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A Comparative Study of Neurocognitive Effects of Aluminum

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Abstract:

In this study, we investigated serum Aluminum levels of healthy individuals in suitability-randomly chosen three different regions of the world in relation to intellectual ability of randomly chosen 16 year male students. Based on socio-economical factors, and the availability of resources and trained staff, the plasma aluminum contents were measured for 30 volunteers from three towns; in UK-Tower Hamlets, KSA-Al-Dammam and Iraq-Almusaib.

The latter's candidates were found to have the highest levels of aluminum in their plasma. This might be attributed to the relatively high levels of aluminum in drinking water or the use of aluminum cooking scratched pans and pots other than stainless steel or properly coated cooking apparatus especially in frying. Dust is also a contributing factor. Spectrophotometric techniques were used to determine the concentration of Al in water and biological fluids.

Throughout this study morin was used as the chelating agent. It gives a deep-yellow complex with aluminum with a maximum absorbance at 421nm. Acidified (0.0002M H_2SO_4)/ethanolic (50%) solution were used. Absorbance was measured at 421nm. Creatinine and urea levels were used to check for kidney function. They were within normal limits for all participants.

The possible effects of aluminum level in plasma on intellectual ability for a randomly chosen sample of thirty 16 years old pupils in the three towns were studied. Average mathematics school official grades were plotted against plasma aluminum levels. Correlation coefficients indicate a possible link between aluminum levels in plasma with mental ability.

Key Words: Aluminum; ligand; morin; plasma; spectrophotometer; intellectual ability; random sampling.

الخلاصة:

في هذا البحث تمت دراسة العلاقة بين تركيز الالمنيوم في بلازما الدم من جهة وأحد مؤشرات القدرة الذهنية- درجة الرياضيات الرسمية لطلبة المرحلة المتوسطة المنتهية او ما يعادلها - من جهة اخرى.

نموذج الدراسة مكون من ٣٠ طالب بعمر ١٦ سنة في ثلاث مناطق من العالم تم اختيارها لتوفر الامكانات لاجراء البحث فيها–فالاختيار عشوائي من الناحية الاحصائية- حيث لدى الباحث من يمكنه للحصول على المتطوعين والكادر المختص والمؤهل لجمع المعلومات الدقيقة.

شملت الدراسة مناطق تمتاز كونها تعاني من مشاكل اجتماعية–اقتصادية لازدحامها وفقرها النسبي وتلوث بيئتها وهي حي تاور هاملتس في شرق لندن في المملكة المتحدة و الدمام في المملكة العربية السعودية و مدينة المسيب في الحلة في العراق.

تم تقدير تركيز الالمنيوم في الماء والبلازما بواسطة مقياس الطيف الكهرومغناطيسي عند طول موجي ٤٢١ نانومتر وبأستخدام المورين لتكوين معقد تساهمي ثابت في محيط حامضي من محلول مخفف من حامض الكبرتيك (0.0002M) و ٥٠% محلول من الكحول الاثيلي المائي. وقد تم التأكد من سلامة الجهاز الكلوي للطلاب المشاركين في هذا البحث من خلال قياس تراكيز مادتي الكرياتينين واليوريا في الدم ووجدت ضمن الحدود الطبيعية للجميع .

أظهرت النتائج زيادة ملحوظة لتراكيز الالمنيوم في مدينة المسيب وقريبة منها في الدمام بعكس الحال في منطقة تاورهاملتس.

يمكن تعليل ذلك بصورة رئيسية الى ارتفاع تراكيز الالمنيوم في مياه الاسالة أو الى استعمال ادوات مطبخ من الالمنيوم بدلا من الفولاذ المقاوم للصداء وخاصة عند القلي وكذلك كثرة الاتربة اضافة للاستخدام الغير المقيد لمضادات الحموضة، العلاقة عكسية ضعيفة بين المتغيرين الرئيسين.

ولأكمال الدراسة يقترح الباحث استخدام مواد فعالة في تقليل تركيز الالمنيوم في الدم واستعمال نماذج كبيرة لتوضيح الصورة احصائيا وتأكيد النتائج ودراسة مختلف العوامل المؤثرة في البحث.

