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Determination of Heavy Metals in the Hair of Some Occupational Workers in Some Local Government of Adamawa State, Nigeria

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ABSTRACT

This study was conducted to determine the heavy metals concentration in hair samples of occupational workers (mechanics, electricians, and welders) in the Mubi, Gombi, and Numan local government areas of Adamawa State. The hair sample was washed with non-ionic detergent and acetone to remove contamination and digested with 20cm^3 of 3:1 mixture of concentrated nitric acid and perchloric acid. The sample was later analysed using Atomic Absorption Spectrometry for the determination of heavy metals lead (Pb), cadmium (Cd), nickel (Ni), cobalt (Co), Zinc (Zn), chromium (Cr), manganese (Mn) and copper (Cu). The results of this study show that heavy metals in hair samples from different subjects accumulate differently based on exposure. The concentrations of heavy metals in welder workers' hair are the highest values among other occupations (mechanics and electricians), except in Mubi where mechanics workers have the highest concentration. The levels of all the metals increase with respect to age except age 26 – 40 in Mubi which is even higher than the aged group 41 – 55. This research shows that there is a statistically significant relationship between the type of work or workplace and the heavy metal concentration detected in hair samples. There is an instantaneous need for public awareness about the hazards of this occupation to enable occupational workers to take necessary precautionary measures.

Keywords: Heavy metals, Human hair, Occupational workers (welders, mechanics, and electricians)

INTRODUCTION

The determination of trace elements in hair has been the subject of continued interest in the biomedical and environmental sciences. Hair can be an excretory product; the heavy metals contents of which reflect mineral metabolism in the body. However, their concentrations bear little relation to the levels in other tissues [1, 2, 3]. It should be noted that human hair is an attractive biological material because of the simplicity of sampling, transport and handling as well as providing information about concentrations of heavy metals that are considerably more concentrated in hair than in other biological materials, which makes analysis easier. Heavy metals accumulate in the body over given periods of time; therefore, they reflect the biomedical and environmental history of the body as well as long term metabolic changes [4, 3]. Hair is a filament that grows from a hair follicle in the dermis of the skin. It consists mainly of tightly packed, keratin-filled cells called keratinocytes. The human body is covered with hair follicles except for a few areas, including the mucous membranes, lips, palms of the hands, and soles of the feet. The part of the hair that is located within the follicle is called the hair root. The root is the only living part of the hair. The part of the hair that is visible above the surface of the skin is the hair shaft. The shaft of the hair has no biochemical activity and is considered dead [5, 6]. Heavy metals are non-biodegradable pollutants in the environment that can enter human bodies through different routes, such as food consumption and worker place, (which is also the main route of exposure to heavy metals [7], and then can be accumulated in the body [8]. Many of these metals are essential micronutrients (such as Fe, Cu, Zn, Cr, and As), but they can become toxic at higher concentrations than the amount normally required [9], whereas some non-essential micronutrients (such as Cd, Hg, and Pb), which have unknowing roles in living organisms, are toxic even at very low concentrations [9] eventually posing a serious health risk to human and ecosystem health [10, 11, 12]. For instance, chronic cadmium intoxication may give rise to renal tubular dysfunction, anaemia, and skeletal damage (itai-itai disease). Long-term exposure to lead may cause kidney and liver damage and has an adverse effect on the central and peripheral nervous systems,

