J. Myanmar Acad. Arts Sci. 2026 **Vol. XXIII. No.2**

ANALYSIS OF ELEMENTAL CONCENTRATIONS IN AGRICULTURAL SOIL AND VEGETABLE SAMPLES IN SIN GYAUNG LAY VILLAGE OF PYIN OO LWIN TOWNSHIP

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Abstract

The present study investigated the elemental concentrations of agricultural soil and seasonal vegetables in Sin Gyaung Lay village of Pyin Oo Lwin township, Mandalay Region. The elemental concentrations of agricultural soil samples and vegetable samples were analyzed by using Energy Dispersive X-Ray Fluorescence Spectrometry (EDXRF) and Atomic Absorption Spectroscopy (AAS) techniques. The results obtained Mn ranged from 0.16 % to 0.52 %, Fe ranged from 18.60 % to 26.80 %, Ni ranged from 0.05 % to 0.08 %, Cu ranged from 0.03 % to 0.04 %, Zn ranged from 0.26 % to 0.34 %, As ranged from 0.01 % to 0.02 %, Pb ranged from 0.06 % to 0.13 % respectively in agricultural soil samples. The results obtained show that the concentration of Mn ranged from 0.04 % to 0.17 %, Fe ranged from 0.69 % to 0.97 %, Ni ranged from 0.05 % to 0.10 %, Cu ranged from 0.04 % to 0.07 %, Zn ranged from 0.16 % to 0.19 % were found in vegetable samples, while that Pb value 0.003 % was found in Yellow Mustard sample. According to the AAS analysis, the concentrations of Cr, Cu, Zn, Cd and Pb in soil and vegetable samples were found to be within the WHO standards. However, the concentration of Mn slightly exceeded the WHO value in soil sample S-3. The transfer factor for Pb was consistently found to be 1 in all samples, while the transfer factors for Mn, Fe and Zn were less than 1. Additionally, the transfer factor values for Cu and Cd were greater than 1. The findings highlight the importance of regular monitoring and sustainable agricultural practices to mitigate heavy metal contamination in food crops.

Keywords: EDXRF, Yellow Mustard, Carrot, Bok Choy, Elemental concentrations

Introduction

Pollution of the environment with toxic heavy metals has developed into one of the major issues of concern for human beings. Heavy metals can be highly toxic when they combine with various environmental components, including water, soil, air, humans, and other living organisms that may be exposed through the food chain. The majority of these metals are found in the biosphere, such as in water, soils, and rocks, and are also released into the environment from human activities, mainly commercial and industrial. Agriculture is the main source of the human food supply, and it aims to provide safe products with minimal environmental impacts (M. I. Atta *et al.*, 2023). Soil is a supportive layer for all living things in the world. The most important role of soil is to provide a medium for plant growth, which helps in recycling the nutrients and resources needed by plants. However, both essential and toxic elements were present in vegetables in a wide range of concentrations, as they can absorb metals from the soil (F. Abrham *et al.*, 2021). Vegetables absorb heavy metals from contaminated soils as well as from polluted environmental deposits through the roots and incorporate them into the edible parts of plant tissues or deposit them on the surface of vegetables. Vegetables are edible parts of plants that are a fundamental part of human daily meals (B. S. Sagagi *et al.*, 2022).

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The presence of heavy metals in soil is a major concern for public health. When plants are grown in polluted environments, they can accumulate high concentrations of heavy metals, posing serious risks to human health when consumed. Heavy metals are toxic because they tend to build up in plants and animals, concentrate in the food chain, and target specific organs in the body. Heavy metals, such as lead (Pb), nickel (Ni), copper (Cu), and selenium (Se), are contaminants that can be found on the surface and in the tissue of fresh vegetables and can be harmful to both plants and humans, even at low concentrations. Soil pollution can be caused by misuse of the soil, poor agricultural practices, disposal of industrial and urban wastes, and the application of chemical fertilizers and herbicides. Heavy metal accumulations in soil are a concern in agricultural production due to its adverse effects on food quality, crop growth, and environmental health.

