

Chapter One

1.1 Introduction:

XRF is used to determine different types of materials in its different states solid, liquid, powder, and gas.

In this work XRF is used to determine most kinds of material in the method is fast, accurate and nondestructive and usually requires only a minimum of sample preparation.

The precision and reproducibility of XRF analysis is very high, very accurate, results are possible when good standard specimens are available but also in application where no specific standards can be found.

The measurement time depends on the number of elements to be determined and required accuracy varies between second and 30 minutes the analysis time after measurement is time after measurement is only a few seconds.

1.2 Aim of study:

The purposes of this study are:

- To give some basic information about Energy Dispersive X-ray Fluorescence.
- To perform qualitative and quantitative analysis of different samples (water-dissolutions, powders, oils...) in order to define the sensitivity and detection limits of the equipment.
- To make a comprehensive and easy-to-use manual of the 'ARL QUANT'X Energy Dispersive X-Ray Fluorescence' apparatus
- To give a broad overview of the main spectrometer types and application problem.

- The importance of water in our life .It is abundant substance, essential for all forms of life, it solubilizes and modifies the properties of biomedical and all major components of cells (proteins, DNA, RNA) can dissolve in water.

1.3 The problem of study:

We know the important of water in our life and the elements that dissolve on it, and the hazards of these elements in our health .Hence that must be find a way to detect the water elements, to avert negative results of water.

1.4 Methodology:

Quantitative analysis by measuring the intensities of emitted energy it is possible to determine how much of each element is present in the sample in this work.

1.5 The research Layout:

The rest of dissertation is organized as flows:

Chapter two briefly explains x-ray and its production.

Chapter three briefly XRF it is benefits and the physics of XRF, and describes how this physics applied to spectrometer and their component.

Chapter four explains how an XRF analysis is done also it describes the process of sample taking measuring the sample and calculating the composition from the measurement results.

There are several researches projects at the department of industrial sciences, for some of those projects, elemental analysis is a very interesting technique.

1.6 Literature Review:

One of those projects, for example, is the HAGAR-project. The purpose of the HAGAR project is to give waste fats and oils a second life by transforming them into alkali-esters.

The second example is Analysis of Mine Waters Using X-ray Fluorescence Spectrometry to investigations on the application of XRF method with the helium system for liquid analysis and for the determination of the composition of saline mine water have been presented. The applied procedure allows determination of various elements in broad concentration range of analyzed elements (g/dm^3 - mg/dm^3).

1.7 Electromagnetic Spectrum:

The electromagnetic spectrum is the distribution of electromagnetic radiation according to energy (or equivalently, according to frequency or wavelength). The following table gives approximate wavelengths, frequencies, and energies for selected regions of the electromagnetic spectrum.

Table (1-1) Spectrum of Electromagnetic Radiation

Region	Wavelength (Angstroms)	Wavelength (centimeters)	Frequency (Hz)	Energy (eV)
Radio	$> 10^9$	> 10	$< 3 \times 10^9$	$< 10^{-5}$
Microwave	$10^9 - 10^6$	$10 - 0.01$	$3 \times 10^9 - 3 \times 10^{12}$	$10^{-5} - 0.01$
Infrared	$10^6 - 7000$	$0.01 - 7 \times 10^{-5}$	$3 \times 10^{12} - 4.3 \times 10^{14}$	$0.01 - 2$
Visible	$7000 - 4000$	$7 \times 10^{-5} - 4 \times 10^{-5}$	$4.3 \times 10^{14} - 7.5 \times 10^{14}$	$2 - 3$
Ultraviolet	$4000 - 10$	$4 \times 10^{-5} - 10^{-7}$	$7.5 \times 10^{14} - 3 \times 10^{17}$	$3 - 10^3$
X-Rays	$10 - 0.1$	$10^{-7} - 10^{-9}$	$3 \times 10^{17} - 3 \times 10^{19}$	$10^3 - 10^5$
Gamma Rays	< 0.1	$< 10^{-9}$	$> 3 \times 10^{19}$	$> 10^5$

A graphical representation of the electromagnetic spectrum is shown in the figure below.

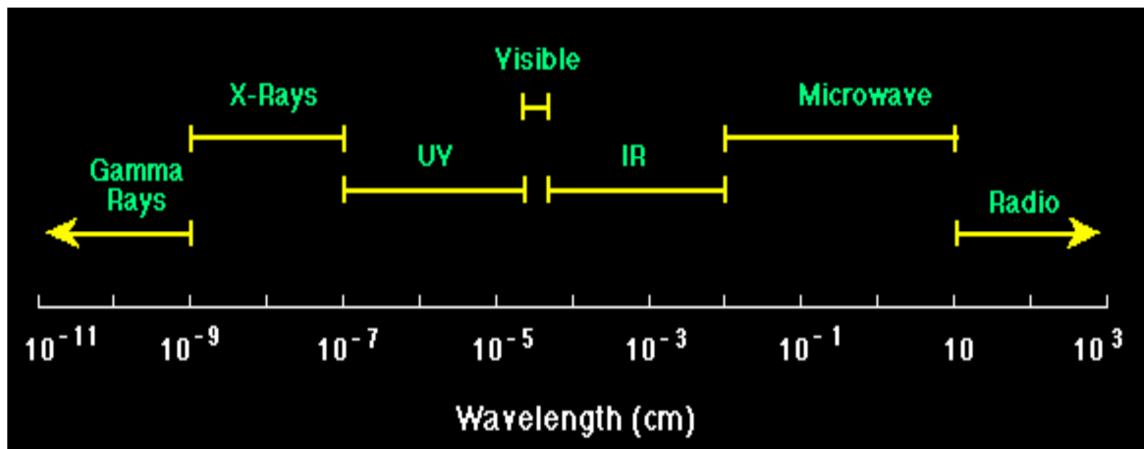


Fig (1-1) electromagnetic spectrum

When an element is bombarded with primary photons, electrons from the atomic sub shells may be excited to unfilled orbital levels. The element regains its initial or “ground” state by transference of outer orbital electrons to the unfilled inner levels and the energy surplus following each transference may be emitted as characteristic radiation. The energy of the emitted x-ray photon is equal to the absolute energy difference between the binding energies of the initial and final states of the transferred electron. Thus the wavelength of the photon is dependent upon the distribution of electrons in the excited atom and hence upon the atomic number of that atom. Since, under a given set of circumstances, many such electron transferences take place simultaneously, several characteristic lines are emitted at the same time and we refer to this total emission as the characteristic emission spectrum of the element.

