Elemental Concentration of Plumeria and Their Uses

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***Abstract*— Elemental concentration of Plumeria (Red and White) flowers were investigated by the Energy Dispersive X-ray Fluorescence (EDXRF) detection technique using Fundamental Parameter balance method, the Shimadzu EDX-7000 spectrometer and analysis software. Potassium element was the largest in both samples. Calcium was the second largest elements. Other elements such as phosphorus, sulphur, iron, strontium, rubidium, copper, zinc, manganese, titanium and nickel were also observed as trace elements. Little amount of bromine was found in Plumeria (White). The advantages of these elements were presented.**

Keywords—Plumeria, Fundamental Parameter Method, Energy Dispersive X-ray Fluorescence, Spectrometer, EDX-7000, Concentration.

I. Introduction

Plumeria (common name **plumeria** or **frangipani**) is a genus of flowering plants in the dogbane family, Apocynaceae. It contains primarily deciduous shrubs and small trees. The flowers are native to Central America, Mexico, the Caribbean, and South America as far south as Brazil but can be grown in tropical and sub-tropical regions.

Jamir is related to the oleander, *Nerium oleander*, and both possess an irritant, rather similar to that of *Euphorbia*. Contact with the sap may irritate eyes and skin. Each of the separate species of *Plumeria* bears differently shaped alternate leaves with distinct form and growth habits. The leaves of *P. alba* are narrow and corrugated, whereas leaves of *P. pudica* have an elongated shape and glossy, dark-green color. *P. pudica* is one of the everblooming types with non-deciduous, evergreen leaves. Another species that retains leaves and flowers in winter is *P. obtusa*; though its common name is "Singapore," it is originally from Colombia.

Plumeria flowers are most fragrant at night in order to lure sphinx moths to pollinate them. The flowers have no nectar, however, and simply dupe their pollinators. The moths inadvertently pollinate them by transferring pollen from flower to flower in their fruitless search for nectar.

Plumeria species may be propagated easily from cuttings of leafless stem tips in spring. Cuttings are allowed to dry at the base before planting in well-drained soil. Cuttings are particularly susceptible to rot in moist soil.

Propagation can also be by tissue culture from cuttings of freshly elongated stems or aseptically germinated seed. Pruning is best accomplished in the winter for deciduous varieties, or when cuttings are desired. There are more than 300 named varieties of *Plumeria*. (American Plumeria society, Florida)

The genus is named in honor of the seventeenth-century French botanist Charles Plumier, who traveled to the New World documenting many plant and animal species. Other countries have their common names.

Indian incenses fragranced with Plumeria (*Plumeria rubra*) have "champa" in their names. Red colored flowers are not used in weddings. Plumeria plants are found in most of the temples in India regions.

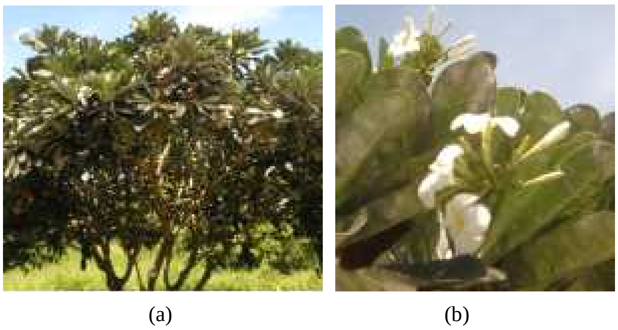
In Sri Lankan tradition, Plumeria is associated with worship. One of the heavenly damsels in the frescoes of the fifth-century rock fortress Sigiriya holds a 5-petalled flower in her right hand that is indistinguishable from Plumeria.

In Eastern Africa, frangipani (Plumeria) are sometimes referred to in Swahili love poems. Some species of *Plumeria* have been studied for their potential medicinal value [1, 2].

The aim of this research is to investigate the elemental concentration of Plumeria flowers. Our purpose is to utilize their elemental concentration for human being. For this work, Plumeria flowers were collected from ***Taungoo University*** Campus (Figure 1 and Figure 2), Taungoo City, Bago Region. The elemental concentration of Plumerias were analyzed by using Energy Dispersive X-ray Fluorescence technique and their usages were presented.

(a) (b)

Figure 1. Plumeria (Red) (a) plant and (b) flowers at *Taungoo University* Campus, Taungoo City, Bago Region



(a) (b)

Figure 2. Plumeria (White) (a) plant and (b) flowers at *Taungoo University* Campus, Taungoo City, Bago Region

II. Fundamental of Materials Characterization

X-rays, Roentgen rays, are electromagnetic radiations having wavelengths roughly within the range from 0.05 to 100 Å . At the short-wavelength end, they overlap with gamma rays, and at the long-wavelength end they approach ultraviolet radiation. X-rays were discovered in 1895 by Wilhelm Conrad Roentgen at the University of Warzbur, Bavaria.

