

## Behavioural Endpoints of Adult Wistar Rats, Following Aluminium Chloride Exposure

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**Abstract:** Aluminium is a ubiquitous element and the third most abundant element in the earth's crust, comprising approximately 8% of the earth's crust, exceeded only by oxygen (47%) and silicon (28%). The elemental aluminium does not occur in its pure state but is always combined with other elements such as chloride, hydroxide, silicate, sulphate and phosphate. Patients on dialysis or on long-term treatment with total parenteral nutrition have been shown to accumulate this metal in different organs. The Morris Water Maze (MWM) was described as a device to investigate spatial learning and memory as well as tools in behavioural neuroscience. The objective of this study was to determine the behavioural endpoints of wistar rats, following the aluminium chloride exposure. Total of thirty wistar rats were used in this study. The wistar rats were divided into five groups; group I was the control, group II received 475 mg/kg, group III received 950 mg/kg, group IV received 1,425 mg/kg and group V received 1,900 mg/kg via oral intubation for a duration of Eight weeks. MWM was used to test for the behaviour of the wistar rats. We observed that at the first run, the wistar rats were trying to learn task; the second and third runs rather showed that wistar rats in the control group get to the platform faster (performed the task better) than the treated groups and the difference observed was significant at  $p < 0.05$ . We therefore conclude that Aluminium chloride exposure has negative effects on behavioural endpoints and can impair learning and memory.

**Key words:** Adult, aluminium chloride, behavioural endpoints, exposure, wistar rats

### INTRODUCTION

Aluminium is a ubiquitous element and the third most abundant element in the earth's crust, comprising approximately 8% of the earth's crust, exceeded only by oxygen (47%) and silicon (28%). The almost ubiquitous presence of this element has so heavily contaminated the environment that exposure to it is virtually inescapable. The elemental aluminium does not occur in its pure state but is always combined with other elements such as chloride, hydroxide, silicate, sulphate and phosphate. The wide distribution of this element ensures the potential for causing human exposure and harm (Berthon, 1996; Candura *et al.*, 1998; Williams, 1996; Zhang and Zhou, 2005). Human exposure to Aluminium has been increasing over the last decades. Aluminium has the potential to be toxic for humans. Patients on dialysis or on long-term treatment with total parenteral nutrition have been shown to accumulate this metal in different organs. (Alfrey *et al.*, 1976; Yokel and McNamara, 2001; Klein, 1993). Evidence for the contribution of Al to Alzheimer's disease (AD) remains contradictory, however, epidemiological studies have indicated a link between Al in drinking water and AD (Flaten, 2001; Gupta, *et al.*,

2005). It has been suggested that there is a relationship between high levels of aluminium and increased risk of a number of neurodegenerative disorders including dialysis encephalopathy, Alzheimer's disease (AD) and Parkinson's disease (PD) (Berthon, 1996; Corain *et al.*, 1996; Becaria *et al.*, 2002; Yokel, 2002). It has been shown clearly that aluminium accumulates in various mammalian tissues such as brain, bone, liver and kidney (Wills *et al.*, 1993; Sahin *et al.*, 1994) and is accompanied by renal failure (Alfrey, 1980) or associated with age (Gómez *et al.*, 1997). It occurs in nature in combination with other elements such as oxygen, silicon and fluoride. Traditionally, aluminium has been considered as nontoxic to humans. However, in recent years, increased attention is being focussed on possible adverse effects of aluminium on human health. Human exposure to aluminium is from its natural occurrence in the environment i.e. through food, water and air as well as from aluminium deliberately introduced into the environment by man. Aluminium compounds are used in pharmaceuticals (antacids, analgesics, antiperspirants) in water treatment processes (as coagulant) and as metal in consumer products. Aluminium is present in virtually all plants. Foods naturally high in aluminium include