haemopoietin system, and cardiovascular system [8]. Therefore, it is important to monitor heavy metal levels, which are very important for assessing the potential health risks of metals to humans [9].
Environmental pollution has an important role in increasing the levels of heavy metals in the human body, which lead to various chronic diseases [3, 10, 13, 14]. The working environment has come to play an important role in this subject, due to the direct relationship between man and the degree of hazards chemical agents present in their workplace environment. In addition, each workplace environment is not unique but also in the degree of hazards it poses to the workers. Furthermore, the pollution of the workplace environment with heavy metals is a worldwide problem [3, 16, 17, 18]. In this context, heavy metals come out in the workplace environment from various uses in the form of spray or dust, which can get into the body of workers mainly either through inhalation and/or dermal contact. Therefore, accurate assessment of heavy metals in the human tissues is extremely important. Therefore, analyzed with some biological materials such as blood, teeth, nails, and hair; it is possible to monitor changes in the body. Various analytical techniques have been considered for the measurement of heavy metals in different biological samples [1, 2, 18, 11]. Hair can be considered metabolic end products, as well as they, are long-term with many trace elements into their structure during the growth process, the trace element contents of which reflect mineral metabolism in the body [19, 20, 10, 4, 13, 14]. Therefore, the measurement of heavy metals content in hair plays an important role to understand as well as monitoring the impact of chemical environmental pollution on various inhabitants of a community. Furthermore, many researchers recommended the use of human hair for monitoring heavy metals. They found that fingernails and scalp hair have the useful as disclosing historical details on the dietary state and chronic diseases as well as exposure of individuals to chemical pollutants, especially heavy metals, including the effects of the workplace. In this context, hair have gained an irreplaceable position in monitoring the impact of chemical environmental pollution than other biological materials due to their easy collection without injuring the donor, elements accumulate over a long period without any changes, and the capacity of hair to accumulate metals during extended periods, reflecting at least 1 year of exposure [1, 2, 19, 18, 10, 4, 14]. In addition, they found higher concentrations of residues are present in hair samples at a rate more than 10 times at least in urine or blood serum samples. For this reason, hair is suitable measures of toxic and heavy elements in polluted areas.

MATERIALS AND METHODS

Sample Area and Sample Collection

The study areas are Mubi, Gombi, and Numan Local Government Area. They are from Adamawa North, Adamawa Central and Adamawa South respectively. [3, 22] methods were adopted in collecting the hair samples. Hair samples was collected from different subjects within Mubi Local Government Area (Adamawa North), Gombi Local Government Area (Adamawa Central) and Numan Local Government Area (Adamawa south) of Adamawa state Nigeria. Samples was collected from those working in welding, electrician and mechanics.

Figure 1 Hair sample

Hair sample was taken using clean stainless-steel scissors, the samples was cut in pieces as small as possible,

Washing of Hair Samples

The methods of [3, 22] was adopted in washing the sample of hair. The hair samples were washed with non-ionic detergent and soaked in deionized water for 10 minutes. It was followed by soaking in acetone to remove external contamination and finally the hair samples were washed with deionized water. The samples were dry in an oven at 60 °C for 30 minute and finally were sealed in plastic bags prior to analysis. According to the International Atomic Energy Agency [23, 14].

Digestion of Samples

Methods of [3, 22] was adopted in digesting the sample of hair. For each of the hair 2g sample was weighed into a clean crucible. It was dried in the oven to partial dryness to avoid explosion. The dried hair samples were digested with 20cm^3 of 3:1 mixture of concentrated nitric acid and per chloric acid, the mixture was heated until complete evaporation to obtain a water clear solution. Each digested samples were transfer into a 100 mL volumetric flask and made up to the mark with distilled water.

Determination of Heavy Metals

The instrumental methods reported by [4, 22] were adapted for the determination of heavy metals in hair. The elemental analysis was made directly on each final solution using Atomic Absorption Spectrophotometer (AAS, Shimadzu Japan 6800) for determination of Cu, Zn, Mn, Fe, Cr, Cd, Ni and Pb. Standard solution of each sample Cu, Zn, Co, Mn, Fe, Cr, Cd, Ni and Pb was prepared according to Sc 2000 manufacturer procedure for Atomic Absorption Spectroscopy to be used. A known 1000mg/l concentration of the metal solution was prepared from their salts.

RESULTS AND DISCUSSION

The concentration of heavy metals in hair samples of unpolluted workers (control) Cd ranges from 0.05 µg/g to 0.79 µg/g; Fe 0.26 µg/g to 0.79 µg/g; Pb 0.49 µg/g to 1.38 µg/g; Ni 0.08 µg/g to 0.49 µg/g; Cr 0.01 µg/g to 0.45 µg/g; Mn 0.45 µg/g to 1.89 µg/g; Zn 1.09 µg/g to 4.23 µg/g; Cu 0.09 µg/g to 0.73 µg/g. These obtained results agree with that reported for other parallel studies and they agree with the international tolerance levels [3, 24, 25]. In this context, the levels of these heavy metals in hair should be below the international tolerance levels as far as possible. However, environmental Pollutants have come to play an important role in introducing these elements into human systems [3, 16, 24]. On the other hand, the obtained results show that the levels of heavy metals in hair and unpolluted workplaces reasonably fluctuated within a relatively narrow range for a given element. Indeed, the relative fluctuation in the obtained values in each studied metal level reflects the variety in culture, age, environment, and habits [3, 24].