A fairly simple set of selection rules covers the normal transitions (diagram lines) but certain lines are observed which do not apparently fit the selection rules. These lines are categorized as forbidden and satellite lines and, although they are generally weak, they do have significance in analytical x-ray spectroscopy.

Chapter Two

2.1 The Physics of X-rays:

As it is said before, x-rays are high-energy photons that are produced when electrons make transitions from one atomic orbit to another. These transitions can be generated via the photoelectric effect as illustrated in Figure (2-1).

If you send a photon into an atom with energy greater than the binding energy of an electron in that atom, the photon can knock that electron out of its orbit, leaving a hole (or vacancy). This hole can then be filled by another electron in the atom, giving off an x-ray in the transition to conserve energy. This process is known as fluorescence. Many different atomic electrons of different binding energies can fill this hole, so you would expect to see many energy peaks in an x-ray spectrum.

The figure (2-1) below, is a pictorial representation of x-ray fluorescence using a generic atom and generic energy levels. This picture uses the Bohr model of atomic structure and is not to scale.

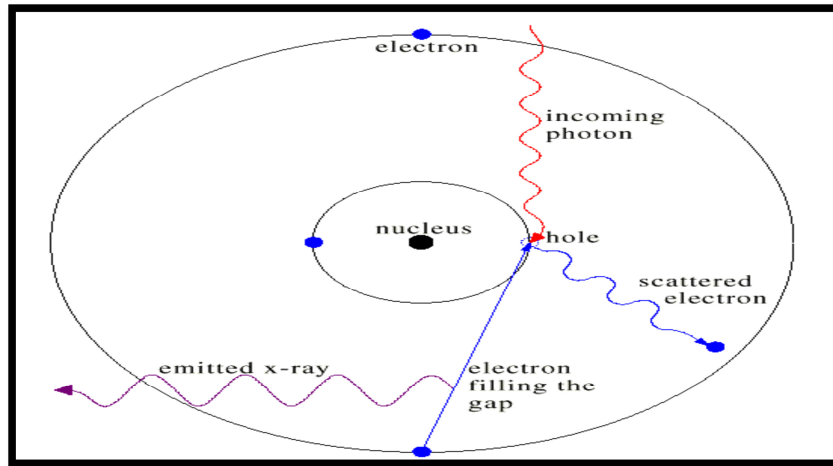


Fig (2-1) Boher model

2.1.1 Characteristic of X-rays:

We know that when orbiting electrons change from a higher permitted energy level to a lower one, the energy content of the atom drops and this excess in energy is emitted from the atom in a photon whose frequency is given by:

$$E_{high} - E_{low} = \frac{hc}{\lambda} \quad (2.1)$$

Where:

E_{high} = energy of higher energy level

E_{low} = energy of lower energy level

h = Planck constant

f = frequency

Such changes between the states of the outer electrons involve small amounts of energy and result in radiation of the longer wavelengths of the infra red, visible and ultraviolet parts of the spectrum. But the innermost electrons being much closer to the nucleus experience larger forces. The

corresponding larger changes of energy involving these electrons result in radiations of higher frequencies.

To the x-ray region of the electromagnetic spectrum. ($\lambda \sim 1-10\text{\AA}$).

All methods of analysis based on x-ray spectrometry involve the excitation of characteristic wavelengths from the elements making up the sample being analysed, separation of these wavelengths by means of a spectrometer, measurement of the intensities of the individual characteristic wavelengths and estimation of elemental composition by use of the measured intensities.

2.1.2 Nomenclature Used:

The electrons in an atom do not all follow the same orbit but arrange themselves in well defined shells around the nucleus; these shells are known as K, L, M, N, O, P and Q; the K shell being nearest to the nucleus.

Each shell represents an energy level, composed of different sub-levels. The K shell has the lowest energy and the Q shell the highest, but it is important to note that the largest energy difference between any two shells is between the K and L shells; the smallest difference is between the outermost shells.

The energy of a given electronic shell depends on the atomic number and thus, it varies from element to element.

X-ray spectral lines are grouped in series: K, L, M, N etc. All the lines in a series result from electron transitions from various higher levels to the same shell.

When a K shell vacancy is filled by an electron from the L shell we get the K_{α} line radiation, whereas when an electron from the M shell fills this vacancy, we get the K_{β} line radiation.

Similarly, if a vacancy in the L shell is filled by an electron from the M shell we get the L_{α} line radiation, if it is filled by an electron from the N shell, we get the L_{β} line radiation and if it is filled by an electron from the O shell we get the L_{γ} line radiation.

Every element has its characteristic K, L and M series. Thus, light elements give rise to only K lines; mid range elements can emit both K and L series while the heavy elements produce K, L and M series. Thus, the spectra get increasingly complex when we go towards heavier elements. In practical XRF, we select the principle lines of K and L series to measure an element although there may be other lines present.

