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# INVESTIGATION OF LECTURER'S CHALK BY X-RAY FLORESCENCE AND FAST NEUTRON ACTIVATION TECHNIQUES

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Different samples of lecturer's chalk were studied, using X-ray florescence (XRF) and Fast Neutron Activation Analysis (FNAA) techniques to ensure the safety of its use. The K (X-rays) and the gamma-rays were measured, using Si(Li) and high-purity germanium (HPGe) spectrometers to detect and determine qualitatively and quantitatively the constituents of the studied samples. The concentrations of the elements (Ca and small traces of Al, Fe, Mg and Si) were measured and their presence was confirmed by γ-ray, lifetime and/or XRF measurements.

***Key Words:*** *X-Ray Florescence; Fast Neutron Activation Analysis; Lecturer's chalk*

## INTRODUCTION

Many years ago, our skins were thought of as an impenetrable barrier, but now we know about it differently. Substances that come into contact with the skin are absorbed and eventually find their way into the blood stream. Toxins and other harmful products accumulate in the vital organs over a period of time causing many problems with our bodies. Lecturer's chalk is a native hydrous magnesium silicate sometimes containing a small portion of aluminum silicate [1] or calcium carbonate. It is similar in its chemical composition as asbestos, a well known cancer-causing agent. chalk's dust harmful effect on human tissues has been known for quite some time [2-6].

There are two separate issues buried in the question of chalk dust safety. In one sense, the main ingredients of chalk dust are considered to be non-toxic, which simply means they do not pose a threat when ingested. In another sense, chalk dust can and does accumulate in the human respiratory system, which means it can create long-term health problems due to over exposure. In short, swallowing a piece of white chalkboard chalk won't kill you, but breathing in chalk dust for a number of years can create or trigger respiratory problems [7].

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It was thought that for the safety of using chalk, it is essential to study its constituents. It is excessively in contact with the skin and its dust could be easily inhaled by teachers. This study was achieved using XRF and FNAA techniques.

## SAMPLING AND EXPERIMENTAL PROCEDURE

Different samples of lecturer's chalk were studied using the XRF, and FNAA techniques. The chalk was grinded and powders were dried and disks of 19 mm in diameter and 2-5 mm thick were pressed, weighed and then used. For the fast neutron activation, the MF Physics neutron generator at the Experimental Nuclear Physics Department, Egyptian Nuclear Research Center was used in the D-T mode (Mono energetic fast neutrons 14 MeV).

The K X-rays were detected using a Si(Li) spectrometer located at the Center Lab, Egyptian Nuclear Research Center, at Inshas. For qualitative and quantitative measurements the prepared samples of 19 mm diameters were excited by X-ray sources with different energies.

## FAST NEUTRON ACTIVATION ANALYSIS (FNAA) MEASUREMENTS

Single gamma-ray measurements were achieved, using a high resolution ORTEC hyper-pure germanium (HPGe) detector of efficiency of 70 % and. A cylindrical lead-shield of five cm thickness, which contains inner concentric cylinders of Cu with a thickness of 5 mm was used to shield the detector and to reduce the effect of background.

Standard gamma sources, of $^{22}$Na, $^{57}$Co, $^{60}$Co, $^{133}$Ba, $^{137}$Cs and $^{152}$Eu, were used for both energy and efficiency calibrations of the system.

The samples were located in contact with the tritium (T) target, of the neutron generator, and were irradiated with fast neutron for a period of 10 minutes for each. The cooling time for each sample was one minute. High purity aluminum foils were used for flux monitoring and the measured flux for each irradiation for samples S1- S7 was ($4x10^7$ - $3 x10^8$ $n.cm^{-2}sec^{-1}$). Each sample was measured several times and the gamma spectra were analyzed, using different tables [8-10] and the Genie™ 2000 *Gamma Analysis* CANBERRA software was used. The concentration was estimated, using the different gamma transitions of each element and the average value is given. The nuclear parameters used in the present investigation were accepted from references [11, 12].