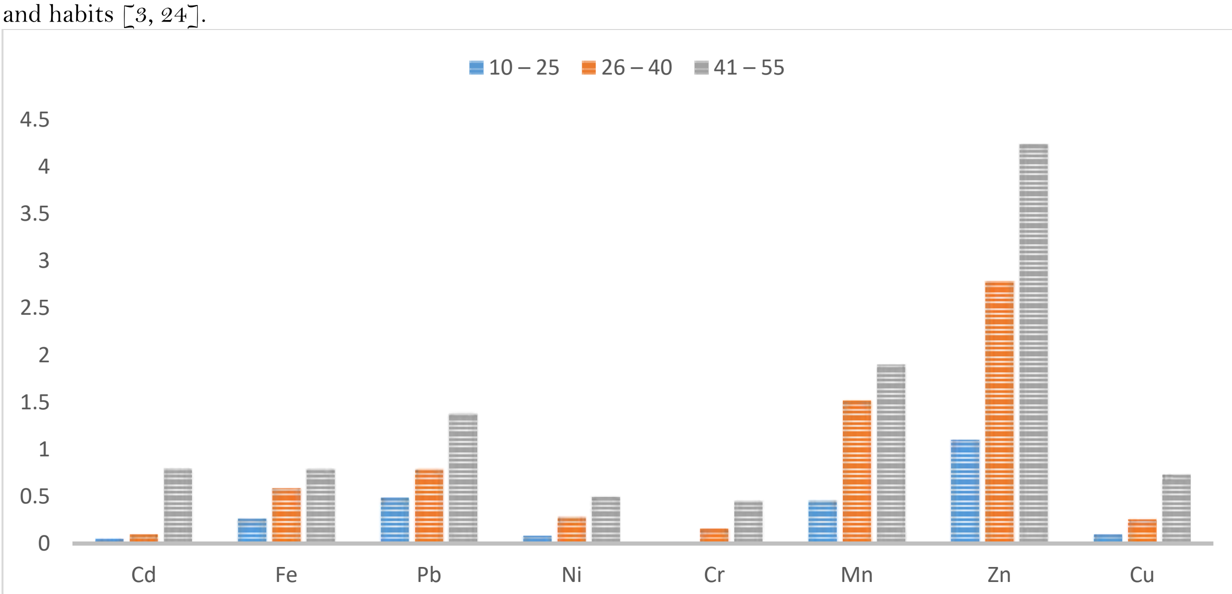

Figure 1: Mean concentration (µg/g) of heavy metals in hair sample of unpolluted workers (control) with respect to age group

In this current study, Figure 1 shows the concentration of heavy metals from occupational workers subject working in mechanics, electricians and welding workshop from Numan. The mean concentrations of Cd ranged from 0.02 µg/g to 3.03 µg/g; Pb 0.58 µg/g to 2.05 µg/g; Ni 0.03 µg/g to 0.81 µg/g; Cr 0.01 µg/g to 0.78 µg/g; Mn 0.45 µg/g to 3.12 µg/g; Zn 1.57 µg/g to 4.76 µg/g; Cu 0.03 µg/g to 0.77 µg/g. The highest mean concentration Zn 4.76 µg/g determined in welding, aged group 41 – 55, followed by Mn 3.12 µg/g; Cd 3.03 µg/g; Pb 2.05 µg/g all were detected in welding worker aged group 41 – 55, Ni 0.81 µg/g; Cr 0.78 µg/g and Cu 0.77 µg/g were recorded in electricians aged group 41 – 55. The lowest mean concentration of heavy metals Cr 0.01 µg/g were determined from mechanics aged 10 – 25. The levels of all the metals increase with respect to age. The levels of the metals were in the following order Zn>Mn>Cd>Pb>Ni>Cr>Cu. Figure 2 shows the mean concentration of heavy metals in hair sample of workers subjects to mechanics, electricians and welders with respects to their aged group in Gombi. The concentration of heavy metals Cd ranged from 0.57 µg/g to 3.58 µg/g; Pb 1.91 µg/g to 3.37 µg/g; Ni 0.50 µg/g to 1.36 µg/g; Cr 0.01 µg/g to 0.65 µg/g; Mn 1.59 µg/g to 4.40 µg/g; Zn 2.57 µg/g to 7.92 µg/g; Cu 0.09 µg/g to 0.92 µg/g. The highest concentration recorded in Zn 7.92 µg/g found from does working in welding workshop aged 26

