SOME PSYCHIATRIC DISORDERS AMONG WORKERS IN ALUMINIUM INDUSTRY

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ABSTRACT

This study was carried out in an aluminium factory in Helwan to assess neuropsychiatric disorders and its relation to occupational exposure to multiple stressors in aluminium industry through clinical assessment, neuropsychiatric tests, determination of serum aluminium, copper & urinary aluminium and environmental samples.

It revealed increased prevalence of neurological symptoms among aluminium workers, most of the workers showed decreased scores in the performed neuropsychiatric tests as cognitive decline, memory affection, depression, anxiety and personality changes.

All aluminium workers had elevated serum & urinary aluminium level compared to control group although environmental aluminium measurements are within permissible level.

Key Words:

Aluminium workers – Neuropsychiatric tests – Serum & urinary aluminium – Environmental samples

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ABBREVIATIONS

AAN	**American Academy of Neurology**
AB	**Amyloid B Peptide**
ACGIH	**The American Conference of Governmental Industrial Hygienist**
Ach	**Acetylcholine**
AD	**Alzheimer's disease**
AL	**Aluminium**
Al_2O_3	**Aluminium Oxide**
Al (OH) $_3$	**Aluminium hydroxide**
APP	**Amyloid precursor protein**
ATP	**Adenosine triphosphate**
BBB	**Blood Brain Barrier**
BCG	**Bacillus Calmetteguerin**
BEIs	**Biological exposure indices**
CDT	**Clock drawing test**
CNS	**Central nervous system**
Cu	**Copper**
DB	**Dry bulb temperature**
DD	**Dialysis dementia**
DES	**Dialysis encephalopathy syndrome**
DFO	**Desferrioxamine**
DPT	**Diphtheria – Pertussis - Tetanus**
EDTA	**Ethylenediaminetetra acetic acid**
EEG	**Electroencephalograph**
ERP-P300	**Endogenous event related potential**
FAO	**Food Agriculture Organization**
GSH	**Glutathione**
GT	**Globe temperature**
HF	**Hydrogen Fluoride**
HLPP	**Hearing loss prevention program**
HR	**Heart rate**

8-Hr TWA	**8 – hour Time weighted average**
HNE	**Hydroxynonenal**
LDL	**Low density lipoprotein**
MCI	**Mild cognitive impairment**
MMSE	**Mini mental state examination**
MSHA	**Mine safety and health administration**
NFTs	**Neurofibrillary tangles**
NIHL	**Noise induced hearing loss**
NIOSH	**National Institute for Occupational Safety and Health**
NO	**Nitric oxide**
NWB	**Natural wet bulb temperature**
OSHA	**Occupational Safety and Health Administration**
ONOO	**Peroxy nitrate**
PAH	**Polynuclear aromatic hydrocarbones**
PEL	**Permissible exposure limits**
PPE	**Personal protective equipment**
PTWI	**Provisional tolerable weekly intake**
REL	**Recommended exposure limits**
REM	**Rapid eye movement**
ROS	**Reactive oxygen speices**
SO_2	**Sulphur dioxide**
SOD	**Super oxide dismutase**
TLV	**Threshold limit value**
TPN	**Total parenteral nutrition**
WBGT	**Wet bulb globe temperature**
WHO	**World Health Organization**

INTRODUCTION

Aluminium (Al) is the most abundant metal in the earth's crust (8%) and it's the third most abundant element after oxygen and silicon, where it is always found combined. Its atomic number is 13 and its atomic weight is 26.98 ***(Kaye, 1998)***.