## RESULTS AND DISCUSSION

Results from XRF as represented in fig. (1), for sample No. 1, shows that Ca is the major element in the sample and beside it there are weak traces of other elements.

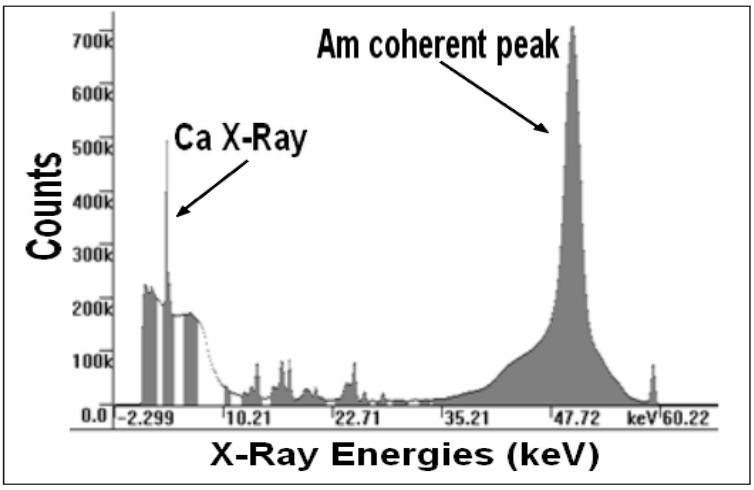


**Fig. (1)** X-ray spectrum measured for sample S1 activated with $^{241}$Am source.

The present FNAA measurements, life time, and/or X-ray detections confirmed the existence of Ca and mall traces of Al, Fe, Mg and Si elements in the studied samples. The concentration values, represented in Table (1), for these confirmed elements were determined utilizing fast neutron activation tool followed by successive gamma-ray measurements [12].

**Table 1.** Concentrations (wt %) of different elements in the studied samples. The uncertainty in the calculated values was found 10 – 17% depending on the quality of the gamma-ray peak shape and its intensity values.

| Elements | Sample s1 | Sample s2 | Sample s3 | Sample s4 | Sample s5 | Sample s6 | Sample s7 |
|---|---|---|---|---|---|---|---|
| **Ca** | **20.3** | **19.7** | **21.2** | **23.4** | **27.5** | **18.3** | **15.7** |
| **Al** | **--** | **3.42** | **1.06** | **0.71** | **4.51** | **0.86** | **--** |
| **Fe** | **--** | **0.03** | **0.27** | **0.24** | **0.39** | **--** | **0.35** |
| **Mg** | **0.12** | **0.44** | **--** | **0.54** | **0.19** | **0.71** | **0.26** |
| **Si** | **0.50** | **2.74** | **2.25** | **4.09** | **6.33** | **2.25** | **1.52** |

From the qualitative analysis, it was thought that the samples contained cerium due to the observation of a gamma transition which was thought to belong to $^{139m}$Ce. Yet, after a careful study and repeating different runs for each sample to measure the life-time of the different gamma transitions, it was confirmed to be the double escape peak of the 1779 keV transition which belongs to $^{28}$Al. In addition, the following gamma transitions 1273, 2029, and 2426 keV were confirmed to belong to $^{29}$Al, each gamma transition was

used to calculate the concentration of silicon in each of the studied samples, but the value obtained using the 1273 keV transition was greater than that using the 2029 and 2426 keV transitions. This was due to the single escape peak of 1779 keV superimposed on it. Therefore, a correction was made by adding the concentration of the double escape peak at 757 keV together with that due to the single escape peak to the concentration due to the photo peak at 1779 keV. This gave a value in agreement with that obtained using the transitions of $^{29}$Al at 2029 and 2426 keV to indicate the concentrations of Si in the different samples, and the average value is given.

It is estimated that since 1962, between one and two million women have had **silicon** breast implants to enhance their physical appearance. Some 30 years later, thousands of women are second guessing the wisdom of this choice because they are now suffering with a new illness, silicon toxicity and immune dysfunction syndrome [13]. Yet, Silicon is often used in herbal remedies to promote strength in the hair, skin, and nails.

