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ORIGINAL RESEARCH

Determination of Trace Metals in Chemicals Associated with Body Painting

Abdulrafiu Majolagbe, Ladidi Hudu

*Department of Chemistry, Faculty of Science,
Lagos State University, Nigeria***Abstract:**

Introduction: Beautification of the skin is a global phenomenon with both males and females engaging in the practice of body painting without regards to the toxicology of the art. The presence of toxic heavy metals as part of the chemicals of body painting have been implicated in a number of health conditions including blood borne diseases, keloids and compromise of the immune status.

Aims: This study was, therefore, designed to determine the concentration of heavy metals in the chemical materials used in body painting.

Materials and Methods: Twenty (20) various samples of body painting chemicals (natural and synthetic) were obtained in four open markets and analysed for heavy metals (Cd, Zn, Pb, Fe, Ni, and Cu) using Atomic Absorption Spectrophotometry (AAS).

Results: The results observed ranged 7.09-106, 0.31-0.50, 0.94-4.81, 0.24-0.89, 0.003-0.6 and 0.002- 0.002 ($\mu\text{g/g}$) for Fe, Cu, Zn, Pb, Ni, and Cd respectively in natural (plant based) materials while in synthetic materials, the results ranged 0.31-5.31, 0.31-0.50, 0.29-2.72, 0.11-0.91, 0.003-0.003 and 0.002-0.002 ($\mu\text{g/g}$) for Fe, Cu, Zn, Pb, Ni, and Cd respectively. The decreasing order of metals in all samples investigated was Fe > Zn > Pb > Cu > Ni > Cd.

Conclusion: The concentrations of some of the metals investigated were relatively high and bio-accumulations of these metals portend health threats. Therefore, health agencies and other regulatory bodies should enforce control on the public use of these body painting chemicals.

Keywords: Painting, Tattoo, Heavy Metals, Colours and Dye

Correspondence*Abdulrafiu Majolagbe, Department of Chemistry,
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1. INTRODUCTION

How we decorate or handle our body tell others who we are as individuals and reveal our inner expression. Applications of special colours and pigments on human skin, result in either permanent or temporary body modification [1].

Many people use their skin as living canvas, showing past experiences, bravery, status, beauty, protection, fertility, magic, transformations and connection with other realms [2]. These incredible kinds of expressions, performances, belongings and traditions have been linked to two reasons: cultural representations and contemporary art referred to as body painting [3].

Body painting is a mode of creative expression such as drawing, gesture, composition, narration, may serve as a way of expressing an inner feeling and is sometimes used as a means of gaining attention in political protests. Body painting can be naturalistic and representational and can also be temporary or permanent. Body painting is practiced all around the world but more visible in Australia, New Zealand, South America and Africa. In New Zealand, 20% of the population has a permanent body painting (tattoo), including one in three people under the age of 30 [4]. About 6% of U.S. adults are tattooed, including over a third of those aged 25–29 years [5]. Despite the art's growing popularity, the toxicology of tattoos is poorly understood [5]. However, some ink components, particularly heavy metals are now raising health concerns. American Environmental Safety Institute (AESI), filed suit against violations of California's Proposition 65, which requires that Californians be warned before exposure to chemicals causing cancer, birth defects, or other reproductive harm [5].

Permanent Body Paintings commonly called 'Tattoo' is a form of body modification, where a design is made with the use of mechanized needle to puncture the skin and ink, dyes or and pigment is injected into the dermis of the skin, just the second layer of the skin. Tattoo ink placed via needles into the dermis layer of the skin, remains permanently (although some colours will fade with time).

A temporary body painting is a non-permanent image on the skin though resemble tattoo. Temporary tattoos can be drawn, painted, airbrushed or needled as a permanent tattoo with an ink which can dissolve in blood within 6 months of body painting. A typical example of temporary tattoo is mehndi, made from henna (Henna is a dye that is used to colour the skin, hair and fabrics). Mehndi is the application of henna dye on the skin from ancient India, in which decorative designs are created using a paste of powdered dry leaves of the henna plant, *Lawsonia Inermis*. Henna is applied only on the outer layer of the skin (epidermis), it lasts only for 1 - 4 weeks depending on our skin's response when exposed to hot water, detergent and chemicals. Mehndi is still a popular form of body art among the woman of India subcontinent, Africa and the Middle East [6].

