58.11 and 43.07 ± 22.39 mg/kg respectively. The concentration of cobalt in the incinerated waste was above the set standard limit (Corning, 1979) which could pose some related health problems such as inhibition of cellular respiration and enzymes of the citric acid cycle, exposure to cobalt carboxyl may change reflexes and electric activity of the brain. The toxicity of cobalt is independent of its chemical form as its toxic effects are contributed by oxides, metals and are not masked by alloy (Coates and Watson, 1971; Steve, 1972; Bowen, 1979; Taylor and Hawkins, 1987). Cobalt could be found in the composition of some tannery pigment, skins of the animals about 0.04 % on the dry weight of the skins (Adegboye and Agina, 1983). Other natural sources may include; soil, dust, volcanic eruption, fresh fires, burning coal and oil, cars, trucks and airplane exhaust and from industrial processes that use the metal or its compound (Steve, 1972).

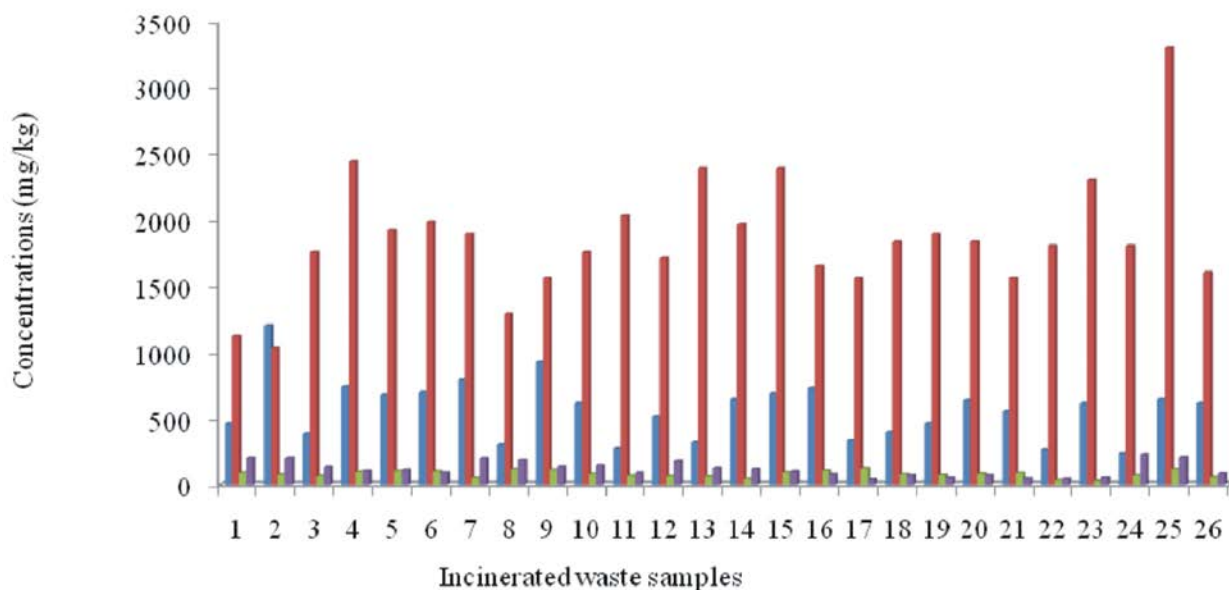


Figure 5: Concentration of Zn, Fe, Pb and Co in Tannery Incinerated Wastes (mg/kg)

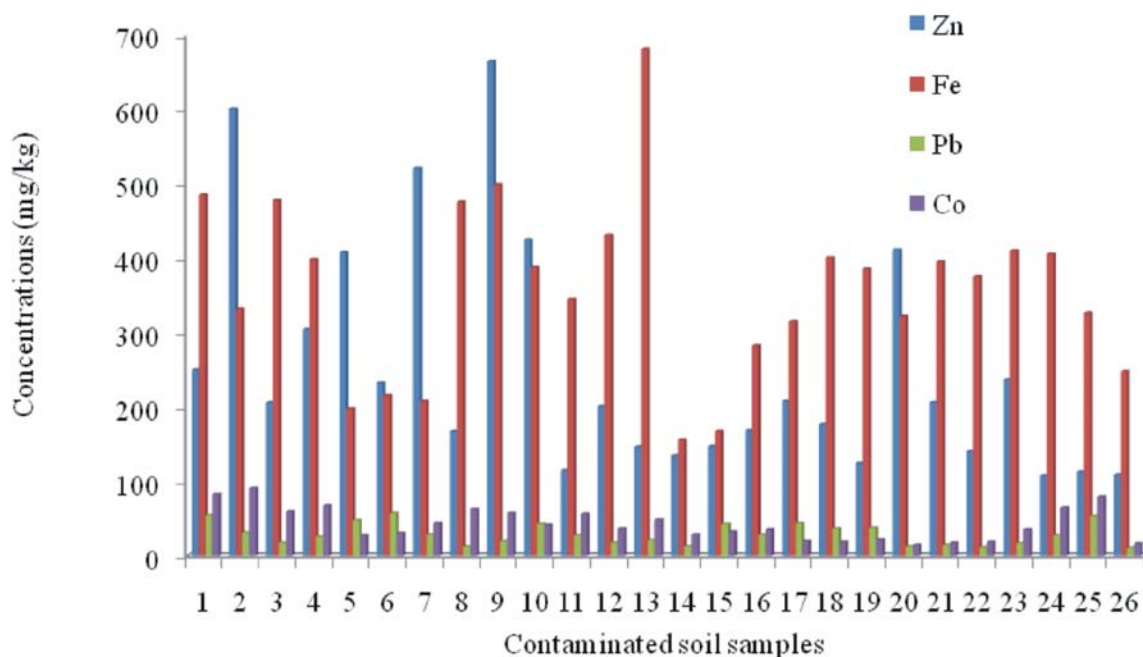


Figure 6: Concentrations of Zn, Fe, Pb and Co in Contaminated Tannery Soil Sample (mg/kg).

CONCLUSION

This study has shown that heavy metals in the tannery incinerated waste ranges from 77.88 ± 25.23 (Pb), 116.23 ± 58.11 (Co), 565.07 ± 225.71 (Zn), 1823.33 ± 364.23 (Fe) in mg/kg and for the contaminated soil sample it ranges from 29.19 ± 14.61 (Pb), 43.07 ± 22.39 (Co), 251.20 ± 157.28 (Zn), 362.73 ± 130.08 (Fe) in mg/kg respectively. The high concentration of iron in both parameters could be attributed to the use of iron salt for tanning in the industries with high percentages offered. Furthermore, some of the pigment dopes stinks after a long period of time when not properly preserved with biocides consequently ends in the dump site contributing to the concentration of these metals, to curtail this scenario a periodic monitoring of the incinerated wastes and contaminated soils should be embarked upon as a pollution index. The use of combination tannage with polyphenolic materials be encouraged and the composition of the pigments screened to check the bioaccumulation of heavy metals in the studied sites.

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