The selection of an analysis line depends mainly on the type of sample, the elements present in it, the concentration range of the elements and the excitation conditions.^[2]

2.1.3 Emission of X-rays:

X-ray production typically involves bombarding a metal target in an x-ray tube with high speed electrons which have been accelerated by tens to hundreds of kilovolts of potential. The bombarding electrons can eject electrons from the inner shells of the atoms of the metal target.

Those vacancies will be quickly filled by electrons dropping down from higher levels,

Emitting x-rays with sharply defined frequencies associated with the difference between the atomic energy levels of the target atoms.

As it is said before, x-rays are generated by large energy transition of electrons within an atom from outer orbital's to core orbitals. Most x-rays are created by bombarding a metal target with energetic electrons.

The electron beam typically ejects core electrons from the target metal, making the atoms unstable. The atoms relax from this position by dropping an outer valence electron to the core level. This large decrease in energy required for an electron to be able to drop to the core level requires the emission of the excess energy in the form of a photon. These photons have the energy of x-rays.

An electron can be ejected from its atomic orbital by the absorption of a light wave (photon) of sufficient energy. The energy of the photon ($h\nu$) must be greater than the energy with which the electron is bound to the nucleus of the atom.

When an inner orbital electron is ejected from an atom, an electron from a higher energy level orbital will be transferred to the lower energy level orbital. During this transition a photon maybe emitted from the atom. This fluorescent light is called the characteristic x-ray of the element. The energy of the emitted photon will be equal to the difference in energies between the two orbits l occupied by the electron making the transition. Because the energy difference between two specific orbital shells, in a given element, is always the same (i.e. characteristic of a particular element), the photon emitted when an electron moves between these two levels, will always have the same energy. Therefore, by determining the energy (wavelength) of the x-ray light (photon) emitted by a particular element, it is possible to determine the identity of that element.

For a particular energy (wavelength) of fluorescent light emitted by an element, the number of photons per unit time (generally referred to as peak intensity or count rate) is related to the amount of that analytic in the sample.

The counting rates for all detectable elements within a sample are usually calculated by counting, for a set amount of time, the number of photons that are detected for the various analysts' characteristic x-ray energy lines.

It is important to note that these fluorescent lines are actually observed as peaks with a semi- Gaussian distribution because of the imperfect resolution of modern detector technology.

Therefore, by determining the energy of the x-ray peaks in a sample' s spectrum, and by calculating the count rate of the various elemental peaks, it is possible to qualitatively establish the elemental composition of the samples and to quantitatively measure the concentration of these elements .^[2]

2.2 Production of X-ray:

A brief discussion of x-ray production, X rays originate from atomic electron transitions and are element-specific. In the stable atom, electrons occupy discrete energy levels that are designated (in order of decreasing binding energy) K, L1, L2, L3, M1 ... Ms, N1, N7 and so forth. The binding energy is the energy that must be expended to remove an electron from a given orbit. The vacancy thus created is filled by an electron from an outer orbit. The Resultant loss in potential energy may appear as an x ray whose energy is equal to the difference in the binding energies of the two electron states. For example, if a uranium K electron is removed from the atom and an electron from the L3 level falls into "its place, the energy of the emitted x ray is 98.428 keV (115.591 keV minus 17.163 keV). The x ray produced by this transition is designated Kn_1 .

The K-series x rays are produced by outer electrons filling a K-shell vacancy. Each x-ray transition has a specific probability or intensity. The K-to-L3 transition is the most probable, and other intensities are usually expressed relative to $K_{\alpha 1}$. Figure 10.2 depicts the transitions involved in the production of the most abundant K and L x rays. Table 10-1 presents the major K and L lines of uranium and plutonium, along with their relative intensities

2.2.1 X- ray Tube:

All X-ray tubes work on the same principle: accelerating electrons in an electrical field and decelerating them in a suitable anode material. The region of the electron beam in which this takes place must be evacuated in order to prevent collisions with gas molecules. Hence there is a vacuum within the housing. The X-rays escape from the housing at a special point that is particularly transparent with a thin beryllium window. The main differences between tube types are in the polarity of the anode and cathode and the arrangement of the exit window. The two most significant types are the end-window tubes and the side window tubes.

2.2.1.1 Side window tube:

In side-window tubes, a negative high voltage is applied to the cathode. The electrons emanate from the heated cathode and are accelerated in the direction of the anode. The anode is set on zero voltage and thus has no difference in potential to the surrounding housing material and the laterally mounted beryllium exit window.

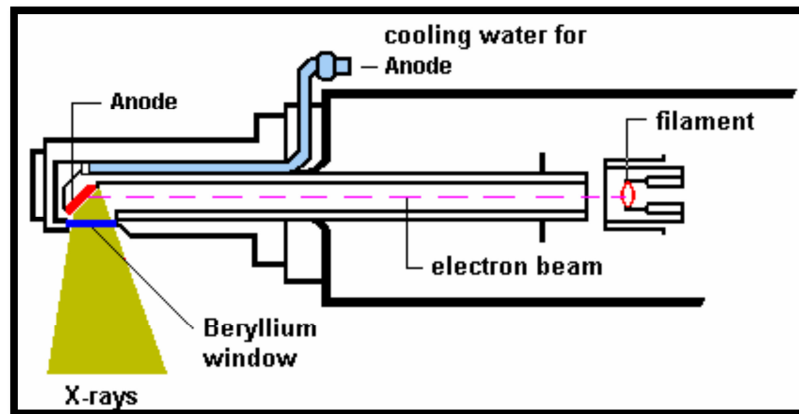


Fig (2.2) side window tube

For physical reasons, a proportion of the electrons are always scattered on the surface of the anode. The extent to which these backscattering electrons arise depends, among other factors, on the anode material and can be as much as 40%. In the side-window tube, these backscattering electrons contribute to the heating up of the surrounding material, especially the exit window. As a consequence, the exit window must withstand high levels of thermal stress and cannot be selected with just any thickness. The minimum usable thickness of a beryllium window for side-window tubes is 300 μm . This causes an excessively high absorption of the low-energy characteristic L radiation of the anode material in the exit window and thus a restriction of the excitation of lighter elements in a sample.