Tattoo inks contain a number of chemicals and heavy metals, including some that are potentially toxic [7]. Those elements including titanium, aluminium, chromium, nickel, and other metals are found either in the preservatives, colorants or as contaminants in the tattoo ink. There is circumstantial evidence that shows

tattoo pigments travel around the body and nanoparticles from tattoo ink can move from the skin to lymph nodes in the human system. These deposits in lymph nodes may not be initially of health concern because lymph nodes act as a barrier to colon cancer cells [8]. Since the process of tattooing involves damaging the skin and possibly breaking blood vessel, tattooing may constitute direct route of metals into the bloodstream. However, the body responds with the white blood cells called dendritic cells making attempt to absorb the foreign particles and dispose them off in the blood stream.

Inductively coupled plasma mass spectrometry (ICP-MS), was used to detect of certain inorganic elements in both the skin and lymph nodes of the tattooed subjects compared with those without tattoos.

Heavy metals in the environment constitute a major source of concern to environmental researchers and engineers not only because heavy metals are harmful to humans and animals, but also tend to bio-accumulate in the food chain [9]. The heavy metals most commonly associated with poisoning of humans include lead, mercury, arsenic and cadmium. Heavy metal poisoning may occur as a result of industrial exposure, air or water pollution, foods, medicines, improperly coated food containers, or the ingestion of lead-based paints.

Heavy metals can bind to vital cellular components, such as structural proteins, enzymes, and nucleic acids, and interfere with their functioning. Symptoms and effects can vary according to the metal or metal compound, and the dose involved. Generally, long-term exposure to toxic heavy metals can have carcinogenic, central and peripheral nervous system and circulatory effects [10]. Accumulation of trace metals in human body has been reported to be responsible for neurodegenerative diseases, disrupting important bodily functions, and even causing cancer [11].

This study was, therefore, designed to determine the concentration of heavy metals in the commonly used commercial chemicals (colours and dyes) used in body painting and possibly compare with the allowable limits from regulatory bodies.

2. MATERIAL AND METHODS

Twenty (20) various chemicals (colours and dyes) materials used in body painting were obtained from four (4) open markets (Agege, Idi Araba, Alaba and Island) in Lagos, Nigeria. These chemical materials are plant-based samples (PBS), semi-solids (SSS) and liquid samples (LQS). Only PBS samples are natural while the others, SSS and LQS are synthetic. They are produced in countries such as Pakistan, Indian, China and Nigeria.

2.1 Chemical Analysis

1.0 g of ground oven-dried samples was accurately weighed and digested with aqua regia. It was refluxed for 2hrs, after which the sample was washed, rinsed with demineralized water, filtered using Whatman No.1 filter paper and made up to 100ml in standard flask.

The samples were analysed using Buck scientific 210VGP model Atomic Absorption Spectrophotometer. Calibration curve was prepared through standard solution of pure metals of concentration ranging from 0.0 – 35.0mg/l at 5mg/l increment through same

procedure described earlier. Duplicate analysis was carried out of each of the sample to test for the reproducibility of the method.

2.2 Data Statistical Analysis

Descriptive analysis of data generated were carried out using GraphPad Prism (version 5.00). Correlation coefficient was performed in a pair wise fashion employing Pearson correlation coefficient.

3. RESULTS AND DISCUSSION

The results of metal analysis of sample materials used in body painting is presented in Tables 1.0, 2.0 and 3.0 for plant based, semi solids and liquid sample materials respectively.