– 40 followed by Mn 4.40 µg/g; Cd 3.58 µg/g; Pb 3.37 µg/g; Ni 1.36 µg/g; Cu 0.92 µg/g and Cr 0.65 µg/g, all were determined in welding worker aged group 41 – 55 except Cr found in electricians. The lowest concentration was detected in Cr 0.01 µg/g found in mechanics workers aged 10 – 25. The levels of all the metals increase with respect to age except age 26 – 40 which is even higher than the aged group 41 - 55

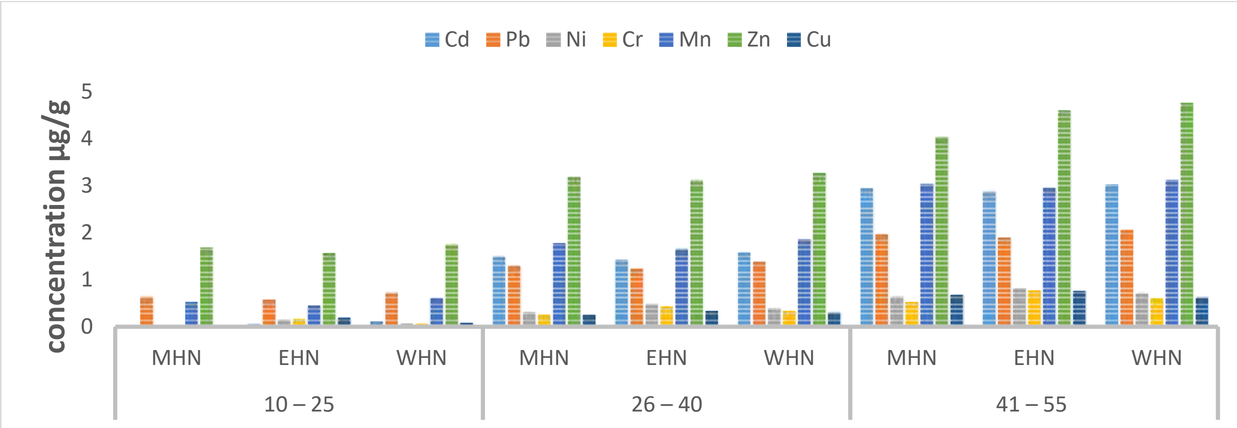

Figure 2: Concentration of heavy metals in hair sample of workers subject in mechanics, electricians and welding workshop with respects to their aged group in Numan.