Experimental Arrangement and Measurement

Sample Collection and Preparation

Sin Gyaung Lay village is located between North latitudes 21° 58′ 5″ and 21° 58′ 21″ between East Longitudes 96° 29′ 3″ and 96° 29′ 19″. It is located about 6.5 miles south of Pyin Oo Lwin. The figure of the study area, sample collection and sample preparation are shown in Figure (1) to Figure (3). Agricultural soil samples, Yellow Mustard, Carrot and Bok Choy samples were collected from the target area of Sin Gyaung Lay village. The soil samples were collected from the study area by using PVC pipe. All samples were collected in polythene bags to avoid direct sunlight. The edible part of the vegetable samples (Yellow Mustard, Carrot and Bok Choy) was washed with tap water and distilled water. After then vegetable samples were cut into small pieces and allowed to dry at room temperature for two weeks. The dry samples were crushed into fine powder using mortar and pestle. After crushing, the powder samples were sieved with mesh for particles size distribution. Before elemental concentrations analysis, all fine powder samples were stored in polythene bags. Finally prepared samples were analyzed for elemental concentrations by using Energy-Dispersive X-ray Fluorescence (EDXRF) at Kyaukse University without any chemical treatment. The coordinates of the sampling location for the study area are presented in Table (1).

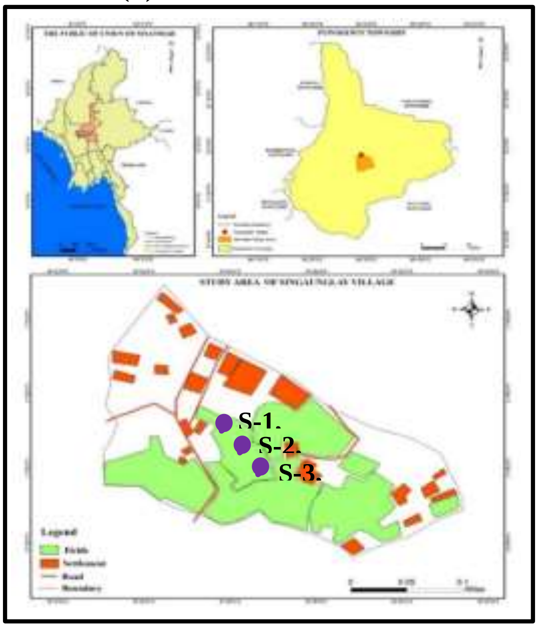

Figure 1. Geographical Map of Sin Gyaung Lay village, Pyin Oo Lwin Township

Table 1. Description of Samples List

Samples Code	Characteristics	Location
Yellow Mustard Soil sample (S-1)	clay	Latt: E 22° 37′ 38″
		Long: N 96° 48′ 30″
Carrot Soil sample (S-2)	clay	Latt: E 22° 37′ 25″
		Long: N 96° 47′ 33″
Bok Choy Soil sample (S-3)	clay	Latt: E 22° 37′ 24″
		Long: N 96° 48′ 28″
Vegetable sample(V-1)	Yellow Mustard	Latt: E 22° 37′ 38″
		Long: N 96° 48′ 30″
Vegetable sample(V-2)	Carrot	Latt: E 22° 37′ 25″
		Long: N 96° 47′ 33″
Vegetable sample(V-3)	Bok Choy	Latt: E 22° 37′ 24″
		Long: N 96° 48′ 28″

