

# **MODERN TRENDS IN NEUTRON ACTIVATION ANALYSIS. APPLICATIONS TO SOME AFRICAN ENVIRONMENTAL SAMPLES**

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## **ABSTRACT**

This review covers the results of several published articles which deal with the modern trends in neutron activation analysis techniques using some of African research reactors for some environmental samples. The samples used have been collected from different areas in Egypt, South Africa, Ghana, Morocco, Nigeria, and Algeria. The neutron irradiation facilities and the advanced detection systems in each country are outlined. The prompt and delayed gamma-rays emitted due to neutron capture have been applied for investigation of the elemental constituents of such samples. Covered applications include exploration, mining, industrial environment, pollution of air, foodstuffs, soils and irrigation water samples. Some of the developed software programmes as well as the modern methods of data analysis are presented. The thermal and epithermal neutron activation analysis techniques have been applied for estimation of major, minor and trace elements in each material. Some of these data are presented with several comments.

## **1- INTRODUCTION**

Nowadays, the Neutron Activation Analysis (NAA) is accepted as an important technique for elemental analysis of local environmental studies of different materials. This will serve in the local industry and economy in each regional area. In fact, the applications of this technique are initiated by the national needs. So, it is hard to point out international trends in the use of (NAA). Accordingly, trends in the use of (NAA) in East – Asian countries for example will differ from those in Latin American and in African countries.

The extensive use of (NAA) in environmental control and monitoring can be demonstrated by the large number of papers presented at the symposia organized by the IAEA in these fields : “Applications of Isotopes and Radiation in Conservation of the Environmental” in 1992 [1], “Harmonization of Health – Related Environmental Measurement Using Nuclear and Isotopic Techniques” [2], the symposia : “Nuclear Analytical Methods in Life Sciences” [3 – 4] and the most recent one held in Cairo (2 – 3 Dec. 2007)” the 5th African conference (RAF / 4 / 020) on Research Reactor Utilization” [The Role of Research Reactors in Nutrition Environment and Health Related Research [5]. This in addition to the topics discussed at the regular conferences on “Modern Trends in Activation Analysis “MTAA”.

This work summarizes the discussions and conclusions resulting from several papers of different NAA laboratories in Africa for different materials, just to improve the role of this technique in many applications using the African research reactors.

## **2- PRINCIPLES**

\* As we know, the (NAA) technique achieves a qualitative and quantitative analysis of unknown sample by irradiating this sample with neutrons [cold, thermal, epithermal and fast], which based on the measurement of the characteristic radiation from radio nuclides formed directly or indirectly by neutron irradiation of such sample.

\* The basic principle of this technique is not a new one. It was applied for the first time in (1936) by Hevesy and Levi [6] using the [Ra / Be] isotopic neutron source for irradiating their sample. The experiment was followed by several authors. The sensitivity of the method increased considerably with the availability of high neutron fluxes from nuclear reactors.

\* The purpose of this work is not to present of all aspects of the theoretical basis of the technique, which one can found in many of text books [7, 8].

\* In principle, there are two ways to use neutrons for elemental analysis and isotopic abundance analysis of the samples under investigations. The first is called “off line” method, since the neutron – induced radioactivity is observed after the end of irradiation and second is the method which call “On – line” consists in observing the capture gamma-rays during neutron bombardment.

\* The activation analysis method consists mainly of the following major steps as follows : Selection of the optimum nuclear reaction, Preparation of the sample for irradiation, Irradiation of the sample, Counting of the irradiated sample and Analysis of the counting results. This will be discussed next.

## **3- CURRENT TRENDS IN “NAA”**

NAA has been applied for determining many elements usually trace elements in different fields [9 – 12], as follows :

\* Archaeology, bone, ceramics, coins, glasses, painting, pottery, raw materials, soils and clays., .....

\* Biomedecine, blood, brain cell components breast tissue, cancerous tissues, drugs and medicines., ....

\* Environmental science and related fields, aerosol, dust, fossil fuels and their ashes, birds, insects, fish, plants, trees, leaves, ...

\* Forensics; explosive detection, paint, hair, shotgun pellets, .....

\* Geology and geochemistry : asbestos, bore-hole samples, petroleum, rocks, .....

\* Industrial products : alloys, fertilizers, fissile material detection, plastics, pharmaceutical products, .....

\* Nutrition : food, food colours, grains, honey spices, .....