Aluminium is soft, durable, light weight, malleable metal with high heat conductivity, for that aluminium is used widely throughout industry and in larger quantities than any other non-ferrous metal and also widely used in cooking utensils and containers ***(Elinder and Sjogren, 1986).***

Although it was considered to be harmless, recently considerable toxic effects of aluminium have been found ***(Pierre et al., 1995).***

It was found that occupational exposure to aluminium may affect the central nervous system and results in a wide variety of neuropsychiatric effects, ranging from subtle behavioural disturbances to overt psychosis. ***(Candura et al ., 2000).***

Aluminium foundry workers were found to have changes in psychomotor and intellectual abilities, which could be a consequence of the long lasting toxic effect of aluminium ***(Hosovski et al., 1990).***

It was found that exposure of miners to aluminium powder as a prophylactic agent against silicotic lung disease performed less well than did unexposed workers on cognitive state examinations ***(Rifat et al., 1990).***

In Italian foundry workers, there is evidence of neurotoxic effects with mild cognitive impairment due to exposure to aluminium dust, these effects could be the prelude to Alzheimer’s disease or Alzheimer’s disease like neurological deterioration ***(Adams, 2003).***

In aluminium industry, aluminium is alloyed with a variety of other materials including copper which makes it more malleable, strong and easily extruded. Copper (Cu) is a chemical element and its atomic number is 29. It is a ductile metal with excellent electrical conductivity, and finds extensive use as an electrical conductor, heat conductor, as a building material and as a component of various alloys ***(Callister , 2003).***

Copper is involved deeply with all aspects of the central nervous system, and it is highly associated with most psychological, emotional and often neurological conditions. These include memory loss, especially in young people, depression, anxiety, bipolar disorder, schizophrenia, panic attacks, migraines, insomnia, nervousness and irritability ***(Wilson L, 2008).***

It has been suggested that aluminium and copper may be involved in the pathogenesis of Alzheimer's disease through their interaction in the promotion of oxidative events ***(Becaria et al., 2003).***

In aluminium industry, there is a possibility of heat disorders especially during periods of hot weather; also there is a risk of exposure to high noise levels in aluminium foundry ***(Bertram, 1998).***

It was found that occupational exposure to physical agents like (noise and temperature) may be related to mood disorders and suicide ***(Jong-M, 2008).***

AIM OF THE WORK

The objective of this study is to search for a relation between occupational exposure to multiple stressors like aluminium, copper, heat and noise in aluminium industry and the possibility of some psychiatric disorders by analysis of aluminium, copper, heat, noise and psychiatric assessment of:

- Cognitive decline
- Memory impairment
- Depression
- Anxiety
- Personality changes

Aluminium industry and exposure

Occurrence

Aluminium is the most abundant metal in the earth's crust, where it is found in combination with oxygen, fluorine and silica, but never in the metallic state. Bauxite is the principal source of aluminium. It consists of a mixture of minerals formed by the weathering of aluminium-bearing rocks. Bauxites are the richest form of these weathered ores, containing up to 55% alumina. Some lateritic ores (containing higher percentages of iron) contain up to 35% aluminium oxide (Al_2O_3).Commercial deposits of bauxite are mainly gibbsite ($Al_2O_3.3H_2O$) and boehmite (Al_2O_3. H_2O) and are found in Australia, Guyana, France, Brazil and Ghana. Gibbsite is more readily soluble in sodium hydroxide solutions than boehmite and is therefore preferred for aluminium oxide production ***(Nordberg, 1998).***

Aluminium occurs in nature as inorganic compounds. Aluminium oxide (Al_2O_3) is the raw material used in industrial production of the metal. This oxide occurs in two major forms. α-aluminium oxide (α-Al_2O_3) constitutes a high temperature form and is formed on heating aluminium hydroxide ($Al(OH)_3$) at a temperature of 1000°C or above, it is very hard and resistant to hydration and acids. γ-aluminium oxide (γ-Al_2O_3) is generated at 500°C and readily takes up water and dissolves in acids. Other minor forms are generated when heating $Al(OH)_3$ include: χ -, κ-, δ-, θ-Al_2O_3 ***(Trunov et al., 2005).***

Physicochemical Properties

Aluminium is a soft, durable, lightweight, malleable metal with appearance ranging from silvery to dull grey, depending on the surface roughness. Aluminium is neither magnetic nor sparking. Aluminium has about one-third the density and stiffness of steel, its density is of 2.7g/cm3, it is ductile, and easily machined, cast and extruded . Its atomic number is 13 and atomic weight is 26.98 ***(Kaye, 1998).***