When a beam of X-ray photons interacts with matter, the different interactions occur. The intensity of incident X-ray beam is attenuated due to these interactions. Two basic processes in the XRF analysis are the photoelectric effect and X-ray scattering. Three sub-interactions included in the photoelectric effect are the characteristic X-ray emission, the photoelectron ejection and the Auger electron ejection. Also, both coherent scattering and incoherent scattering can occur. These interactions are strongly influenced by the spectral distribution of the incident X-ray beam and the sample composition. Detailed information on the interactions can be found elsewhere.

In the photoelectric interaction, a photoelectron is emitted when the incident photon energy E is greater than the binding energy ϕ of the electron in the atom. The atom becomes unstable due to the removal of a bound electron and undergoes a rearrangement to reach the normal state. The transition of an electron from an outer shell to inner shell emits energy as X-ray photons. These X-ray photons can either escape from the atom or be absorbed to eject an outer shell electron (Auger electron).

When a charged particle (e.g. electon, proton, etc) or photon is incident an electron of the inner shell in an atom, if its energy is larger than the binding energy of that atom, the inner shell electron is ejected from that shell and it becomes a vacancy. This vacancy is immediately filled by electrons falling into them from outer shells. The energy given up by the electrons in changing shells is released as X-rays and the energy of these X-rays is characteristic energies of the electron shells and hence of the electron shells and hence of the atoms themselves. These X-rays are called characteristic X-rays.

Characteristic X-ray lines are emitted from each chemical element when excited by higher energy radiation, by which is fast above the absorption edge of the element interest. Each element emits its characteristic spectra and for each transition series K, L and M, there is a simple relationship between the energy of the characteristic X-ray line and atomic number. By measuring the energy and intensity of these characteristic lines one can recognize what element and how much are present in a sample. This X-ray fluorescence spectrometry is utilized for routine quantitative and qualitative analysis. Sensitive available for most elements reach the low parts per million ranges and the method is equally applicable at high or low concentration levels.

The production of characteristic X-ray involves of the orbital electrons of atoms in the target material between allowed orbits, or energy states, associated with ionization of the inner atomic shells. When an electron is ejected from the K shell by electron bombardment or by the absorption of a photon, the atom becomes ionized and the ion is left in high-energy state. The excess energy of the ion has over the normal state of the atom is equal to the energy (the binding energy) required to remove the K electron to a state of rest outside the atom. If this energy vacancy is filled by an electron coming from an L level, the transition is accompanied by the emission of an X-ray line known as K_α line. This process leaves a vacancy in the L shell. On the other hand, if the atom contains sufficient electrons, the K shell vacancy might be filled by an electron coming from an M level that is accompanied by the emission of the K_β line. The L or M state ions then remains may also give rise to emission if the electron vacancies are filled by electrons falling from further orbits.

In recent years, the “fundamental” approaches have been developed to deal with the matrix effects in XRF analysis. The fundamental parameters method can be applied mostly to relatively simple situations. Hai Fe has developed a quantitative procedure which can be used on a personal computer for EDXRF that can handle nearly any sample from and matrix and provide accurate results even if only a limited number of standards are available.

The X-ray fluorescence spectrometer consists of three main parts of the excitation source, the specimen presentation apparatus and the X-ray spectrometer. The function of the excitation source is to excite the characteristic X-ray in the specimen via the X-ray fluorescence process. The specimen presentation apparatus holds specimen in a precisely defined position during analysis and provides for introduction and removal of the specimen from the excitation position. The X-ray spectrometer is responsible for separating and counting the X-ray of various wavelengths or energies emitted by the specimen. The term X-ray spectrometer denotes the collection of components used to disperse, detect, count and display the spectrum of X-ray photons emitted by the specimen. When referring to the entire instrument, including excitation source, sample preparation apparatus, and X-ray spectrometer, the term of X-ray fluorescence spectrometer will be used.

For the excitation of characteristic X-ray, X-ray tube and radioactive sources are used. Commonly X-ray tube is used not only in primary energy dispersive system but also in secondary target energy dispersive spectrometer. In X-ray tube, a filament with adjustable current control is heated to generate free electrons. The electrons are accelerated to the anode (Rh or W) where they generate X-rays. If the X-rays have enough energy, an atom in the sample may absorb the energy and emit a characteristic X-ray. The X-ray leaves the sample and travels to the detector. In giving bias to X-ray tube; tube voltage must be set higher than the highest absorption edge energy. The range of tube voltage is 4 to 50 kV with the increment of 1 V and the tube current is 0.01 to 0.99 μA with the increment of 0.01 μA. Sometime, filter is used between the X-ray tube and the sample to reduce background in energy region, to estimate X-ray tube characteristic lines, which overlap with an element of interest and to transmit X-rays of sufficient energy for the excitation.