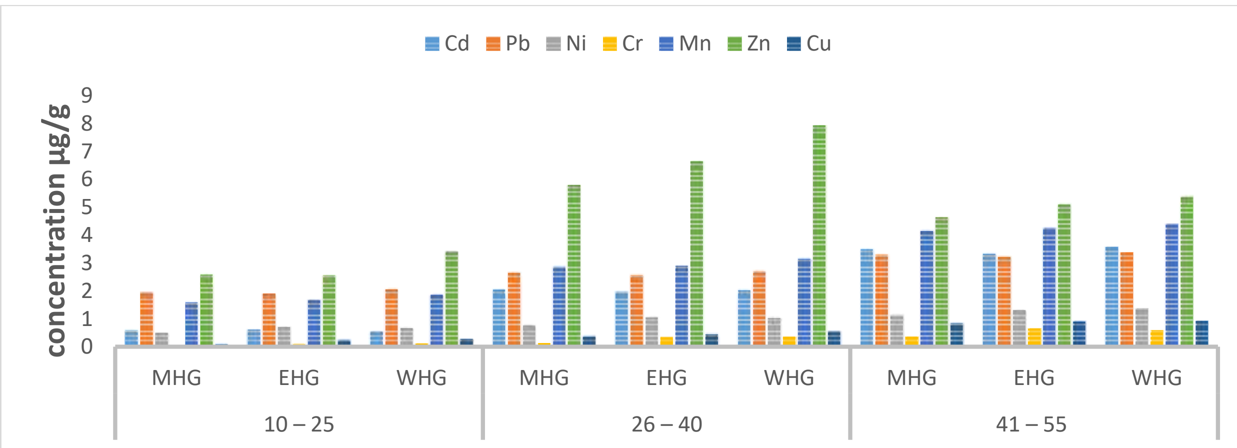

Figure 3: The concentration of heavy metals in hair sample of workers subjects to mechanics, electricians and welders with respects to their aged group in Gombi.

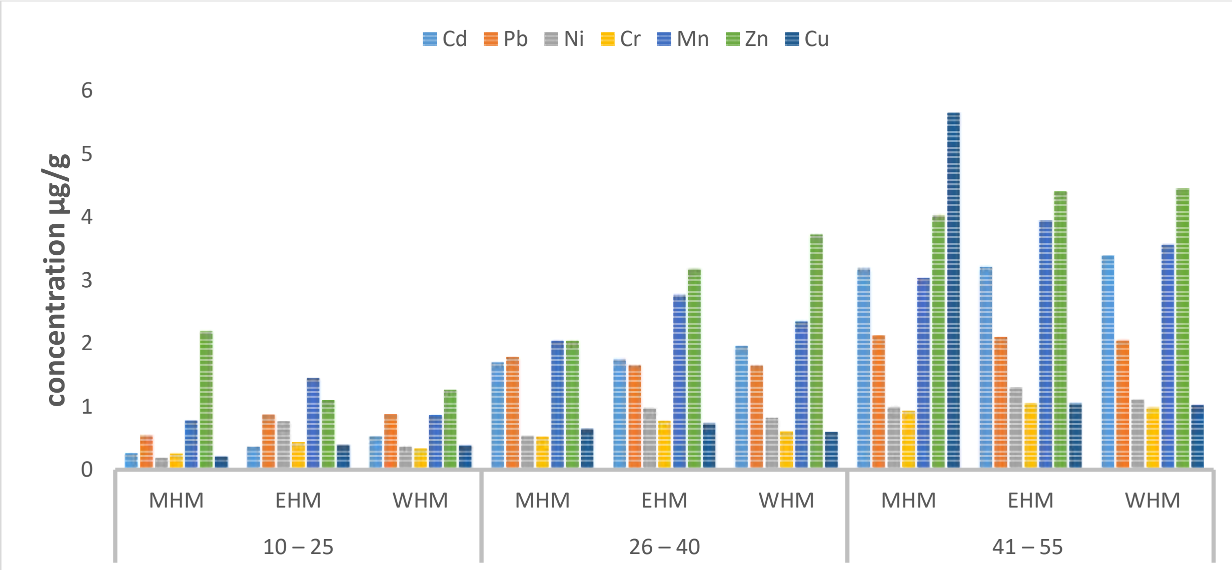

Figure 4: The concentration of heavy metals in the hair sample of workers subjects to mechanics, electricians and welders with respects to their aged group in Mubi.