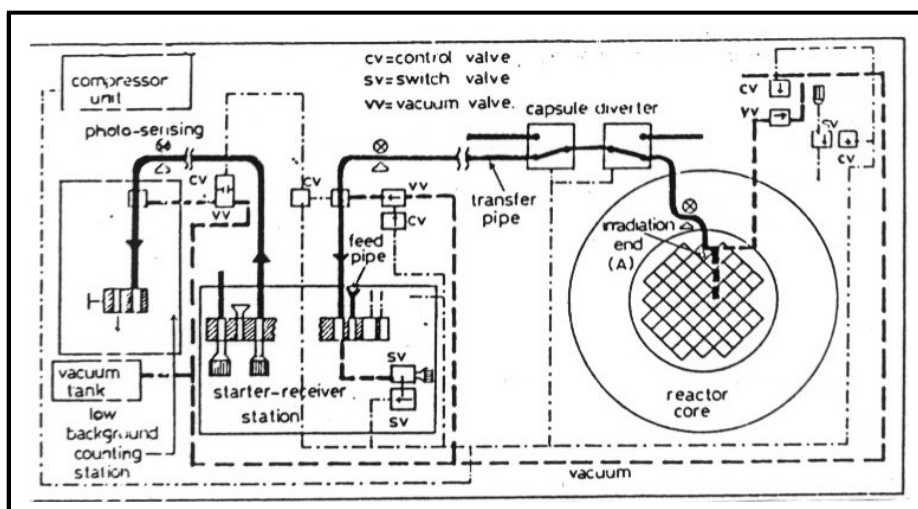
\* Quality Assurance of Analysis and Reference materials, .... See reference [13].

## **4- THE APPLICATIONS OF RNAA IN SOME AFRICAN LABORATORIES**

In more than 39 developing countries which together have about 84 operated research reactors according to the IAEA DATA BASE [14]. Most of them are suitable source of

neutrons for Reactor Neutron Activation Analysis (RNAA). As mentioned above, the RNAA has been extensively applied to environmental sciences, nutritional studies, health related studies, geological and geochemical sciences, material sciences, nuclear data measurements and it has a role in the quality assurance of chemical analysis. This is due to high sensitivity and accuracy of this technique. In Africa many of research reactors are used with great success for RNAA applications (see ref.5), of the 5th African conference (RAF / 4 / 020) on Research Reactors Utilization (2007). A brief review on some applications published by many authors working in the RNAA laboratories in the last decades, could be summarized as follows :-

**4.1 In Egypt**, there is a research program in this field for multielemental investigations of different geological, biological and industrial Egyptian samples. This is performed by means of Delayed Gamma – ray Neutron Activation Analysis (DGNA) and Prompt Gamma Ray Neutron Activation Analysis techniques (PGNAA), using the facilities of the first Egyptian Research Reactors. ET – RR – 1 (2 MWRR) and the second one ET – RR – 2 (22 MWRR). The Rabbit Pneumatic Transfer Systems (RPTS) in each reactor is used for short lived isotope identifications. For long lived isotopes the core of reactor is used for irradiating the samples under investigation. Channel number (8) and the thermal column of ET – RR – 1 were prepared for external target measurements of the prompt gamma – rays emitted due to thermal and epithermal neutron capture [see figs. 1,2 and 3]. The computerized HPGe – detection systems are used for gamma – ray detection and analysis. More than 60 articles covering the most important trends in RNAA field have been published by our group in the last two decades. Some of these articles have been selected covering a variety of topics could be reviewed on the following with some comments:



**Fig. (1)** A Schematic Diagram of the Rabbit Pneumatic Transfer System (RPTS) at the (RNP) Laboratories

#### 4.1.1 NUCLEAR TECHNIQUES IN PROSPECTING FOR GOLD IN THE ARAB REPUBLIC OF EGYPT [15]

- \* Samples taken from one of the famous ancient gold mines (BARAMIYA) in Egypt.
- \* Packed in thin Al sheet, together with gold foils of different weight as standard were irradiated in the vertical dry channel. Of ET – RR – 1 for 48 hours at neutron flux of  $10^{11} \text{ n / cm}^2 \cdot \text{s}$ .
- \* 30 cm<sup>3</sup> Ge (li) detector with a 4096 – PDP – 11/05 computer (based m. ch. Anal.) and necessary electronics are used for detection of  $\gamma$ . Rays.
- \* The 412 keV photo – peak of <sup>198</sup>Au was used.

- \* About 200 samples were investigated.
- \* Both thermal and epithermal activation were applied.