Introduction:

Aluminum in life and especially in medicine was the subject of extensive work presented recently in Keele, UK [1]. Its toxicity was studied and reviewed and confirm the possible link with neurodegenerative disease.[2-4] Aluminum intoxication in healthy individuals was studied and found that 20% had serum aluminum levels in the toxic range, above 100ug/L [5].

However, aluminum toxicity is mainly linked with chronic renal failure and the retention of aluminum in the body affects the CNS[6]. Aluminum (III) has similar properties to Fe(III). Therefore it is expected to interfere with Fe (III) receptors. Such a link was suggested by microcytic anemia that does not respond to iron therapy is mainly due to aluminum poisoning. Aluminum might cross the blood-brain barrier causing senile dementia, Alzheimer's disease [7].

High levels of aluminum may be found in areas where aluminum utensils are commonly used.

Such an increase might be due to cooking and storing acidic foods and drinks in aluminum containers or from excessive use of antacids. Aluminum sulphate is widely used as a coagulant in water purification. The danger of aluminum in drinking water comes from being in uncomplexed form, hence it forms a major part of the total aluminum absorbed from the gastrointestinal tract.

Aluminum is slightly soluble in the pH range 4 - 8.5. Some types of food and drink have pHs within this range. For example uncooked and cooked apple sauces have aluminum contents of 0.13 and 7.1ug/g. Aluminum form in the human gut is a pH dependent [8].

The most toxic form, the free ion - Al^{3+} which is the predominantform in the stomach – pH 3-5. At the intestine, pH 7-8, the hydroxide ion $Al(OH)_4^-$ is the main ion. Aluminum ions in our diet are non-bioavailable from the small intestine as the aquatic charged ions are not able to penetrate the lipid protein membranes of the duodenal mucosa and thus pass on into the plasma and deposit small amounts in tissues including bones and the brain.

The element may cross the blood-brain barrier in a mechanism similar to that of the iron, with transferrin as the major carrier.

However, aluminum cannot be utilized by mitochondria and ferritin will be unavailable as a sink.

The accumulation of this element is mainly in long-lived cell such as the neurons [7]. The relative binding strength of important ligands will determine the pathway for aluminum in vivo and its competition with other ions such as Mg^{2+}[9].

The long term accumulation of this element in humans and the wider environment the release of aluminum from soil by acid rain has seriously affected the level of this element in food consumed by humans. In addition to increased use of aluminum in food packaging and kitchen tools.

The prolonged use of aluminum medications such as antacids or food additives or as food packaging and kitchen tools in addition to its use in water treatment has led to increased levels of aluminum in body fluids[7].

Toxic aluminum would seem to best be approximated by the sum of the solution sum Al^{3+} and $Al(OH)_4^-$. Aluminum reacting within 30 seconds is essentially inorganic monomeric aluminum[8].

Recent studies have shown evidence that Al is deposited in the central region of the senile plaque core of the brain. Al has been implicated as a major factor in the progressive encephalopathy which affected many patients on haeodialysis for chronic renal failure. Epidemiological studies have suggested a geographical correlation between exposure to Al in water supplies and the risk of neurodegenerative disorders [10].

Aluminum–morin (3,5,7,2',4'-ta-hydroxyflavone) complex is highly

florescent offering a highly sensitive method for aluminum determination compared to conventional methods[11]. However, at low pH this compound can be monitored spectrophotometrically[12]. A more sensitive spectrofluremetric method using morin in ionic liquid mixtures was recently used [13].

The neurocognitive effects of aluminum was studied in 35 hemodialysis patients by Bolla and found that a decline with attention and concentration was related to increased levels of aluminum[14].

In this study we investigated Al levels in three different regions of the world in relation to intellectual ability of 16 year students. UK-Anglian, KSA-Dammam and Iraq-Almusaib water supplies. Spectrophotometric technique was used to determine the concentration of Al in water and biological fluids. Throughout this study morin was used as the chelating agent.