Table 1. Concentration of heavy metals (µg/g) in plant-based samples in body painting

Sample	Fe	Cu	Zn	Pb	Ni	Cd
PBS1	7.09	0.34	0.94	0.27	0.003	0.002
PBS2	12.8	0.31	2.69	0.53	0.3	0.002
PBS3	63.1	0.44	1.34	0.76	0.4	0.002
PBS4	41.3	0.40	2.58	0.69	0.003	0.002
PBS5	106	0.50	4.81	0.89	0.6	0.002
Mean	46.1	0.40	2.47	0.63	0.43	0.002
S.D	40.4	0.07	1.51	0.24	0.26	0

Table 2. Concentration of heavy metals (µg/g) semi solid samples used in body painting

Sample	Fe	Cu	Zn	Pb	Ni	Cd
SSS1	4.14	0.37	0.71	0.14	0.003	0.002
SSS2	4.33	0.33	0.97	0.69	0.003	0.002
SSS3	5.31	0.35	0.64	0.16	0.003	0.002
SSS4	3.44	0.37	2.72	0.77	0.003	0.002
Mean	4.31	0.36	1.26	0.44	0.003	0.002
S.D	0.77	0.02	0.98	0.34	0	0

The metals investigated are of two categories; toxic metals including Pb, Ni, and Cd, while Fe, Cu, and Zn can be grouped as nutritive metals, though depending on the concentration of the metals. Metal pollution in human system can be through ingestion, inhalation and through dermal absorption. All metals investigated in this study were observed in all the sample analysed. The decrease order of metals in all samples investigated is Fe > Zn > Pb > Cu > Ni > Cd.

The concentration of metals observed in plant-based samples (produced in Nigeria) is higher than that of synthetic samples (imported) particularly in Iron and Lead.

This observation could be as a result of Fe rich soil in Nigeria [12] and heavy load of atmospheric lead that has been reportedly characterize the Nigeria atmosphere [13,14].

Table 3.0: Concentration of heavy metals (µg/g) Liquid samples used in body painting

Sample	Fe	Cu	Zn	Pb	Ni	Cd
LQS1	3.92	0.50	0.66	0.11	0.003	0.002
LQS2	3.76	0.44	0.35	0.36	0.003	0.002
LQS3	3.32	0.45	0.29	0.11	0.003	0.002
LQS4	0.31	0.37	0.60	0.12	0.003	0.002
LQS5	4.03	0.31	2.61	0.48	0.003	0.002
LQS6	3.4	0.37	1.61	0.75	0.003	0.002
LQS7	4.57	0.32	4.68	0.91	0.003	0.002
LQS8	3.31	0.31	0.58	0.13	0.003	0.002
LQS9	3.08	0.31	2.61	0.73	0.003	0.002
LQS10	3.2	0.39	0.68	0.57	0.003	0.002
Mean	3.29	0.38	1.47	0.43	0.003	0.002
S.D	1.14	0.07	1.43	0.31	0	0

The sources of lead in environment include; burning of fossil fuel, automobile exhaust, etc.

The high level of Iron (Fe) and Lead (Pb) observed in this work portend health problems. Though iron is an essential element for man and animals necessary for some metabolic functioning, but at very low concentration. It is an important component of haemoglobin and facilitates the oxidation of carbohydrates, protein and fat, thereby controlling body weight, which is a very important factor in fight against diabetes [15]. However, excessive dietary iron is toxic. Once the body iron build-up exceeds the natural ability to store iron, various health conditions set in for there is no known psychological mechanism to remove excess iron in human body [16]. Iron toxicity has been implicated in various health conditions including heart dysfunctioning, cardiomyopathy [17,18], hepatic complications such as fibrosis [19] and compromised immune condition [20]. The excess ferrous iron reacts with peroxides in the human body, producing free radicals [21]. Other side effects of taking high doses of iron include constipation, nausea, vomiting and stomach pain. Very high doses of iron can be fatal, particularly in children, a disease condition called hemochromatosis [22]. The excess iron accumulates in the liver, resulting in siderosis and organ damage [23]. Pb is a toxic metal whose allowable limit both in water is 0.001µg/g and food is 0.1µg/g have been exceeded in this study hence, the observed result is really of health concern. Acute exposure of high load of lead can cause encephalopathy (brain dysfunction), nausea and vomiting while chronic exposure can lead to anaemia encephalopathy, foot drop/wrist drop (palsy) and nephropathy (kidney disease) [24].