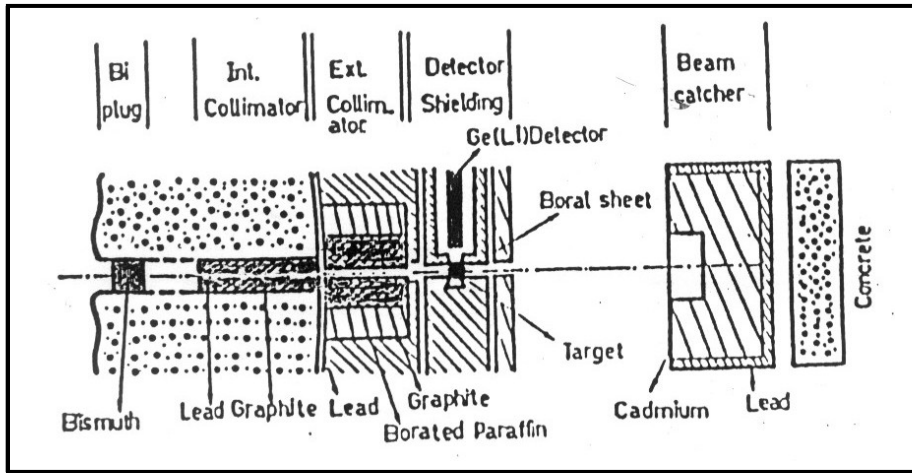


Fig. (2) Horizontal Channel (8) of (ET - RR - 1) Shielding Arrangements

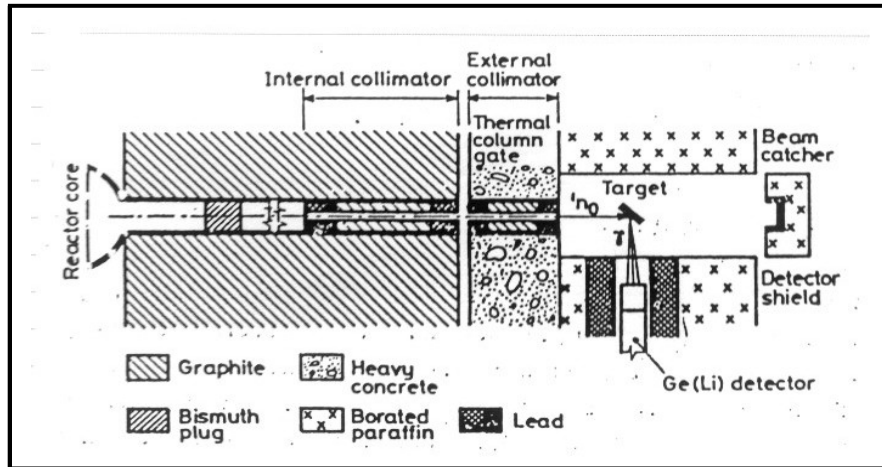


Fig. (3) Thermal column of ET - RR - 1 and Detector shield Arrangement.

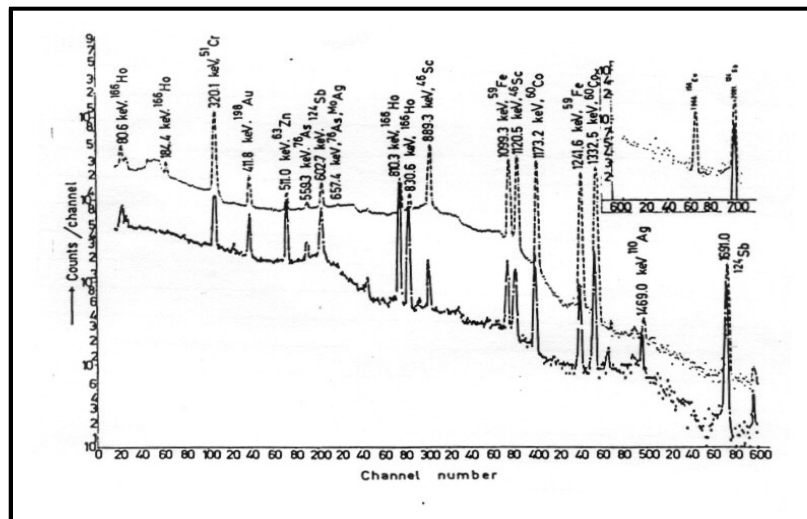


Fig. (4) Gamma - Ray Spectrum of Sample No. 34, thermal Irrad. 06g, Epith. Epith. Irrad. (4.0168 g) taken from Ref. (29).

- \* The average of Au content rises to :  
8.73 g / Ton, The results were compared with spectrochemical analysis (favorably).
- \* This result permits to suppose that considerable commercial are bodies can be expected at this area.
- \* Gamma. Ray Spectrum of sample no. 34 was as shown in fig (4)

#### **4.1.2 RAPID DETERMINATION OF VANADIUM IN EGYPTIAN CRUDE OILS (BALAYIM) BY NON-DESTRUCTIVE ACTIVATION TECHNIQUE [16]**

- \* Rapid Determination of Vanadium as a trace and industrially important one in Egyptian Crude Oils of “Balaim” source (marine and land) was achieved in this work.
- \* The RPTS at RNPDLaboratories of the ET – RR – 1 was used as well as the cyclic mode of irradiation using 5 Ci Pu / Be isotopic neutron source.
- \* A Ge(Li) detection system was used for data collection.
- \* The  $\gamma$  – ray line at 1434.2 keV of  $^{52}\text{V}$  was used for this purpose.
- \* Vanadium as a trace elements in oil was estimated as  $44 \pm 4.4$  and  $80 \pm 8.0$  ppm and  $45 \pm 2.4$  and  $92.0 \pm 4.6$  ppm using both methods for marine and land sources respectively which was in fair agreement with the previous data.

#### **4.1.3 VARIATION OF ELEMENTAL CONCENTRATIONS IN HAIR IN RELATION TO BILARZIA DISEASES [17]**

- \* N. A. A. Technique was applied for investigating of trace elements such as : Cu, Mn, Se, Ni, Cd and Hg, with the purpose of differentiation between, healthy persons and patients suffering from “Belharizia” diseases.
- \* The Ko – method is applied as a new standardization technique.
- \* Short lived nuclides were determined by a short neutron activation using the RPTS of the ET – RR – 1 at our laboratories.
- \* The patient’s head hair samples showed significant differences in Cu, Zn & Cd, but had no clear significant effect in Mn, Ni, Se and Hg.
- \* The results obtained indicate that early diagnosis by means of trace elements determination could be possible.