2.2.1.2 End window tube

The distinguishing feature of the end-window tubes is that the anode has a positive high voltage and the beryllium exit window is located on the front end of the housing Fig(2.3).

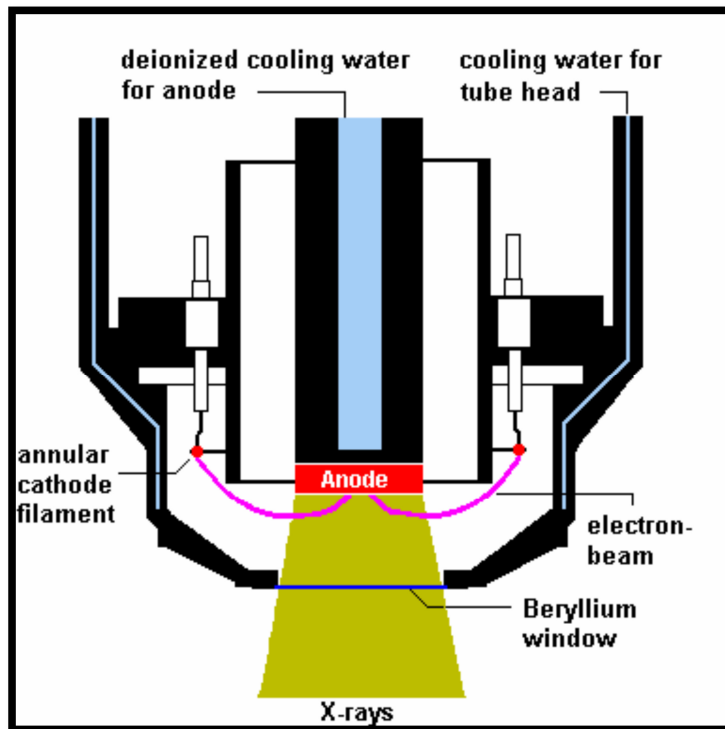


Fig (2.3) end window tube

The cathode is set around the anode in a ring (annular cathode) and is set at zero voltage. The electrons emanate from the heated cathode and are accelerated towards the electrical field lines on the anode. Due to the fact that there is a difference in potential between the positively charged anode and the surrounding material, including the beryllium window, the backscattering electrons are guided back to the anode and thus do not contribute to the rise in the exit window's temperature. The beryllium window remains "cold" and can therefore be thinner than in side-window tubes. Windows are used with a thickness of 125 μm and 75 μm . This provides a prerequisite for exciting light elements with the characteristic L radiation of the anode material (e.g. rhodium).

Due to the high voltage applied, non-conductive, deionizer water must be used for cooling. Instruments with end-window tubes are therefore equipped with a closed, internal circulation system containing deionizer water that cools the tube head as well. End-window tubes have been implemented by all renowned manufacturers of wavelength dispersive X-ray fluorescence spectrometers since the early 1980's. ^[1]

2.3 Interaction of X-rays with Matter:

Ionization is the ejection of one or more electrons from an atom or molecule to produce a fragment with a net positive charge (positive ion).

The classification of radiation as "ionizing" is essentially a statement that it has enough quantum energy to eject an electron. This is a crucial distinction, since "ionizing radiation" can produce a number of physiological effects, such as those associated with risk of ionizing radiation cannot directly produce at any intensity.

The mechanisms of interaction for ionizing radiation in the form of x-rays and gamma-rays include the photoelectric effect, Compton scattering and at high enough energies, electron positron pair production.

Although the precise ionization energy differs with the atom or molecule involved, a general statement is any radiation with quantum energy above a few electron volts is considered to be ionizing radiation. The threshold for ionization lies somewhere in the ultraviolet region of the electromagnetic spectrum, so all x-rays and gamma-rays are ionizing radiation. ^[2]

2.3.1 Photoelectric Effect:

Classically, electromagnetic radiation is a wave. The energy it carries is diffuse, distributed continuously along a broad wave, front and its intensity (energy per unit time per unit area) is proportional to E_0^2 , where E_0 is the amplitude of the electric field oscillations. Long before the advent of quantum physics, it was known that a beam of light directed at the surface of metal could eject electrons. This is called the photoelectric effect, light producing a flow of electricity. It was also known that a certain minimum energy is required. The electron is bound to the metal, and pulling it loose requires a certain amount of energy, with any surplus energy becoming the freed electron's kinetic energy. The amount of energy required to free an electron, the work function, is a characteristic of the metal.

If light is a wave, several definite things should be observed. First, if the light of one wavelength is able to eject electrons, then light of any wavelength should be able to do so; independent of the wavelength, the rate at which electrons are ejected, could be increased to any arbitrarily large value simply by increasing E_0 . Secondly, if the intensity is low, although electrons might still be ejected, measurable time lag should be evident; a wave being diffuse, considerable time may be required for enough energy to accumulate in the electron's vicinity. Finally, at any given frequency, if the intensity is increased, the departing electrons should be more energetic; a stronger electric field should produce a larger acceleration.

2.3.2 Compton Scattering:

The interaction of x rays and electron is simply a collection of two-particle collisions between photon and electron .electron is struck by an x ray photon of wave length λ .afterward the electron moving at speed u and scattered photon of wavelength λ' depart at angles ϕ and Θ .