The cadmium observed is of constant level in all samples showing it might be a natural constituent of the samples or a contamination as shown by Ni in all synthetic samples analysed.

Both zinc and copper are nutritive elements needed for normal metabolic functioning in human body system, though required at low level. The levels of these metals observed in present study: Cu (Zn) ranged from 0.31 (0.94) to 0.50 (4.81), 0.33 (0.71) to 0.37 (2.72), and 0.31 (0.29) to 0.50 (4.68) µg/g in plant based, semi-solid and Liquid samples respectively. Copper is essential for activity of several cellular enzymes, particularly tyrosine and the formation of melanin pigment. It is also needed for utilisation of Iron. Iron deficiency anaemia in infancy

is often accompanied by copper deficiency. Menkes disease whose symptoms include weak muscle tone, sagging facial features, seizures, mental retardation, developmental delay and kinky, colorless hair, is an X-linked recessive disorder characterized by copper deficiency resulting in a diminished function of copper dependent enzymes [25]. More often, most patients die in early childhood [26]. Wilson disease is characterised by high level of Cu in liver, brain and kidney [22]. Various clinical abnormalities of the nervous system, liver and kidney are related to copper accumulations. Copper toxicity seldom occur in humans as a result of transport systems that regulate absorption and also human ability to excrete excess copper through bile [27]. Excessive copper intake can cause nausea, vomiting, abdominal pain and cramps, headache, dizziness, diarrhea, and a metallic taste in the mouth (associated with water containing copper concentrations greater than 6 mg/L) [28].

Zinc is a common element in every environmental sample. It is present in most foodstuff, water and air. Seafood and whole grain are high in zinc content. Most zinc is in the brain, muscle, bones, kidney and liver, with the highest concentrations in the prostate and parts of the eye. Zinc helps in various human catalytic activities, plays a role in immune function, wound healing, protein synthesis, DNA synthesis and cell division. Zinc is required for proper sense of taste and smell and supports normal growth and development during pregnancy, childhood, and adolescence [25]. Excess zinc can be harmful. Excessive absorption of zinc suppresses copper and iron absorption. Acute adverse effects of high zinc intake include nausea, vomiting, and reduced immune functions. Death could also result due to gastrointestinal bacterial and fungal sepsis [25].

The correlation coefficient of metals analysed in the plant-based samples is shown in Table 4.0.

Table 4.0: Correlation coefficient of metals in the plant-based samples

	Fe	Cu	Zn	Pb	Ni
Fe					
Cu	0.97				
Zn	0.71	0.56			
Pb	0.90	0.85	0.69		
Ni	0.77	0.65	0.64	0.72	

The correlation coefficient of metals (Table 4.0.) shows both moderate and strong positive chemical association. Zn/Cu, Ni /Cu, Ni/Zn and Pb/Zn are of moderate correlations while Cu/Fe, Pb/Fe, Ni/Fe, Ni/Pb, Pb/Cu show strong correlations. The results show there is a common factor responsible for origin or sources(s) of these metals in the plant-based sample. Increase in concentration of one metal will also lead to increase in concentration of the other.

4. CONCLUSION

The art of body beautification keeps gaining patronage globally despite low level of its toxicology awareness. The levels of both toxic and nutritive metals observed in

this study are not too far from levels reported in literature (Cosmetics studies). However, concentration of iron and lead are high, indicating health problems. Both moderate and strong positive correlations were observed among the metals investigated suggesting their common source or origin. The health agencies and various stakeholders must come together to formulate control and enforce same so as to ensure safety of lives. Strong campaign may be necessary to enlighten the public on the dangers attached to the use of these chemicals and the art of body painting.

COMPETING INTERESTS

Authors have declared that no competing interests exists.

AUTHORS' CONTRIBUTIONS

Abdulrafii Majolagbe designed the study and wrote the protocol. Abdulrafii Majolagbe and Ladidi Hudu performed the laboratory protocols and statistical analysis. Ladidi Hudu wrote the first draft of the manuscript and managed the literature searches. All authors read and approved the final manuscript.

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