#### **4.1.4 INVESTIGATION OF AN EGYPTIAN PHOSPHATE ORE SAMPLE BY NEUTRON ACTIVATION ANALYSIS TECHNIQUE [18]**

- \* An Egyptian phosphate ore sample was analyzed by means of the prompt and delayed  $\gamma$ . Ray spectrometry.
- \* For long time irradiation, the vertical. Channel. Of the ET – RR – 1 is used (48 hours) and two (2.5 Ci each) Pu / Be neutron sources are used as well for prompt (n,  $\gamma$ ) analysis.
- \* A hyper pure Ge detection systems were used for data collection, and special programs using PCA and VAX computers programs were applied.
- \* Estimation of 22 elements out of 36 identified elements were achieved.
- \* Phosphate is one of the most important materials used for fertilization and the percentage values of its elemental constituents is very essential.

#### **4.1.5 DETERMINATION OF URANIUM AND THORIUM IN EGYPTIAN MONAZITE BY GAMMA-RAY SPECTROMETRY [19]**

- \* a sample of pure monazite prepared from beach sands of Abu – Khashaba area close to Rosetta in Egypt was investigated by means of passive and active measurement techniques.

- \* For active measurements, the core of the ET –RR – 1 is used [of  $\phi = 1013n / cm^2.s.$ ] for samples and standards irradiations.
- \* The sensitivity curves method is applied in both cases (Passive and Active) measurements.
- \* Gamma – Ray lines at : 270, 583, 911, 968 and 2204 keV for Th and U daughters in passive measurements and the  $\gamma$ . Ray lines at 311.8 and 277.6 keV in case of active measurements were used.
- \* The values obtained were : 46 to 59 ppm and 687 to 729 ppm for [U] and [Th] respectively.

#### **4.1.6 MULTIELEMENTAL NEUTRON ACTIVATION ANALYSIS OF SOME EGYPTIAN CEMENT SAMPLES [20]**

- \* Multielemental analysis of : Sea – Water, Karnak and Normal Cement Samples were performed by N. A. A. T. using the ET – RR – 1 for samples irradiation.
- \* The data were collected and analyzed by HPGE detection system and PCA computer programs.
- \* 23 elements : Na, Al, Cl, K, Ca, Sc, Cr, Mn, Fe, Co, Zn, Sr, Zr, Ba, La, Sm, Eu, Yb, Lu, Ta, Au, Th & U were identified and analyzed with concentration. Values ranging from : 1 ppm up to 62 % - [Comments and Comparisons] are given in this paper.
- \* The results of this work were very important in evaluating the hazards to the cement producers and users as well as the environmental pollution.

#### **4.1.7 EFFECT OF ZINC ON GRAIN CHARACTERISTICS OF DRAUGHT – RESISTENT RICE MUTANTS [21]**

- \* Zn concentration percentage was determined in kernels results on plants of six drought – resistant rice mutant lines, fertilized with “Zn Sulphate”.
- \* Zn content in the kernels ranged from 5.63 to 91.4 ppm, in the unfertilized control lines. This range was enlarged due to Zn fertilization of plants to be 93.51 to 554.53 ppm.
- \* It was noticed that Zn fertilization increased seed heaviness in varying degrees depending on the line itself. (So How important this Zn % values) ? which achieved with great accuracy using the R. N. A. A. Technique.

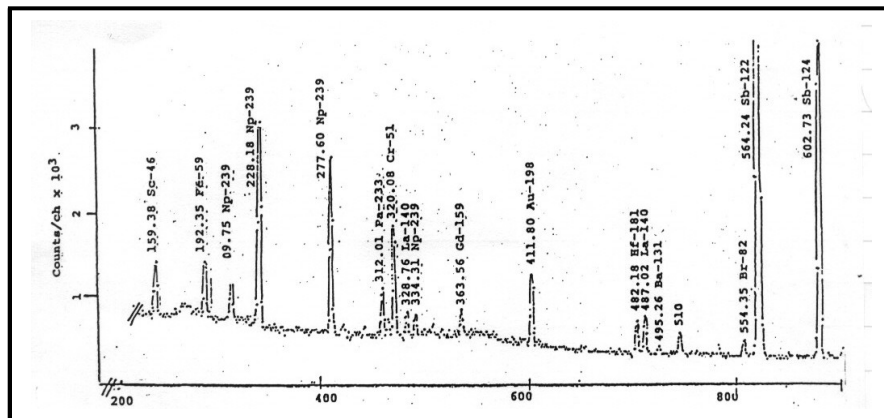
#### **4.1.8 ELEMENTAL ANALYSIS OF SOIL AND PLANT SAMPLES AT EL – MANZALA LAKE BY NEUTRON ACTIVATION ANALYSIS TECHNIQUE [22]**

- \* A soil and plant samples were taken from two locations, Bahr El – Bakar and Bahr Kados at El – Manzala Lake, where a high pollution is expected.
- \* The samples were irradiated in (ET – RR – 1) and the HPGe detection system is used for data collection.
- \* Among the 34 identified elements, Fe, Co, As, Ru, Cd, Te, La, Sm, Eu, Tb, Hg, Th and U are of special significance because of their toxic deleterious impact to living organisms.
- \* The data obtained stands as a reference basic record for any future follow up of the contamination level.