Creatinine and urea levels were used to check for kidney function.

Materials and Methods:

Thirty 16-years old male pupils from three areas understudy were randomly chosen. Mental ability in mathematics as reflected by their school records. Five ml IV blood samples were collected by local certified staff placed in polythene vials and centrifuged. 3 ml plasma were collected and immediately frozen at -4^{o}C prior to use. All measurements were carriedout at 37^{o}C. Aluminum level in plasma was determined spectrophotometerically using 1 ppm solution of morin, from Fluka was dissolved in 50% IMS, industrial methylated spirit, and 0.001M H_2SO_4. Internal standard additions of 0.1ml plasma to standard aluminum chloride, from Fluka, 1 ppm solution were used. All solutions were freshly prepared and used once. Duplicate runs were made and the average is recorded. Spectrophotometric measurements were taken at 421nm using. Aluminum concentration in tap water was determined using internal standard additions. Duplicate samples were taken from five locations in each town during April 2010-March 2011.

Results and Discussion:

Aluminum level of Tap water in the three locations was monitored throughout the year, once every two months. Five sites in each location were studied. The results for water analysis are shown in Table-1 below.

Table-1: Aluminum concentration of tap water between April 2010 and April 2011

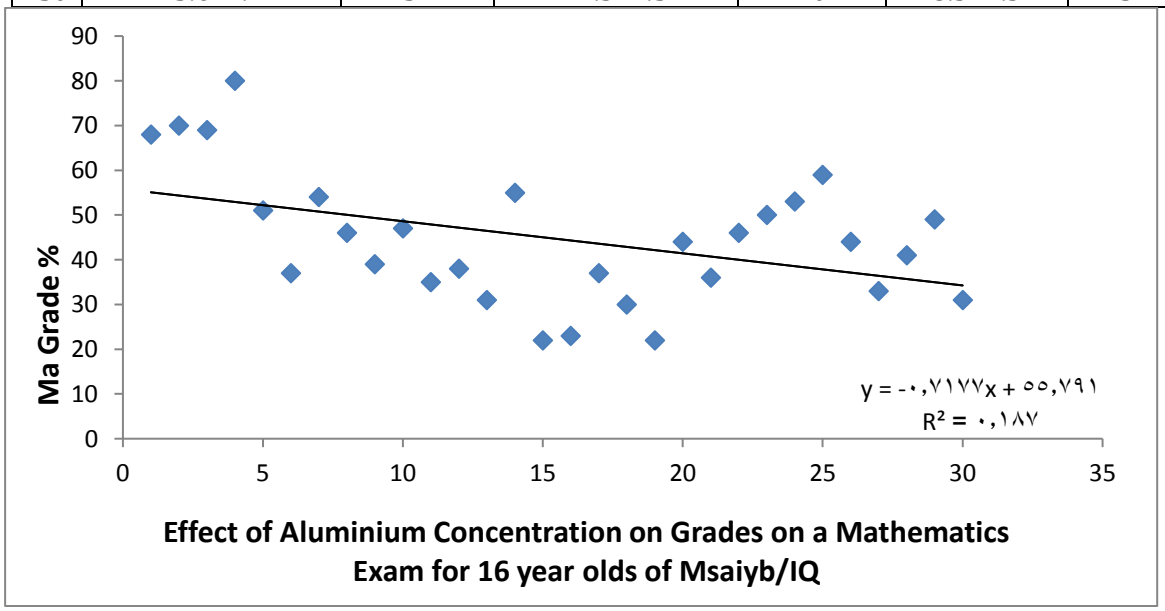
	Aluminum level in tap water / ppb
Tower Hamlets/UK	27 ± 8
Dhammam/KSA	66 ± 10
Al-Mysaib/IQ	227 ± 47