The concentrations of heavy metals in hair samples from mechanics, electricians and welders of different age group are as presented in Figure 3. Cd concentrations ranged from 0.26 µg/g to 3.38 µg/g; Pb 0.54 µg/g to 2.13 µg/g; Ni 0.19 µg/g to 1.29 µg/g; Cr 0.26 µg/g to 1.06 µg/g; Mn 0.78 µg/g to 3.95 µg/g; Zn 1.10 µg/g to 4.46 µg/g; Cu 0.22 µg/g to 5.65 µg/g. The highest concentration of hair sample of workers subjects to mechanics, electricians and welders from Gombi were detected Cu 5.65 µg/g found in mechanics aged 41 – 55, followed by Zn 4.46 µg/g detected in welders, Mn 3.95 µg/g determined in electricians, Cd 3.38 µg/g found in welders, Pb 2.13 µg/g determined in mechanics, Ni 1.29 µg/g recorded in electricians and Cr 1.06 µg/g determined also in electricians. The lowest was determined in Ni 0.19 µg/g found from mechanics aged 10 – 25. The results of this study show that heavy metals in hair samples from different subjects accumulate differently based on exposure. The concentrations of heavy metals in welder workers' hair are the highest values among other occupations (mechanics and electricians), except in Mubi were mechanics workers have the highest concentration. This may be due to exposure to welding smoke which represents a mixture of very fine particles (fume) and gases, the fume contains toxic heavy metals. As it reported by [26]. Nickel is found inside the stream of welding fume and causes nasal lung cancer. Zinc oxide which is emitted during welding may get inhaled to produce acute respiratory illness. Also, it may cause manifestations flues like symptom, appetite loss, nausea, vomiting, and slow digestion. Exposure to zinc by welders most often comes from the galvanized coating on metal, which is welded [26, 27]. A previous study recorded that Cd in welding fumes cause inhalation lung injury. Welders use different instruments like oxyacetylene and electrical arc welding machines to repair silencers and welding other parts of the car that produce harmful smoke. The inhalation of vapor of Nickel carbonyl by welding workers leads to increasing Ni levels in their hair [28]. Results of the current study showed that the mechanic records the lowest concentrations of heavy metals in their hair which may be produced by the type of their work, except in Mubi aged 41 – 55 which recorded the highest concentration. Their work includes dissembling and assembling parts such as car and motorcycle engines and other related vehicle parts which are in line with the work of [26, 3]. Mechanics workers exposed to lead during the dissembling of car engine parts, lead poisoning, and death cases were recorded by inhaling and ingestion of gasoline. Most workers suck petrol and washed their hands with it, which leads to the absorption of tetraethyl by mucosa and elevated blood levels [26, 29]. There is a positive relationship between age groups and heavy metals concentrations in hair. Most of the electricians, cars, and motorcycles worker shops are open and lay beside roads this makes workers exposed continuously to heavy metal pollutants from different sources, which accelerate the accumulation of heavy metals in body tissue [26, 3]. The concentration of heavy metals in hair samples might be attributed to the incorporation of elements into the keratin structure of hair which takes place by binding to the sulfhydryl groups that are present in the follicular protein. In this regard, detergents such as soap, shampoos, hair pomades, lotions, hair bleaches, and dyes compete with the complexing ability of these reactive sites, thus leading to significant leaching of elements from the shaft bulk [26, 22].

Copper is a common environmental metal and is essential in cellular metabolism but at high concentrations it can be highly toxic to fish [3, 22]. Copper is an essential substance to human life, however, in high concentrations, it can cause anaemia, liver and kidney damage, stomach and intestinal irritation. Copper is generally remobilised with acid-