#### **4.1.9 TRACE ELEMENTS CONCENTRATION VALUES IN SOME DOMESTIC ALUMINIUM SAMPLES [23]**

- \* Four Egyptian Aluminium samples used in domestic purposes have been analyzed for TRACE elements using NAA Technique.

- \* The concentration values of : Sc, Cr, Fe, Co, Zn, As, Ba, La, Sm, Gd and Hf were estimated.
- \* The samples appear safe to use far from human diet. A portion of the gamma – ray spectra is shown in fig. [5]



**Fig. (5)** A Portion of the Gamma – Ray Spectrum of the Final Product. Aluminum Sample (D) [150 – 610 Ke V]

- \* For more industrial purification to bring down the level of the non-essential elements and those that could be toxic when present at high concentration, some requirements are needed.
- \* Also, from this work one can conclude that the presence of such high number of elements in Al foils and the products of local market may cause a great danger to the users.

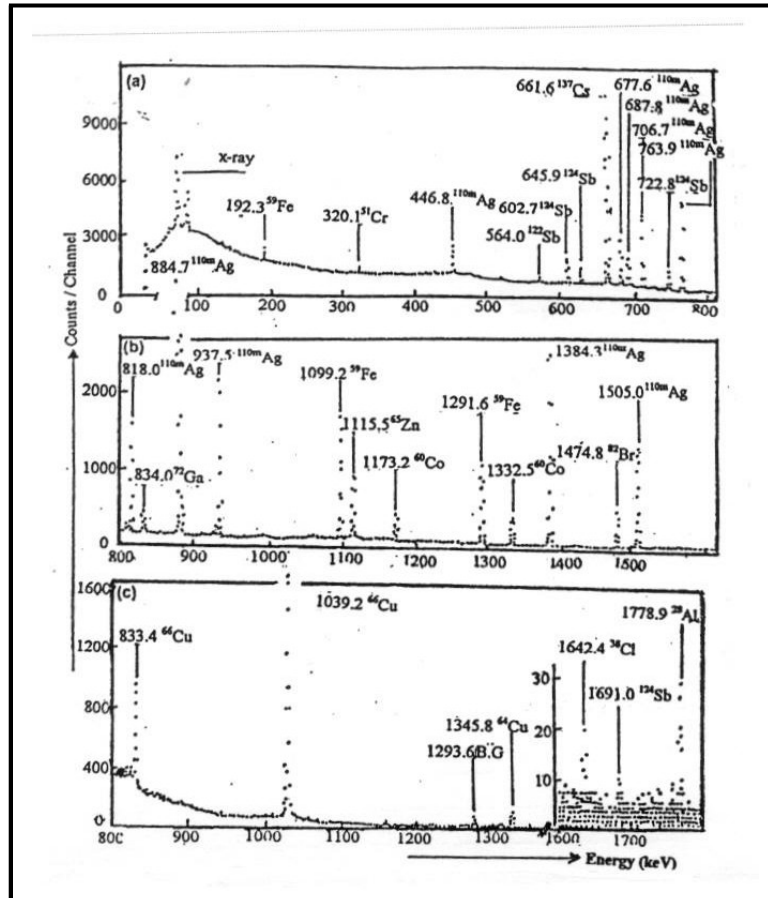
#### 4.1.10 ELEMENTAL ANALYSIS OF BRAZING ALLOY SAMPLES BY NEUTRON ACTIVATION [24]

- \* Two brazing alloy samples have been investigated by NAAT.
- \* The [RPTS] of [ET – RR – 1] was used for short time irradiation (30 S.), with  $\phi = 1.6 \times 10^{11} \text{ n/cm}^2\text{s.}$ ,  $\frac{\phi_{th}}{\phi_{epi}} = 106.$
- \* Long time irradiation (48 hours) was performed at the ET – RR – 1 core periphery at  $\phi_{th} = 3.3 \times 10^{12} \text{ n/cm}^2\text{s.}$  and  $\frac{\phi_{th}}{\phi_{epi}} = 79.$
- \* Al, Cr, Fe, Co, Cu, Zn, Se, Ag and Sn, concentration values were estimated and compared with reported values.
- \* Fig. (6) shows a portion of the gamma – ray spectrum of CP2 sample Fig 6

#### 4.1.11 RELATIVE AND KO NEUTRON ACTIVATION METHODS FOR ASSAY OF TRACE ELEMENTS IN AIR DUST NEAR AND AWAY FROM ELECTRICITY GENERATION STATIONS IN CAIRO [25]

- \* Some results were presented on the NAA of air dust samples taken from various localities near and away from electricity generation stations in Cairo.
- \* Ba, Ce, Co, Cr, Cs, Eu, Fe, Hf, La, Sb, Se, Sm, Sr, Ta, Tb, Th and U, were analyzed.
- \* As a standard [Andesit KA, 3/69 from Deut sch. GmbH] was used.

- \* Irradiation of sample for 48 hours in ET – RR – 1, and the gamma – ray spectra were collected. By the HPGe detection system.
- \* Results of the relative method were compared with the value for many elements calculated by the Ko method, using either Co or Sc as comparator.
- \* The results showed different levels near the electricity generations.