Momentum conserved:

X -component:

$$\frac{h}{\lambda} = \frac{h}{\lambda'} \cos \theta + \gamma_u m_e u \cos \phi \quad (2-2)$$

Y-component:

$$0 = \frac{h}{\lambda} \sin \theta - \gamma_u m_e u \sin \phi \quad (2.3)$$

Energy conserved:

$$h \frac{c}{\lambda} + m_e c^2 = h \frac{c}{\lambda'} + \gamma_u m_e c^2 \quad (2-4)$$

Equations have been found to agree completely with the experimental observation when a photon collides with free electron. All tests since Compton's original one have reaffirmed the conclusion: the momentum of a photon is given by:

$$p = \frac{h}{\lambda} \quad (2-5)$$

The Compton effects most striking departure from classical expectation is

the large and immediate wavelength shift in the scattered radiation .this is made most clear by eliminating the electron speed u and scattering angle θ from the three equations

$$\lambda' - \lambda = \frac{h}{m_e c} (1 - \cos \theta) \quad (2.6)$$

The difference in wavelength between the incident and scattered photons depends only on the angle of scatter, energy smaller, than the incident.

This must be the case because the electron gains kinetic energy .in particular ,the maximum increase in wavelength is for backward scatter of the photon ($\theta=180^\circ$),because a head –on collision imparts the maximum possible energy to the electron .

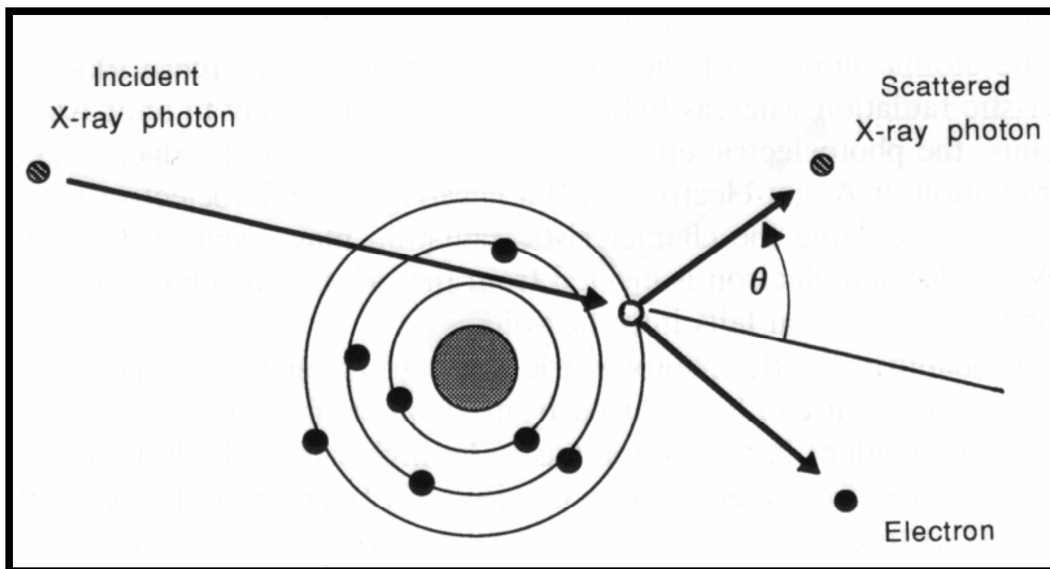


Fig (2-4) Compton Effect

2.3.3 Pair production:

The photoelectric effect and the Compton Effect are two important ways in which electromagnetic radiation interacts as a particle with matter. We now discuss a third—pair production. In 1932, a new particle was discovered. Carl D. Anderson (Nobel of "cosmic ray", energetic particles that constantly bombard earth's surface, when he noticed a particle behaving like an electron, but of positive charge. It curved the right amount but the "wrong" way in a magnetic field. The positively charged electron was termed the positron. We now know that its creation is quite common in the process known as pair production. The process which occurs whenever very high energy photons, such as gamma ray photons from space, typically, it would be revealed using a bubble chamber detector in which charged particles leave visible trails of bubble immersed in a magnetic field. From an initial absence of charged particles, there suddenly appear two charged particles that deflect in similar paths but opposite directions. The energy to produce the massive electron–positron pair comes from high energy photon, which, being uncharged, leaves no trail. Charge is conserved because the total charge of the pair is zero. ^[9]

Chapter three:

3.1 X-Ray Fluorescence (XRF):

XRF is an analytical method to determine the chemical composition of all kinds of material. The material can be in solid, liquid, powder, filtered or other form.

XRF can also sometimes be used to determine the thickness and composition of layers and coating.

The method is fast, accurate and non-destructive, and usually requires only a minimum of sample preparation. Applications are very broad and include the metal, cement, oil, polymer, plastic and food industries, along with mining, mineralogy and geology, and environmental analysis of water and waste materials. XRF is also a very useful analysis technique for research and pharmacy. ^[7]



Fig (3.1) XRF device

3.2 Principles of X-Ray Fluorescence:

3.2.1 X-ray Excitation:

X-ray excitation is produced when a primary x-ray photon has sufficient energy to eject electrons from inner shells and therefore vacancies are created. These vacancies present an unstable condition for the atom. As the atom returns to its stable condition, electrons from the outer shells are transferred to the inner shells in the X-Ray Fluorescence process. ^[2]