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base ion exchange or oxidation mechanism [22]. Copper is an essential substance to human life, but its critical doses can cause anemia, adrenal hyperactivity and insufficiency, allergies, hair loss, arthritis, autism, cancer, depression, elevated cholesterol, depression, diabetes, dyslexia, failure to thrive, fatigue, fears, fractures of the bones, headaches, heart attacks, hyperactivity, hypertension, infections, panic attacks, strokes, tooth decay and vitamin C and other vitamin deficiencies [22]. Cadmium (Cd) is very toxic, its long-term exposure to lower levels leads to a build-up in the kidneys and possible kidney disease, lung damage, and fragile bones. Hypertension, arthritis, diabetes, anaemia, cancer, cardiovascular disease, cirrhosis, reduced fertility; hypoglycaemia, headaches, and strokes are its some odd long-term results [30], The levels of cadmium in the hair samples were above the reference values of various countries Italy is 0.03 mg/kg, England 0.11 mg/kg, Japan 0.05 mg/kg [31]. The bioaccumulation nature of Cd and the pattern of exposure as shown in the results, cannot rule out the long-term health complications of Cd in the various subjects. Iron (Fe) the level of mean concentration of iron might be attributed to the presence of iron oxide fumes in the environment of the workplace as various processes involved emanate oxides of iron. [31]. The toxicity of iron in humans has been found to bring about vomiting, cardiovascular collapse, and diarrhea. While iron deficiency may lead to failure of blood clotting [32]. The high accumulation of Pb could have resulted from the exposure to Pb contaminated food and drinking water World Health Organization [31]. Production of batteries, smelting and metal plating process, and exhaust from vehicles, pigment additives, gasoline, are also the possible sources of Pb exposure in the environment [32]. A Previous study reported that the higher cereal intake of Pb leads to elevations in workers' hair tissue [31]. Lead (Pb) enters into the body system through air, water, and food and cannot be removed by washing fruits and vegetables [33]. It is a serious cumulative body poison, which can affect every organ and system in the body. Exposure to its high levels can severely damage the brain, and kidneys and ultimately cause death [34]. and long-term exposure results in de-creased performance in some tests that measure the functions of the nervous system; weakness in fingers, wrists, or ankles; small increases in blood pressure [32]; and anaemia. Others are abdominal pain, anaemia, arthritis, attention deficit, back problems, blindness, cancer, constipation, con-avulsions, depression, diabetes, migraine headaches, thyroid imbalances and tooth decay [22]. Children exposed to high lead levels are particularly at risk. The levels of lead in the analyzed nail and hair samples for the entire subject studied exceeded the upper limits for the various countries Italy is 0.03 mg/kg; Japan 1.4 mg/kg) [33]. Indicating the presence of this metal in the environment and the workplace of the subjects as well as their proneness to illness and hazards of this metal in cases of long-term exposure. WHO guidelines show that maximum venerable Pb amount in hair/nail (μg/gm) 0.2 μg/gm. The results of the present study, clearly demonstrate that individual who participated in the present study were exposed to increased heavy metal concentration [34]. Nickel the highest mean concentration of Nickel attributed to the inhalation of vapors of nickel carbonyl from the work type (mechanic, electrician, and welder) also causes elevation in Ni levels [34]. The presence of all the metals in occupational worker could be attributed to the environmental exposure [33]. The concentrations of all the metal studied in hair samples from occupational worker subjects increased significantly [22]. The younger group showed the lowest levels when compared with the older groups [34]. Nickel is known to be responsible for cancer (oral and intestinal), depression, heart attacks, hemorrhages, kidney dysfunction, low blood pressure, malaise, muscle tremors and paralysis, nausea, skin problems, and vomiting [33]. The levels of nickel were spatially and temporarily high in the hair samples. However, long-term exposure can cause decreased body weight, heart and liver damage, and skin irritation [22].

Zinc (Zn) The results of this study show that heavy metals in hair samples of occupational workers accumulate differently based on exposure. It was observed that the highest concentration might be attributed to exposure of subjects working in welder workshops [34]. This indicates that the concentrations of metals in the body is a function of metal in the work environment, this was in line with the work of [30]. Smoking habit among workers of all types of occupations leads to an increase in the levels of Zn concentrations in their hair. World Health Organization (WHO). Some metals such as Zn, Cr, Mn, and Cu are necessary nutrients for various physiological functions. These metals are also present in pharmaceutical products. It may accumulate in the human body when taken, which may add to this metal content in the body. The levels of elements such as Cu, Zn, Cr, Ni, Mn, Fe, Pb, and Cd increase with age, which indicates the bio-accumulative properties of these elements [34].

CONCLUSION

Based on this study hair samples of occupational workers (mechanic, electrician, and welder) reveal high levels of some heavy metals. Elements such as Pd, Cu, Zn, Cr, Ni, Mn, and Cd levels increase with age, indicating the bio-accumulative properties of these elements. This research shows that there is a statistically significant relationship between the type of work or workplace and the heavy metal concentration detected in hair samples. There is an instantaneous need for public awareness about the hazards of this occupation to enable occupational workers to take necessary precautionary measures. It is also deemed essential that certain preventive measures including the use of Personal Protection Equipment (PPE) such as hand gloves, helmets, and masks should be taken to safeguard the health of the subject working in mechanic, electrician, and welding workshop.

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