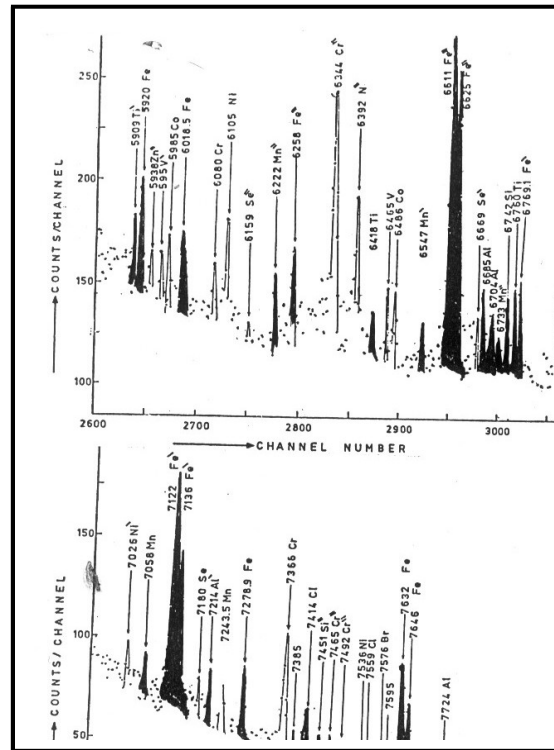
**Fig. (6)** Partial Gamma – Ray Spectrum of Silver Brazing Alloy (CP2) for 48 Hours. Irradiation Time.

#### 4.1.12 ANALYSIS OF SOME EGYPTIAN CRUDE OILS, MAZOUTS AND LUBRICATING OILS BY PARID NEUTRON ACTIVATION [26]

- \* The RPTS was used for rapid neutron activation of Crude Oil, Mazout and Lubricating Oils for two Egyptian oil fields, Shokair and Aguiba.
- \* Time of irradiation was 60 s for each sample at  $\phi_{th} = 1.6 \times 10^{11} \text{ n/cm}^2\cdot\text{s}$  and  $1.3 \times 10^9 \text{ n/cm}^2\cdot\text{s}$  for  $\phi_{epi}$ .
- \* HPGe Detection System with simple computer programs were used.
- \* Na, Mg, Al, Cl, Ca, V, Mn, Br, Yb, Ta, Re and Au were identified.
- \* The concentration values were estimated.

In addition, the horizontal channel no.8 is used for several investigations of materials by means of the prompt gamma – ray neutron activation analysis such as iron, aluminum and potassium ore samples. A portion of the prompt gamma – ray spectra of Hematite is shown on fig (7).





**Fig. (7)** A portion of the Neutron Capture  $\gamma$  - Ray spectrum of Hematite Ore Sample Using the Reactor Neutrons and the 87.2 cm<sup>3</sup> Ge (Li) Detector for 3 Hours Irradiation Time. The role of research reactors in nutrition environment and health related research has been discussed in Cairo from 2 to 3 Dec. (2007). This was through the 5th conference (RAF/4/202) on research reactor utilization, organized by the IAEA, AFRA project, and the Egyptian Atomic Energy Authority (EAEA) [5]. More than 25 articles have been presented in this meeting which include the activities realized in many countries of Africa in NAA applications. I found it is very useful to have a brief review and comment on some of them, just to show, how the number of NAA users is increased and some problems in health and economy faced the developing countries could be partially solved by applying the modern trends of this technique.

**4-2 In South Africa,** [5] three important papers have been presented by [Mr. A. Faanhof]. The first one dealing with the “FOODSTUFFS GROWN IN A CATCHMENT AREA IFLUENCED BY MINING AND MINERAL PROCESSING INDUSTRIES”. In his paper. he mentioned that a variety of foodstuffs were collected, dried and ashed, and analyzed for uranium, thorium and a suite of base metals observes through NAA based on intermediate lived nuclides (Silver, Arsenic, Gold, Barium, Cadmium, Cobalt, Chromium, Iron, Nickel and Manganese). Further more low background gamma-spectrometry was applied to analyze for a suite of progeny form the natural Uranium and Thorium and Actinium decay series (NORM).

In his second paper, “THE SPECIFIC STUDY FOCUSED ON THE EVALUATION OF URANIUM AND A SUITES OF BASE METALS AS DETERMINED BY INAA USING THE SAFARI-1 RESEARCH REACTOR”.

Four sediment samples were analyzed for their natural occuring Radioactive Material (NORM) radionuclide contents as well as a suite of base metals.