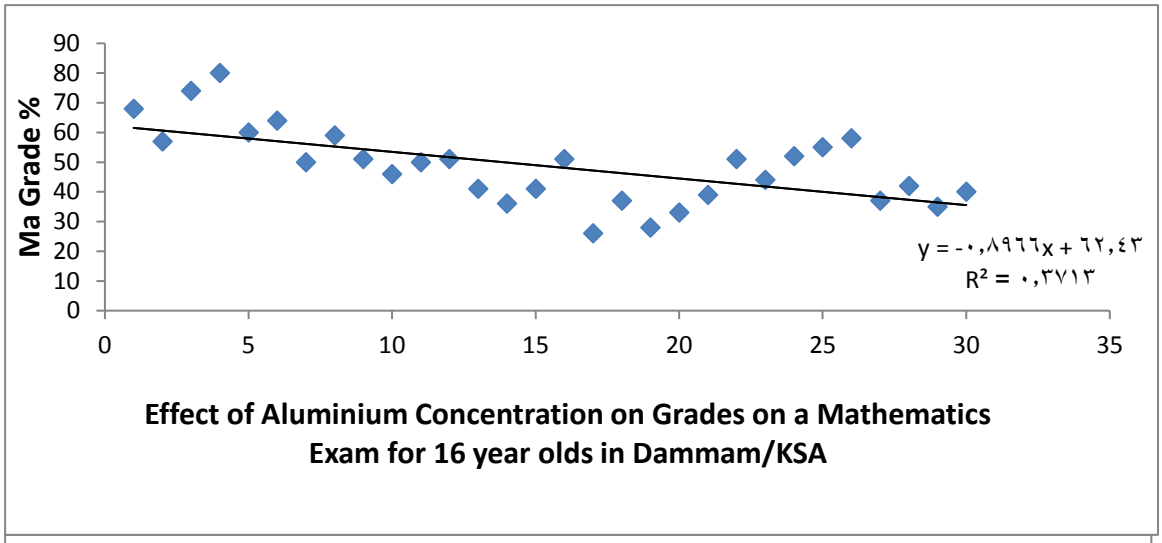
Results of the effects of aluminum level in plasma on intellectual ability, as measured by official exam results for a randomly chosen sample of thirty 16 years old pupils in the three towns understudy are shown in Table 2 below. Low values of R^2 (0.3-0.5) reflect the weakness of the correlation. Plasma aluminum levels of the studied individuals from Tower Hamlet and in Dammam were higher than the acceptable range, below 7 ppb[15]. The corresponding levels in Msaiyb were much higher than expected. This might be attributed to high levels of contamination including dust and drinking water.

The work needs to be extended further and involvement of larger samples. Currently we are studying the effectiveness of using non-invasive novel methods for reducing the levels of plasma aluminum hence attempting improvement of mental ability. Star labeled,*, labeled are for control who live outside the area understudy.

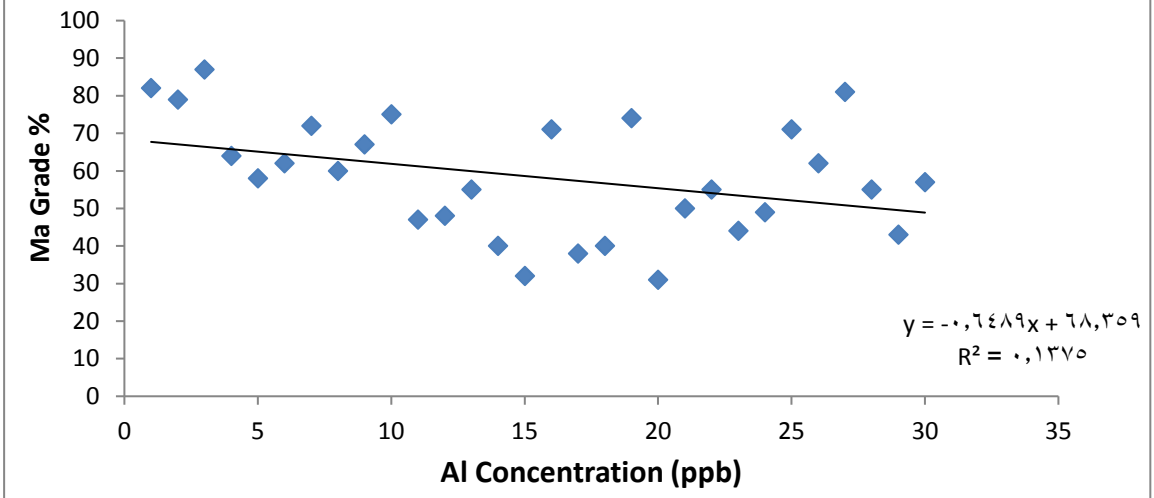
Table-2: Aluminum plasma level for thirty 16-years old Secondary School male students.