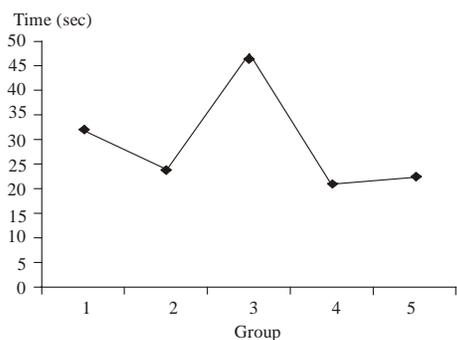


Fig. 1: Graph of Morris Water Maze test for the first run showing that the wistar rats were trying to learn task

potatoes, spinach and tea. Processed dairy products, flour and infant formula may be high in aluminium, if they contain aluminium compounds as food additives (WHO, 1998). Behaviour is the manner of acting or controlling yourself. The action or reaction of something under specific circumstances. In psychology, it is the aggregate of responses or reactions or movements made by an organism in any situation. It is also the way a person, or organism, or group responds to a specific set of conditions. (Encarta, 2009) It refers to the actions and mannerisms made by organisms, systems, or artificial entities in conjunction with its environment, which includes the other systems or organisms around as well as the physical environment. In humans, behavior is believed to be controlled primarily by the endocrine system and the nervous system. It is most commonly believed that complexity in the behavior of an organism is correlated to the complexity of its nervous system. Generally, organisms with more complex nervous systems have a greater capacity to learn new responses and thus adjust their behavior. Behaviors can be either innate or learned. (Dusenbery, 2009)

**Aim and objective:** The objective of this study was to determine the behavioural endpoints of wistar rats, following the aluminium chloride exposure.

## MATERIALS AND METHODS

This experiment was conducted in the Department of Human Anatomy, Faculty of Medicine, Ahmadu Bello University, Zaria, Kaduna State, Nigeria.

**Experimental animals:** Thirty (30) Adult wistar rats were used for this experiment. The wistar Rats were housed in stainless steel cages maintained at standard environmental conditions (12h-12h light-dark cycle with light on at AM) with sufficient food, water and under good ventilation. The wistar rats were kept for two weeks

before commencement of Aluminium chloride administration. This was to enable the wistar rats acclimatised to the environment.

**Experimental design:** The wistar rats were divided into five groups: control group was given distil water while the four Aluminium exposed groups were given various concentrations of aluminium chloride as follows:

- Group I was the Control
  - Group II received 475 mg/Kg
  - Group III received 950 mg/kg
  - Group IV received 1,425 mg/kg
  - Group V received 1,900 mg/kg (LD25)
- The LD50 was 3,800 mg/kg

The duration of administration was Eight weeks.

**Experimental procedure:** After oral administration of various concentrations of Aluminium chloride to each group of the Wistar rats except group I (control), Morris Water Maze was set up in order to test for the behavioural end points of the wistar rats. The wistar rats were trained. At first the some of the wistar rats swim around the side. After a while they understood there were no way out by doing that. Then they searched more to the centre. For any wistar rats that did not find the platform after approximately one minute, were gently guided to the platform. This is something else to learn, that there is anescape platform. A total of three runs (tests) were given to each wistar rats.

**Statistical analysis:** SPSS for Windows Version 10.0 was used to perform one-factor analysis of variance (ANOVA) in order to compare the results of the treated with the control and to check whether the differences observed was statistically significant or not. The probability level was set at  $p < 0.05$  (i.e., 95% confidence interval).

## RESULTS AND DISCUSSION

The average intake of aluminium per day by an adult may range from 5-14 mg from all exposure routes (WHO, 1998; Health Canada, 1997), which comes primarily from food. Drinking water contribution has been estimated to be ranging from 3 to 8% (WHO, 1998; Health Canada, 1997). Persons, who regularly ingest aluminium containing antacids and buffered analgesics may be consuming as high as 5 g aluminium per day. Contribution of air for the total aluminium exposure is generally negligible.

Morris Water Maze (MWM) was used to test for the behaviour of the wistar rats. The Morris Water Maze Task is a behavioral task, that is, the dependent measure is the animal's behavior. Behavioral tests measure the responses

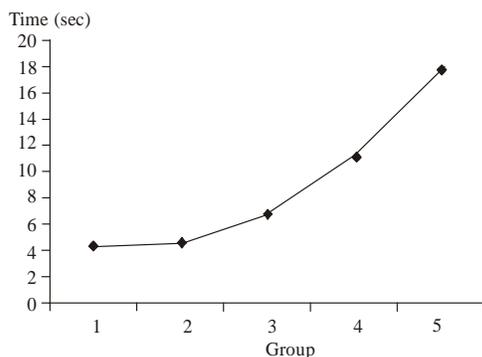


Fig. 2: Graph of Morris Water Maze for the second run showing that the control group performed the task faster (and better) than the treated groups and the differences observed were significant at  $p < 0.05$