Computerized data handling has become on established part of analytical practice. Mainly, there are two main steps in the analytical process of using step, computer can control the instrument and process signal and can transform raw-data into meaningful results such as concentration. Next one is the interpretation relevant to the problem under investigation. Moreover, it could be possible to remove errors in measuring [3,4,5,6,7,8].

In present research work, Plumeria (Red and White) flowers were analyzed by the energy dispersive X-ray fluorescence (EDXRF): Shimadzu EDX-7000 system. The fundamental parameter (FP balance) method was used to determine the concentration of elements that contained in the samples. The FP method is an important analysis method. Based on this, the Shimadzu EDX-7000 is provided with high performance FP software as standard.

III. Sample Preparation

Plumeria (Red and White) flowers were dried under the temperature of 35 °C. The dried sample was crushed and ground in order to get fine powder by using grinding machine (Figure 3 and Figure 4). It was ground fine enough so as to meet the conditions for homogeneous dense materials, and to ensure reproducibility in measurements. And then, these powders were poured into a sample cell in which the bottom of it is covered with film (mylar). The diameter of the sample cell is 31.6 mm.

Sample preparation is important in the EDXRF analysis (Figure 5) because it is required to get homogeneous fine powder for best results. Generally, biological samples are heterogeneous and so making sample to be dried, ground and homogenized. To obtain reliable results in X-rays emission spectrometry, sample preparation is a very important process prior to actual experiment [9].

Sample preparation needs to be done carefully not to contaminate from grinding devices. We should take care of the grinding process in order to minimize the particle size effect. The guiding principles for specimen preparation techniques are reproducibility, accuracy, simplicity, low cost and rapid of preparation.

Specimen preparation is crucial to the relationship between spectral line intensity and the element concentration. Factors such as surface roughness, particle shape, particle size, homogeneity, particle distribution, and mineralization can affect this relationship [10].

(a) (b)

Figure 3. Dried Plumeria (a) Red and (b) White

Figure 4. Grinding with agate mortar and pestle (traditional)

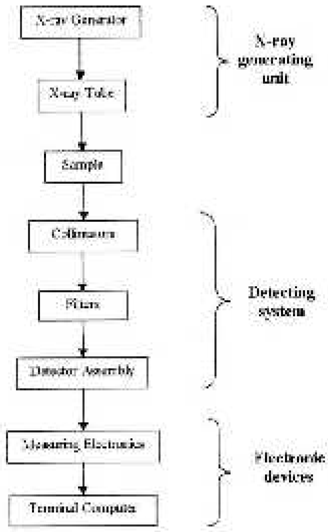


Figure 5. Schematic diagram of a sequential EDXRF Analysis

IV. Results and Discussion

The EDXRF analysis is given qualitative and quantitative results. The energy dispersive has been superior resolution and has high counting rates. The measuring time was 100 s in air. From this measurement, potassium element was the largest in both samples. Calcium was found as second largest element. Other elements such as phosphorus, sulphur, iron, strontium, rubidium, copper, zinc, manganese, titanium and nickel were also observed as trace elements. Little amount of bromine was found in Plumeria (White). The energy spectra and the concentration of elements contained in these samples were described in Figures 6, 7, 8 and Table I.

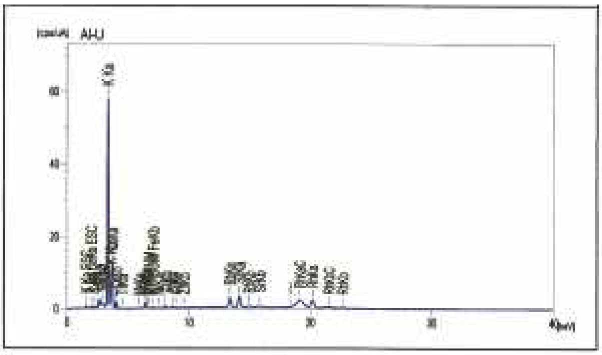


Figure 6. Energy spectrum results of Plumeria (Red)

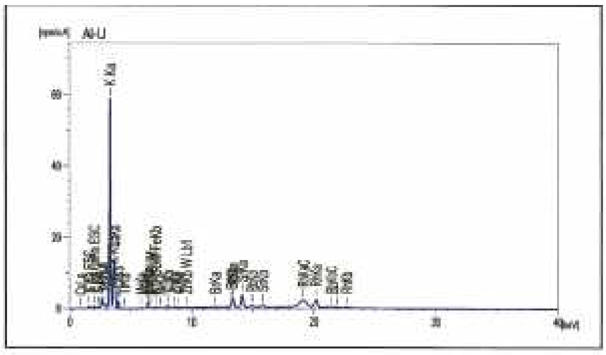


Figure 7. Energy spectrum results of Plumeria (White)