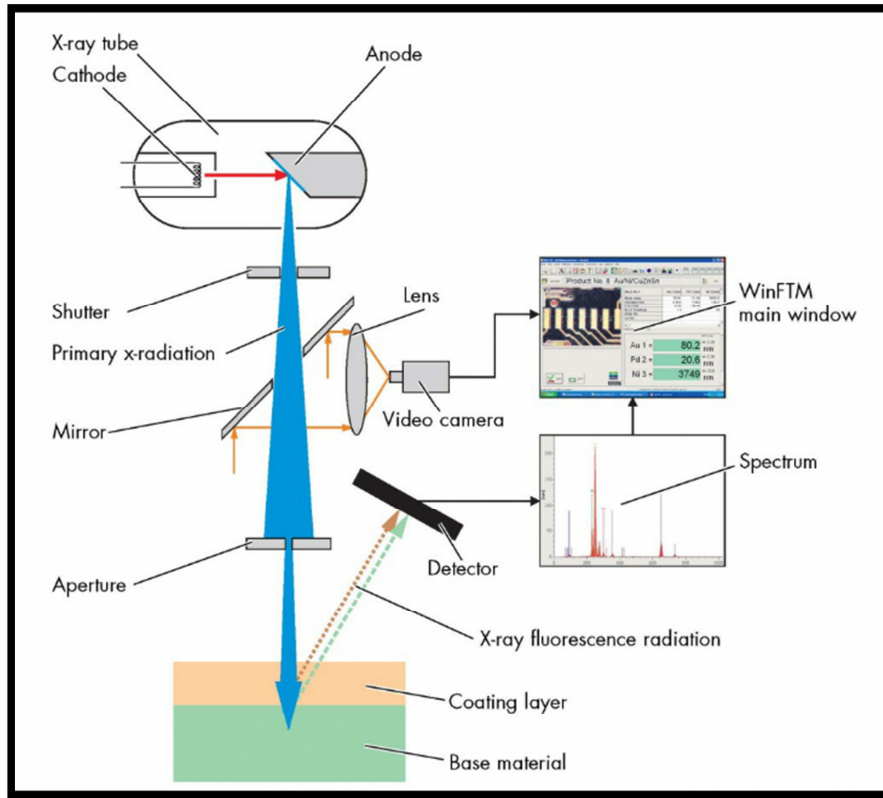


Fig (3-2) X-ray Excitation

3.2.2 Electron Excitation:

Electron excitation is the movement of an electron to a higher energy state.

When a high-energy electron is deflected from its original trajectory it becomes a scattered electron. Thus a secondary electron is generated as ionization product. It is called ‘secondary’ because is generated by other radiation (the primary radiation). This radiation can be in the form of ions, electrons, or photons with sufficiently high energy.^[2]

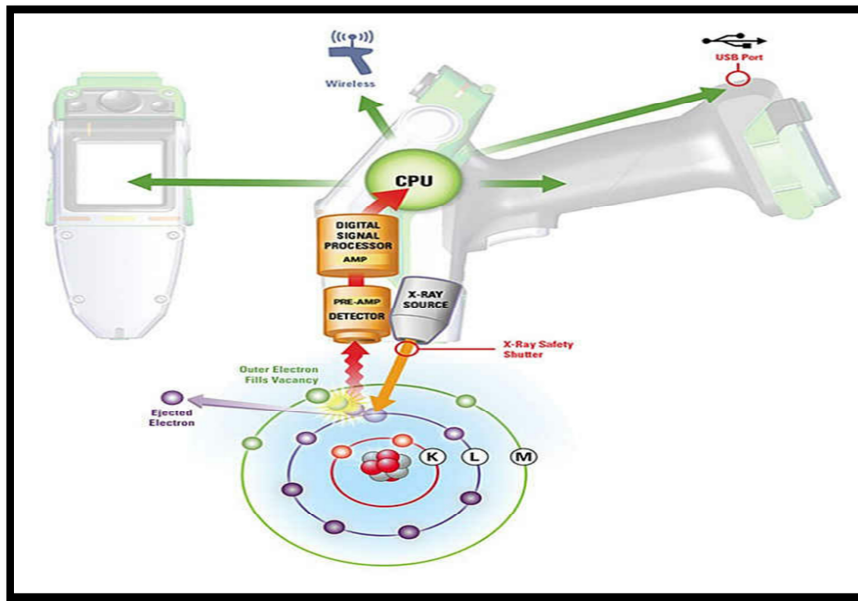


Fig (3-3) Electron Excitation

3.3 Fluorescence Yield:

When an electron is ejected from an atomic orbital by the photoelectric process, there two possible results: X-ray emission, or Auger electron ejection one of these two events occurs for each excited atom, but not both. Therefore, Auger electron production is a process which is competitive with X-ray photon emission from excited atoms in a sample.

The fraction of the excited atoms which emits X-rays is called the Fluorescent yield. This value is a property of the element and the X-ray line under consideration. Shows a plot of X-ray fluorescent yield versus atomic number of the elements for the K and L lines. It is an unfortunate fact that low atomic number elements also have low fluorescent yield.

The probability that an x-ray photon will be emitted (instead of an Auger electron) is called Fluorescence Yield. The K lines are more probable than the L lines which explain the difference in the yield for the K and L

type transitions. In practical x-ray spectrometry, we use the K lines to measure elements with low to medium atomic number while we switch over to measure L lines for the heavy elements, or even to the M lines.