Aluminium is characterized by certain properties such as low specific gravity, high tensile strength, reflectivity, high electrical and heat conductivity and its silvery white

appearance. In moist air, a protective oxide coating of aluminium oxide is formed on its surface, producing a corrosion resistant form ***(Bengt and Carl- Gautaf, 1994).***

Aluminium is insoluble in hot or cold water, concentrated nitric acid, alcohol and hot acetic acid; soluble in hydrochloric acid, sulfuric acid and alkalies. The water solubility of aluminium compounds is limited except for its salts, namely the chloride, nitrate, sulphate and chlorate. Aluminium metal, aluminium oxide and aluminium hydroxide are nearly insoluble in water and organic solvents, while freshly prepared aluminium metal surfaces do react with water to form an inert protective coating. By contrast, powdered aluminium can react with water to yield hydrogen gas ***(Krewski et al., 2007).***

Uses

The largest markets for aluminium metal and its alloys are in transportation, building construction, packaging and in electrical equipment. Transportation uses are one of the fastest growing areas for aluminium use. Aluminium powders are used in pigments, paints, fuel additives, explosives and propellants. Aluminium oxides are used as food additives and in the manufacture of abrasives, refractories, ceramics, electrical insulators, catalysts, paper, spark plugs, light bulbs, artificial gems, alloys, glass and heat resistant fibres. Aluminium hydroxide is used widely in pharmaceutical and personal care products ***(Krewski et al., 2007).***

Aluminium hydroxide is used in stomach antacids, in buffered analgesics and other pharmaceuticals, as well as in antiperspirants, dentifrices, a filler in cosmetics, plastics, rubber, paper and as a soft abrasive for brass and plastics, it is also used pharmaceutically to lower the plasma phosphorus levels in patients with renal failure and as a vaccine adjuvant ***(ATSDR, 2008; Baylor et al., 2002).***

Aluminium hydroxide is also the basis for producing fire retardant materials. Food related uses of aluminium compounds include preservatives, fillers, colouring agents, anti-caking agents, emulsifiers and baking powders; soy-based infant formula can contain aluminium. Natural aluminium minerals especially bentonite and zeolite are used in water purification, sugar refining, brewing and paper industries ***(Krewski et al., 2007)***.

Aluminium is used widely throughout industry and in larger quantities than any other non-ferrous metal; it is alloyed with a variety of other material including copper, zinc, silicon, magnesium, manganese and nickel. Aluminium and aluminium alloy ingots can be extruded or processed in rolling mills, wire-works, forges or foundries. The finished products are used in shipbuilding for internal fittings and superstructures; aircraft industry for airframes; automobile industry for bodywork, engine blocks and pistons; light engineering for domestic appliances and office equipment and in the jewellery industry. A major application of sheet is in beverage or food containers, while aluminium foil is used for packaging ***(Nordberg, 1998).***

Aluminium sulphate is used as an accelerator for concrete solidification (high alumina cements) and in water treatment **(*Bengt and Carl- Gautaf, 1994).***

Aluminium production

Aluminium is extracted from bauxite ores by open-pit mining. The lower grade ores may be beneficiated by crushing and washing to remove clay and silica waste. The production of the metal comprises two basic steps:

1. Refining: It include production of melted alumina from bauxite by the Bayer process in which bauxite is digested at high temperature and pressure in a strong solution of caustic soda. The resulting hydrate is crystallized and calcined to the oxide in a kiln or fluid bed calciner.
2. Reduction: This step involves reduction of alumina to virgin aluminium metal employing the Hall-Heroult electrolytic process using carbon electrodes and cryolite flux. ***(Bertram, 1998).***

There are two major types of Hall-Heroult electrolytic cells in use:

a- "Pre-bake" process which utilizes carbon electrodes. In such smelters, exposure to polycyclic hydrocarbons normally occurs in the electrode manufacturing facilities, especially during mixing mills and forming presses.

b- Smelters utilizing the "Soderberg-type cell" do not require facilities for the manufacture of baked carbon anodes. Rather, the mixture of coke and pitch binder