The results obtained were evaluated in terms of the radiobiological impact to humans as a result of

- \* External exposure due to an infinite thick layer of the sediment.
  - \* Respiration of environmental respirable airborne dust generated from the dried sediment 50 µg/lm<sup>3</sup>; as well as.
  - \* Ingestion due to soiled hands or foodstuffs (estimated at 100 mg per week for 50 weeks per year.
- High elemental concentrations of various elements are observed in the sediments, although evaluation of Arsenic as the only toxic element in the measured suite seems limited using the assumed intake rates and pathways evaluated.
- The relative high concentrations of some of the elements regarded to be essential (Mn, Cr and Fe) indicate potential problems for the pathways evaluated.
- The third paper of Mr. A. Faanhof of South Africa, entitled “A FIRST ORDER ASSESSMENT OF THE AGRICULTURAL USE SEDIMENTS FROM A CATCHMENT AREA INFLUENCED BY MINING AND MINERAL PROCESSING INDUSTRIES USING INAA”. Some of 250 sediments samples were collected, homogenized and delivered to the radio analytical laboratories of “Nasca” for analysis of: Uranium, Thorium and a suite of base metals observed through Neutron Activation Analysis base on intermediate lived nuclides (Silver, Arsenic, Gold, Barium, Cadmium, Cobalt, Chromium, Iron, Nickel and Manganese).
- Some elements proved to be below the detection limit of technique applied for most of the samples and accordingly some elements were not used in the final evaluation.

**4.3 In Ghana**, several papers have been presented in Cairo – meeting [5] using the GHARR – 1 MNSR facility. Mr. Amin – Samponge and B. J. B. Nuarko et al. From the Ghanian Atomic Energy commision, also Mr. A. A. Affum, talking about different applications. The article of Mr. A. A. Affum was very interesting, which entitled: “THE USE OF TRANSPLANTED LICHENS FOR BIOMONTORING OF AIRBORNE HEAVY METALS ALONG A ROAD IN ACCRA, GHANA”

Lichens, collected from an unpolluted forest (background) in November 2004, transplanted at 41 sampling sites along the Madina – Tetteh Quarshie road, retrieved in February 2005 analysed via neutron activation and atomic absorption spectroscopy, were found to contain higher concentrations of Manganese (Mn), Vanadium (V), Lead, Cadmium (Cd), Chromium (Cr) and Nickel (Ni) than in the background. At all the sampling stations, Mn concentrations were observed to be highest than the other elements with the highest value of  $1561 \pm 10$  mg / kg which exceeds the background by a factor of 3, occuring near an intersection. It was further observed that the concentration of the heavy metals decreased with increasing distance off the road. Statistical analysis also revealed a relatively even dispersion of the studied elements on the western side of the road than on the eastern side. Correlation coefficients calculated for the pairs of studied elements were 75 % for Mn – Ni, 66 % for Mn – Cr and 62 % for Mn – V.

**4.4 In Morocco**, [5] two articles have been presented by M. Bounakhla et al. “ON THE ASSESSMENT OF THE ATMOSPHERIC POLLUTION AND ITS IMPACT ON THE HEALTH OF THE CITY OF KENITRA” AND THE SECOND PAPER DEALING WITH “ THE PGAA OD HEAVY METALS ANALYSIS IN TAILINGS IN ZAIDA ABANDONNED MINE, HIGH MOULOUYA, OF MAROCCO”.

In the first paper the results show that the contents recorded in the sites of survey (Port, Former Road station and Bab Fe’s) concerning the suspended particles, Lead, Cadmium and (SO<sub>2</sub>) Sulfur dioxide, exceed the norms recommended by the world Health Organization and the EU. While in the second paper, the results obtained show

that the distribution of heavy metals in the basin is inhomogeneous with a very significant contamination by Pb, Zn, Cu, Cd, Cr and Ni close to the lead mine sites.

**4.5 In Nigeria,** [5] Nine articles have been presented by different authors could be summarized five of them follows:

**4.5.1** Mr. Ewa, I. O. B. et al. present a paper on:

“INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS FOR SOIL MICRO-NUTRIENTS AND HEAVY METALS OF THE NIGERIAN SAVANNA”. It deals with the Nigerian Savanna (Guinea, Sudan, Sahel) soils constitute a vast arable land where subsistence farming is practiced for the sustenance of the agrarian needs of the country most especially in food and fiber. Thermal neutrons from the Nigerian Research Reactor (NIRR – 1) were used in instrumental analysis of these soils. Soil pH and conductivity were equally measured as complementary physical parameters. Their results showed data for elemental abundances of twenty six elements. Concentration range for some soil essential elements like Fe, K Mg determined were 1.20 – 2.46 %; 1.37 – 2.67%, 0.2432 % respectively. The large data sets obtained for the elements identified from the twenty two sampling sites were subjected to Cluster Analysis using squared Euclidean distances in WARD’S METHOD. Dendrograms obtained as outputs showed a segregation of element data for the Guinea savanna with respect to that of the Sudan and Sahel Savanna. Soils of the Guinea savannah equally portrayed physical reflecting the (ferruginous) types.

**4.5.2** The Second paper of Mr. Ewa, I. O. B. et al. Entitled, DOSE VARIATIONS AND HEAVY METAL EFFECTS ON THE NEURO-SENSITIVITY OF EXTRACTS OF A MEDICINAL PLANT SECURINEGA VIROSA L. ADMINISTERED ON RODENTS

The paper reported the heavy metal contributions on the toxicity variation with dose increments of the medicinal plant Securinega virosa were investigated. Aliquots of both aqueous and methanol extracts at varying doses were irradiated using the Nigerian Research Reactor–1 while the remaining portions were administered both orally and intraperoneally to mice. Claims of the potency of the extract by the local community of the cure of epilepsy and mental disorders were tested through the observation of the neuro – sensitive response of the mice to varying doses.