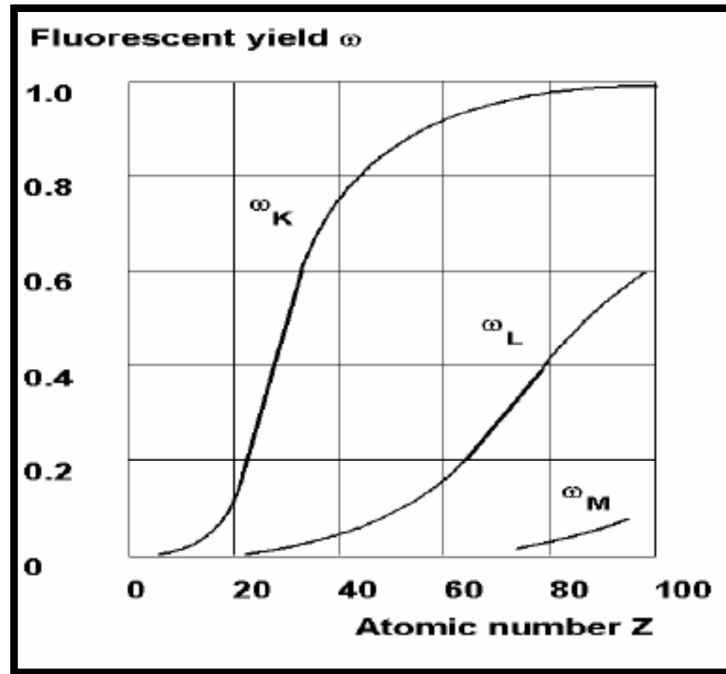


Fig (3-4) Fluorescent yield

3.4 Sample Preparation:

X-ray fluorescence (XRF) analysis is a fast, non-destructive and environmentally friendly analysis method with very high accuracy and reproducibility. All elements of the periodic table from beryllium to californium can be measured qualitatively, semi-quantitatively and quantitatively in powders, solids and liquids.

Concentrations of up to 100% are analyzed directly, without any dilution, with reproducibilities better than $\pm 0.1\%$. Typical limits of detection are from 0.1 to 10 ppm. Most modern X-ray spectrometers with modular Sample changers enable fast, flexible sample handling and adaptation to customer-specific automation processes.

XRF samples can be solids such as glass, ceramic, metal, rock, coal, or plastic. They can also be liquids, like petrol, oil, paint, solutions, blood or even wine. With an XRF spectrometer both very small concentrations of very few ppm and very high concentrations of up to 100% can be analyzed directly without any dilution process. Based on its simple and fast sample preparation requirements, XRF analysis is a universal analysis method that has been widely accepted in the fields of research and industrial process control. XRF is particularly effective for complex environmental analysis and for production and quality control of intermediate and end products.

The quality of sample preparation for XRF analysis is at least as important as the quality of measurements.

An ideal sample is prepared so that it is:

- Representative of the material.
- Homogeneous.
- Thick enough to meet the requirements of an infinitely thick sample.
- Without surface irregularities.
- composed of small enough particles for the wavelengths to be measured. ^[1]

Here we want to study about liquid sample.

3.4.1 General Liquid Sample Preparation:

Liquid samples can be the easiest or most difficult samples to work with depending on the composition and stability. A sample cup is filled about $\frac{3}{4}$ full and then presented to the analyzer. The problems with liquid samples are that they evaporate, stratify, and precipitate.

The liquid may attack or be absorbed by the window film, wick up and out of the cup. Because of these issues liquid samples should be freshly prepared, preferably immediately prior to analysis, although some liquids are stable for a day or more. Solutions should be well mixed prior to pipetting them into a sample cup. The sample should be taken from the center of the container since some components may concentrate on the walls.

3.4.2 Alternative Liquid Sample Preparation Method:

Since many liquid samples are inherently unstable there are a number of alternative methods for stabilizing the samples. There are also a number of pre-concentration techniques that are available that have been used with some success.^[2]

Chapter four

4.1 Materials and Methodology:

4.1.1 Apparatus and equipment:

Flask, sample cup XRF device thermometers cooler, heater, boiler and two sample of water (river water and purified water).

4.1.2 Method:

Sample of water which is being tested by using XRF is prepared river water and purified water.

1/4 liter of water at room temperature putted on sample cup then XRF is putted over the liquid inside the container for 6 to 10 seconds. The previous steps are repeated for three times in order to calculate the average value of readings and stander deviation (this readings done by the device itself or auto read). A previous step was repeated for different temperature (8°C , 32°C and 97°C) for two different samples, river water, purified water the results shown in the tables (4.1 to 4.6). In order to find elements exist in this samples and to investigate the effect of temperature on mechanism of detecting the elements in the samples. The results. are drawn by excel.

Results:

Elements	%	STD
W	43.35	3.508
Cu	0.50	0.345
V	0.28	0.199
Fe	38.01	0.307
Cr	0.29	0.112

Table (4.1) river water at 8°C

Elements	%	STD
W	42.28	2.820
V	0.56	0.219
Cr	0.34	0.169
Mn	0.05	0.092
Fe	37.26	0.193
Cu	0.35	0.318
Ni	0.12	0.212

Table (4.2) river water at 32°C

Elements	%	STD
Pb	0.00	0.000
Zn	0.00	0.002
Cr	0.02	0.005
Fe	0.27	0.190
Ni	0.01	0.001

Table (4.3) river water at 97°C

Elements	%	STD
W	43.04	1.172
V	0.64	0.251
Cr	0.26	0.227
Fe	37.53	0.599
Cu	0.50	0.289
Mn	0.01	0.010

Table (4.4) purified water at 8°C

Elements	%	STD
W	43.03	2.953
Cu	0.65	0.137
Cr	0.29	0.064
Fe	37.62	0.628
V	0.42	0.254