No.	Msaiyb /Iraq		Dhammam / KSA		Tower Hamlets/UK	
	PlasmaAl level (ppb)	**Maths Grade%**	**Plasma Al level (ppb)**	**Maths Grade%**	**Plasma Al level (ppb)**	**Maths Grade %**
1*	10.9 ± 1.2	68	13.1 ± 2.0	68	4.2 ± 4.0	82
2*	19.3 ± 1.7	70	13.1 ± 1.3	57	4.6 ± 3.3	79
3*	9.7 ± 2.0	69	13.6 ± 1.6	74	5.0 ± 2.4	87
4*	20.6 ± 1.8	80	13.8 ± 1.3	80	5.0 ± 2.4	64
5*	20.6 ± 2.3	51	14.0 ± 1.7	60	5.1 ± 2.2	58
6	22.2 ± 2.2	37	14.1 ± 2.0	64	5.8 ± 2.6	62
7	22.4 ± 2.4	54	15.2 ± 1.8	50	5.8 ± 2.3	72
8	22.6 ± 2.0	46	15.2 ± 1.6	59	6.3 ± 1.9	60
9	22.9 ± 1.8	39	15.9 ± 1.9	51	5.0 ± 1.1	67
10	13.5 ± 1.6	47	17.0 ± 1.4	46	8.1 ± 2.5	75
11	23.5 ±2.2	35	17.4 ±1.4	50	8.1 ± 2.3	47
12	24.4 ± 24	38	17.9 ±1.8	51	8.8 ± 2.2	48
13	24.4 ± 2.7	31	17.9 ± 1.4	41	8.8 ± 1.9	55
14	14.4 ± 2.1	55	18.9 ±1.9	36	9.4 ± 2.3	40
15	24.4 ± 2.1	22	18.9 ± 1.2	41	9.6 ± 2.5	32
16	24.9 ± 2.4	23	19.1 ± 1.9	51	10.1± 2.1	71
17	25.4 ± 2.8	37	19.6 ± 1.5	26	10.3± 2.2	38
18	25.6 ± 2.8	30	19.6 ± 1.5	37	11.0 ± 2.0	40
19	25.6 ± 2.5	22	20.2 ± 1.8	28	11.0 ± 2.4	74
20	25.6 ± 2.8	44	24.0 ± 1.8	33	11.4± 1.9	31
21	24.0 ±2.3	36	11.9± 2.2	39	9.9± 1.6	50
22	22.2 ±2.6	46	12.8±1.5	51	8.2±1.5	55
23	16.9 ± 2.1	50	12.8±1.5	44	8.5±2.0	44
24	17.7± 1.7	53	15.3±1.5	52	12.0±1.6	49
25	17.9±1.9	59	18.3±2.3	55	6.8± 1.4	71
26	15.8± 1.4	44	19.2±1.7	58	5.0±1.6	62
27	20.8±2.2	33	17.7±2.5	37	5.3±1.8	81
28	16.6±2.0	41	15.7±2.5	42	6.3±2.2	55
29	20.3±1.8	49	20.0±2.1	35	15.5±2.3	43
30	23.6±2.4	31	17.9±1.3	40	8.9±1.9	57





Effect of Aluminium Concentration on Grades on a Mathematics Exam for 16 year olds in Dammam/KSA



Effect of Aluminium Concentration on Grades on a Mathematics Exam for 16 year olds of Tower Hamlets/ UK

Our team is currently working on studying the effects of elevated lead plasma levels of vulnerable sections of our society and new techniques of minimizing the health risks involved.

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