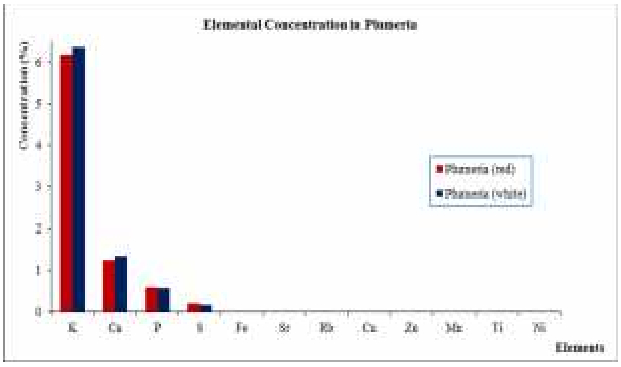


Figure 8. Elemental concentration in Plumeria (Red and White)

Table I. ELEMENTAL CONCENTRATION (%) OF PLUMERIA (RED AND WHITE) USING EDX- 7000 SPECTROMETER

Element	Concentration (%)	
	Plumeria (Red)	Plumeria (White)
Potassium (K)	6.186	6.358
Calcium (Ca)	1.251	1.343
Phosphorus (P)	0.596	0.572
Sulphur (S)	0.199	0.166
Iron (Fe)	0.023	0.023
Strontium (Sr)	0.013	0.015
Rubidium (Rb)	0.012	0.012
Copper (Cu)	0.006	0.007
Zinc (Zn)	0.003	0.003
Manganese (Mn)	0.003	0.004
Titanium (Ti)	0.003	0.004
Nickel (Ni)	0.001	0.001

Figure 9. Shimadzu EDX-7000 Spectrometer at Material Science Lab, Taungoo University

Potassium is an important electrolyte (meaning it carries a charge in solution). It helps regulate the heartbeat and is vital for electrical signaling in nerves. **Calcium** is the most common mineral in the human body — nearly all of it found in bones and teeth. Ironically, calcium's most important role is in bodily functions, such as muscle contraction and protein regulation. In fact, the body will actually pull calcium from bones (causing problems like osteoporosis) if there's not enough of the element in a person's diet. **Phosphorous** is found predominantly in bone but also in the molecule ATP, which provides energy in cells for driving chemical reactions. **Sulfur** is found in two amino acids that are important for giving proteins their shape.

Iron is a key element in the metabolism of almost all living organisms. It is also found in hemoglobin, which is the oxygen carrier in red blood cells. Half of women don't get enough iron in their diet. The additions of **Rubidium** or Cesium (Cs) to potassium-deficient diets prevent the lesions characteristic of potassium depletion in rats and supports near normal growth for short periods of time. **Copper** is important as an electron donor in various biological reactions. Without enough copper, iron won't work properly in the body.

Zinc is an essential trace element for all forms of life. Several proteins contain structures called "zinc fingers" help to regulate genes. Zinc deficiency has been known to lead to dwarfism in developing countries. The omission of **Strontium** caused an impairment of the calcification of the bones and teeth and a higher incidence of carious teeth. ^{90}Sr is one of the most abundant and potentially hazardous radioactive byproducts of nuclear fission and plants are more efficient than animals in the absorption of strontium. Strontium is preferentially excreted, especially in the urine, thereby providing some means of protection against ^{90}Sr. **Manganese** is essential for certain enzymes, in particular those that protect mitochondria — the place where usable energy is generated inside cells — from dangerous oxidants.

Titanium is so reactive that a titanium oxide skin forms spontaneously in contact with air, without the presence of water. It is used in many applications in the construction of industrial equipment such as in heat exchangers or piping systems in the chemicals and offshore industries, and also in process instrumentation such as pumps and valves. The material can also be found in aircraft construction, medical implants, sports goods such as tennis rackets and golf clubs, spectacle frames, jewellery, paint pigmentation, paper and so on.

Nickel is an essential element in animals. It has been speculated that nickel may play a role in the maintenance of membrane structure, control of prolactin, nucleic acid metabolism or as a cofactor in enzymes. It appears that most dietary intakes would provide sufficient amounts of this element.

In this study, the quantitative data calculated by the EDX-7000 software are based on the 100 percent of weightiness of inorganic elements contained in the sample of interest and considered on the organic compounds and dark matrix elements. It means that the data show the relative concentration contained in the sample of analysis.

V. CONCLUSION

Plumeria (Red and White) flowers were investigated by using the Energy Dispersive X-ray Fluorescence (EDXRF) detection technique. In this research, the concentration of elements contained in Plumeria samples were observed and their corresponding benefits were presented. So, Plumeria flowers support not only for traditional use but also for human health. The essence of Plumeria flowers have been used in perfume and other social products. Further investigation on Plumeria flowers would be fruitful the details of it.

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