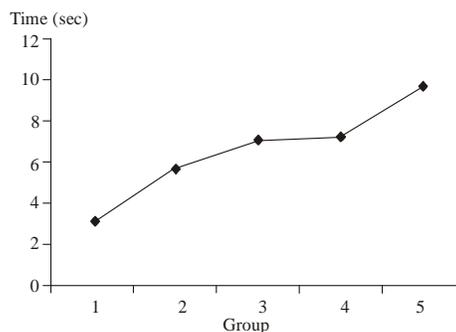


Fig. 3: Graph of Morris Water Maze for the second run showing that the control group performed the task better than the treated groups and the differences observed were significant at  $p < 0.05$

Table 1: Morris Water Maze test for the first run showing that the wistar rats were all trying to learn the task

ANOVA: Single factor (1st run)						
Summary						
Groups	Count	Sum	Average	Variance		
Control GP.1	6	128	32	45.33333		
475 mg/kg	4	96	24	19.3		
950 mg/kg	5	94	47	6.51		
1425 mg/kg	4	85	21.25	124.6667		
1950 mg/kg	5	112	22.4	338.25		
ANOVA						
Source of variation	SS	df	MS	F	p-value	F crit
Between groups	1173.839	4	293.4599	1.831892	0.084441	3.11225
Within groups	3043.705	19	160.195			
Total	2775.789	23				

Table 2: Morris water maze test for the second run showing that the wistar rats in the control performed the task faster (and better) than the treated groups

Anova: Single factor (2nd Run)						
Summary						
Groups	Count	Sum	Average	Variance		
Control GP.1	6	25	4.166667	102.2667		
475 mg/kg	6	26.4	4.4	2.3		
950 mg/kg	5	33	6.61	2.3		
1,425 mg/kg	5	55	11	24		
1,950 mg/kg	6	105	17.5	37.9		
ANOVA						
Source of variation	SS	df	MS	F	p-value	F crit
Between groups	693.6238	4	173.406	4.536153	0.007561	2.795539
Within groups	879.2333	23	38.22754			
Total	1572.857	27				

Table 3: Morris water maze test for the third run showing that the wistar rats in the control performed task faster (and better) than the treated groups.

Summary						
Groups	Count	Sum	Average	Variance		
Control GP.1	6	19	3.166667	1.366667		
475 mg/kg	6	34	5.666667	15.06667		
950 mg/kg	6	42	7.166667	6.2		
1,425 mg/kg	6	43.2	7.2	6.2		
1,950 mg/kg	6	58	9.666667	17.06667		
ANOVA						
Source of variation	SS	df	MS	F	p-value	F crit
Between groups	137.1286	4	34.28214	3.05261	0.037246	2.795539
Within groups	280.7609	25	11.23043			
Total	395.4286	29				

of whole animals, allowing experimental manipulations to affect in vivo systems operating in harmony to provide a clear understanding of the outcome. Because there are so many factors involved between experimental manipulations and behavior, the effects can sometimes be unpredictable, and it can be difficult to ascertain whether the behavior was indeed a main effect of the experiment. Still behavioral experiments offer great insight into the effects of experimental manipulations on whole organisms (Hebb, 1949; Hull, 1943; Kandel *et al.*, 2000).

We observed that at the first run of Morris Water Maze (MWM), the wistar rats were trying to learn task (Fig. 1 and Table 1). The second and third runs showed that although the wistar rats have learnt the task by getting to the platform for escape within the stipulated time (60 s), the control groups performed the task better than the treated (i.e., get to the platform faster than the treated) and the differences observed was significant at  $p < 0.05$ . (Fig. 2 and 3, Table 2 and 3). This was evident by the reduced latencies and path length. (Fig. 2 and 3). Based on our observation, we therefore conclude that Aluminium chloride exposure has negative effects on behaviour of wistar rats (i.e., alters behaviour) and can impair learning and memory.

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