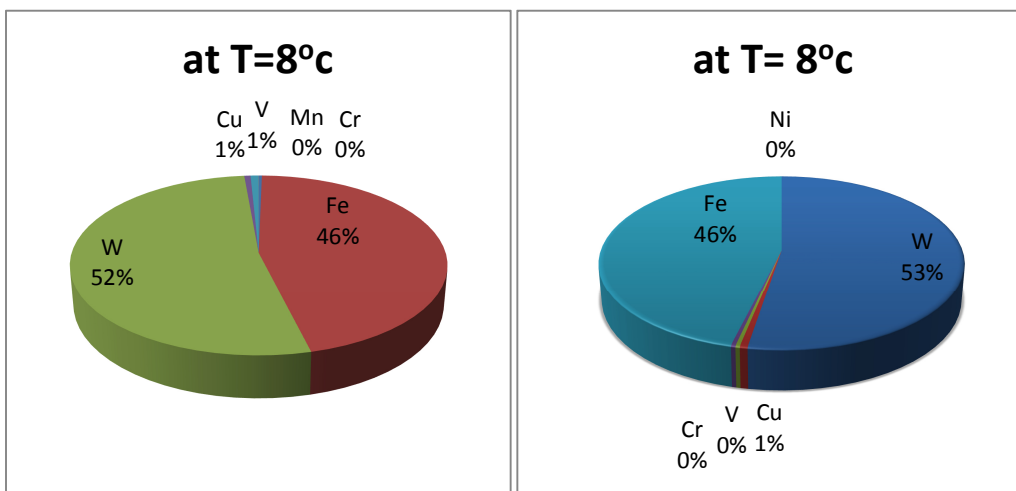
Table (4.5) purified water at 32°C

Elements	%	STD
W	41.27	2.430
Cu	0.81	0.127
Cr	0.40	0.151
Fe	37.82	0.328
V	0.52	0.333

Table (4.6) purified water at 97°C

Purified water (a)

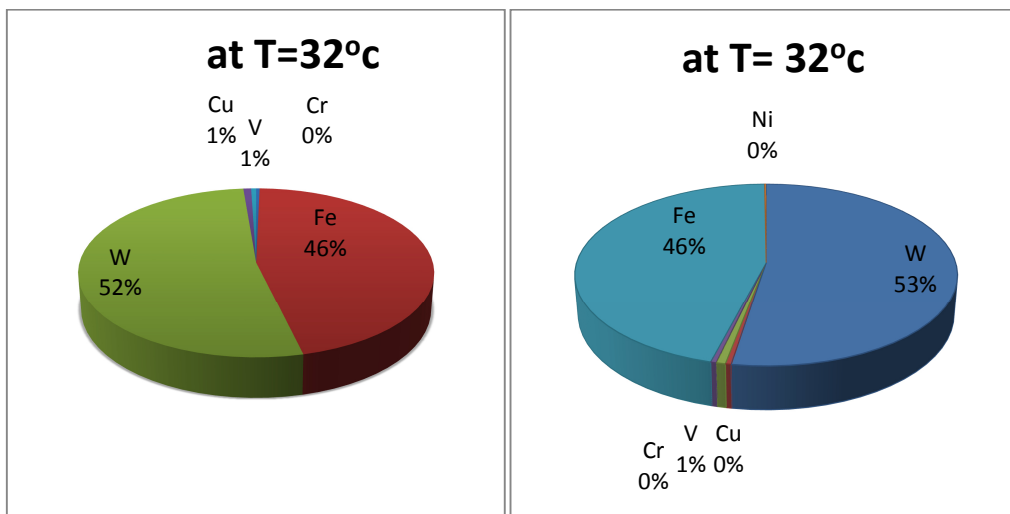
River water (b)



Sample exist on river water (a) and purified water (b) at 8⁰C

(a)

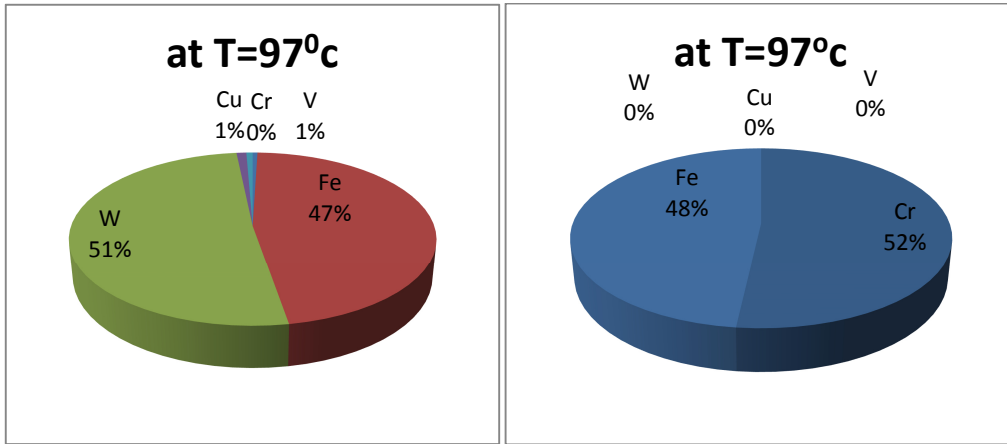
(b)



Sample exist on purified water (a) and river water (b) at 32⁰C

(a)

(b)



Sample exist on purified water (a) and river water (b) at 97°C

Discussion:

The following are the water samples analyzed using XRF. From the figures was obtained, that the ultimate temperature used to detect elements which exist in the two different samples is 32⁰C. below this temperature there are some element disappear and the same thing happened for temperature above this temperature.

The percentage of iron in the two samples remains constant for different temperature and this percentage slightly differed for 8⁰C.

The element W which is available at all temperature for the two samples was disappeared at 97⁰C for river water.

Conclusion:

This study demonstrates the utility of the X-ray fluorescence method to obtain fast and accurate elemental analysis of water samples the extraction of which could be detrimental to the environment and present serious health hazards to the population of Khartoum. The work has analyzed two different water samples which represent a variety of economically important in our live (river and purified water. The samples and that is both affordable and readily accessible is XRF. This technique can also provide a rapid evaluation of the economic potential of a health of the community impacted by the element extraction process.

Recommendations:

Researchers should be encouraged and fully supported by the government of the republic of Sudan. These goals can be met by ensuring that more research centers are created and encouraged by robust funding sources and that industry is incentivized to partner with researchers to preserve the environment for the future.

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