A gamma transition was observed at about 845 keV, which may be due to **aluminum** and/or **iron**, but a 1014 keV transition was observed and proves the presence of Al in the samples. Also, a 1811 keV transition was observed and the presence of Fe is also confirmed. Symptoms of fatigue are often thought to be from too little iron in the body. But, fatigue may also indicate too much iron in the body. Iron is brought into the body from the small intestine. In the blood stream, the iron is transported to be used for making our red cells and to perform other functions in the body [14]. The body stores most of the excess iron in the liver. When the liver is full then the liver starts making storage chemical containers for the iron. It causes hemochromatosis, the disease of iron overload [15].

Humans are exposed to aluminum from a variety of environmental sources. Although an increase in body stores of aluminum as a result of transfer through the skin is probably negligible, exposure is common from the use of deodorants, toothpaste, dental amalgams, baby powder, class chalk dust, cosmetics and others containing aluminum. Aluminum inhaled from dust is retained in pulmonary tissue and prebronchial lymph nodes but is largely excluded from other tissues. The aluminum concentration in pulmonary tissues does not correlate with that in other tissues. Aluminum levels in tissue are generally low in adults with normal renal function. Bone and liver tissues are most frequently affected by increased absorption and/or decreased clearance of aluminum. Physical symptoms of aluminum toxicity may be brittle bones or osteoporosis; also kidney malfunction may also result. Hyperactivity, memory disturbances, and learning disabilities may result from even mildly elevated levels of aluminum. Aluminum is also found in some seniors with extreme memory loss, absent-mindedness, or dementia. Science has been linking elevation of aluminum in the body with Alzheimer's disease for years [16].

The 1369 and 2754 keV gamma transitions obtained in the different spectra, belong to $^{24}$Na which may be produced by $^{27}$Al(n,α) $^{24}$Na and/or $^{24}$Mg(n,p)$^{24}$Na reaction; also the single and double escape peaks of 2754 keV were observed. The $^{27}$Al(n,α)$^{24}$Na reaction was excluded since the concentrations calculated for this reaction was incredibly high and not in agreement with that obtained due to the $^{27}$Al(n,p)$^{27}$Mg reaction and, therefore, the presence of $^{24}$Na was accepted to indicate the presence of magnesium in the samples.

**Magnesium** is an essential mineral and is closely related to calcium and phosphorus in body function. The average adult's body contains approximately one ounce of magnesium. It is the fifth mineral in abundance within the body behind calcium, phosphorus, potassium and sodium. Although, about 70 percent of the body's magnesium is contained in teeth and bones; its most important functions are carried out by the remainder which is present in the cells of the soft tissues and in the fluid surrounding those cells.

**Calcium** and magnesium levels need to be maintained in balance since they have an antagonistic relationship. An excess of one implies a need for the other to maintain balance. High levels of magnesium can develop in patients with kidney failure and in elderly people whose kidney functions are reduced. This is especially true with magnesium supplementation [17,18].

## CONCLUSION

The presence of Ca and small traces of Al, Fe, Mg and Si elements in the different lecturer's chalk samples were confirmed utilizing Fast Neutron Activation Analysis (FNAA), lifetime, and X-ray florescence (XRF) techniques [12]. The concentration values of elements, of different studied samples (wt%), have been evaluated employing fast neutron activation method followed by successive gamma-ray measurements. The results were discussed in details showing their severe effects on human health when they are deviated from the permissible values. It is highly recommended that Chalk dust is considered an irritant and an occupational hazard as shown in this investigation. If you must work around chalk dust for extended periods of time, we agree with many safety experts [7,19,20] and suggest using a filtered mask over your mouth and nose and taking a number of breaks in a fresh air environment and using good ventilation in the working places. On the other hand we recommend using the dustless chalk type. This dustless chalk does generate a form of chalk dust, but the particles are much heavier and tend to fall directly to the floor instead of hanging in the air.

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