**4.5.3** Mr. T. Banire et al : present a paper on:

“EVLUATION OF TOXIC NUTRIENT ELEMENTS IN NIGERIAN CEREALS BY THE K0–NAA METHODS”. The k0–NAA method has been adopted for the evaluation of toxic and nutrient elements in some Nigerian cereals. In this investigation, several species of three Nigerian cereals. Guinea – corn, maize and millet that are widely cultivated in every region of the country were purchased from local retail outlets. The standardized NAA protocols developed for NAA by the relative method with the Nigeria Research Reactor – 1 (NIRR – 1) were modified in this investigation in order to use the k0-NAA method. Furthermore, the dedicated software developed by the International Atomic Energy Agency (IAEA), the k0-IAEA program was installed and implemented with the modified irradiation and counting procedure. Preliminary results obtained with the version 3.12 of the software for the evaluation of toxic and nutrients elements of some Nigerian cereals are compared with

the exiting relative method with WINSPAN – 2004. The Standard Reference Material NIST – 1633b (Coal Fly Ash) was used for quality control of the method.

- 4.5.4** Mr. S.A. Jonah et al. Use the ENAA technique in their paper entitled: “EPITHERMAL NEUTRON ACTIVATION ANALYSIS OF METAL CONTAMINANTS IN NIGERIAN FOOD ADDITIVES USING NIRR-1 FACILITIES”. The concentrations of As, Br, Cd, Cl, Cr, Mn, Na, and Zn in 10 samples of commonly used food additives in Nigeria have been determined by the epithermal neutron activation analysis method. The samples were purchased from local retail outlets in Zaria and environs. With a minimal sample preparation procedure, the samples were irradiated in a movable BN capsule in one of the inner irradiation channels of the Nigeria Research Reactor – 1 (NIRR – 1). The experimental procedure involves one short irradiation and counting only. Corrections due to nuclear interferences and blanks were incorporated. In any sample where an element was not detected, its detection limit was calculated. Validation of the methodology was achieved using the standard reference materials, IAEA – 359 (Cabbage) and IAEA – 336 (Lichen). Results obtained were used to discuss the nutritional implications of the food additives in Nigerian diets.
- 4.5.5** Mr Akpan, et al. studied the: “TRACE ELEMENT ABUNDANCES IN NIGERIAN CRUDE OILS” which summarized as follows : Nigeria is one of the leading exporters of crude oils amongst other members of the Organization for Petroleum Exporting Countries (OPEC). As new oil wells are discovered, the need arises for a continuous analysis of trace elements in these oils in order to ascertain their quality. The Nigerian Research Reactor-1 is a facility that can yield quick analytical results for these elements. Crude oils from eight off shore (Atlantic Ocean) locations (Ubit 101A, Mfem8B, Ubit 106C, Inim 21A, Fnang 3B, Unam 20C, Enang 48E and Inim 11A) of the Mobil Producing Nigeria company, Eket, Akwa Ibom State, Nigeria were subjected to Instrumental Neutron Activation Analysis (INAA) using the Nigerian Research Reactor – 1, notably for Vanadium while an Atomic Absorption Spectrometry (AAS) was used for the determination of Nickel and Lead. Data for Lead from the oil – well Ubit 101A using the dry digestion method in AAS showed the highest concentration of 3.429 ppm. Vanadium data was equally measured for one of the oil wells using a Compton Suppression Spectrometer. The implications of heavy metals as they affect catalysis were are equally discussed.
- 4.6** **In Algeria**, [5] Mrs. Mezoguer et al., studied “THE BLOOD ZN LEVEL IN THYROID PATHOLOGIES BY INAA”. A summary of their work is given as follows:  
Both thyroid hormone (T3) and zinc play important roles in growth and development. The T3 receptor is thought to require zinc to adopt its biologically active conformation. Some of the effect of zinc deficiency, therefore, may be due to loss of zinc from the T3 receptor and impairment of T3 action.  
In this work, they determined the concentrations of zinc in total blood of 37 patients suffering from thyroid pathologies (hyperthyroidies, hypothyroidies and simple goitre) and 25 normal controls, using Instrumental Neutrons Activation Analysis (INAA). The blood zinc concentrations of patients suffering from hypothyroidy was  $2803.42 \pm 291.76 \mu\text{g/l}$ . no significant differences were observed in the concentration of Zn in hyperthyroidies ( $3513.77 \pm 292 \mu\text{g/l}$ ) and simple goitre group ( $3321.7 \pm 292 \mu\text{g/l}$ ) and simple goitre group ( $3321.7 \pm 223.32 \mu\text{g/l}$ ).

## 5- GENERAL CONCLUSION

As a conclusion, what we can say is that:

- \* Activation analysis technique will still active every where in the world. It is a valuable technique due to its nuclear - oriented character, unlike other techniques based on the atomic behaviors.
- \* The researchers working in these fields “mentioned in this review work” needs an international standard samples for evaluation of their analytical process.
- \* For future, plan a network of African centers working in NAA is demanded.

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