Figure 2. Collection and preparation of soil samples

Figure 3. Collection and preparation of vegetable samples

Energy Dispersive X-Ray Fluorescent Spectrometry

Energy Dispersive X-ray Fluorescence (EDXRF) is an analytical method used to qualitatively and quantitatively determine elements in a sample, regardless of their chemical form (P. Wobrauschek *et al.*, 2010). XRF spectrometry is a technique that exposes a sample to excitation X-rays and then measures the specific fluorescence X-ray energies emitted from the sample (T. Moriyama, 2013). Typical applications for EDXRF include analyzing agricultural materials, medical samples, archaeological and historical objects, paintings, fine art objects, as well as environmental samples like soil, ores, water, and aerosol particles. The method is based on the fundamental parameter approach and uses specific expressions for polychromatic excitation and intermediate thick samples. In this system, the X-ray tube was activated using a palladium (Pd) anode target. To enhance sensitivity, the exciting radiation can be optimized by using secondary targets instead of filters. A secondary target material is stimulated by the primary X-rays from the X-ray tube and then emits secondary X-rays that are characteristic of the elemental composition of the target. X-rays emitted from the secondary target were detected by a silicon drift detector (SDD). The system operated at 50 kV and 50 W, and the irradiation chamber was filled with helium gas. The automatic sample changer can hold a maximum of 15 samples. The total measurement time for each sample was 600 seconds. The measured spectra were analyzed using the Advanced RPF-SQX Fundamentals Parameters software, which includes Scattering FP. The photograph and schematic diagram of the EDXRF can be seen in Figure (4).

Figure 4. Photograph of Energy Dispersive X-ray Fluorescence Spectrometry (EDXRF)

Atomic Absorption Spectroscopy

Atomic Absorption spectroscopy is a technique used to determine the elemental composition of an analyte through its electromagnetic or mass spectrum. Atomic Absorption (AA) occurs when a ground-state atom absorbs energy in the form of light at a specific wavelength, causing the atom to transition to an excited state. The amount of light energy absorbed at this wavelength increases as the number of atoms of the selected element in the light path also increases. The relationship between the amount of light absorbed and the concentration of analytes present in known standards can be used to determine unknown sample concentrations by measuring the amount of light they absorb. The photograph of AAS is shown in Figure (5)

Figure 5. Atomic Absorption Spectroscopy (AAS) (Perkin Elmer AA900H),Universities Research Center, University of Yangon

Transfer Factor (TF)

The transfer factor is used to describe the movement of a contaminant (heavy metal) form soil to plants. The transfer factor was calculated by the following equation:

$$\mathrm{TF} = \frac{\mathrm{C}_{\mathrm{plant}}}{\mathrm{C}_{\mathrm{soil}}}$$

$\mathrm{C}_{\mathrm{plant}}$ is the metal concentration in edible parts of vegetables and $\mathrm{C}_{\mathrm{soil}}$ is the metal concentration in soil (W. A. Iyama *et al*., 2022).

Results and Discussion

The individual results obtained for each elemental concentration values are shown in Table (2). The highest elemental concentration values of Ni, Cu, Zn and Pb were found in soil sample S-1. Moreover, the height concentration values of Mn, Fe and As were found in soil sample S-3. The height concentration values of Mn and Fe were found in sample V-3 and the height concentration of Ni, Cu and Zn were found in samples V-2. The concentration value of Pb was found only in vegetable sample V-1 while the concentration value of as was not found in all vegetable samples. The comparison of the data is shown in Figure (6) and Figure (7).

According to AAS results, the concentration values of Mn ranged from 2.23 mg/L to 3.07 mg/L. The concentration value of Mn slightly exceeded the WHO value of 3 mg/L in soil sample S-3. The concentration values of Fe ranged from 39.64 mg/L to 42.14 mg/L. The concentration values of Fe are the height in all soils and vegetable samples as it is abundant elements in nature. The concentration values of Cu ranged from 0.05 mg/L to 0.08 mg/L and Cd ranged from 0.01 mg/L to 0.02 mg/L. The concentration values of Cu and Cd was found below the WHO permissible limit value is 1. The concentration value of Zn ranged from 1.12 mg/L to 1.14 mg/L. The concentration value of Zn was found below the WHO limit of 3 mg/L in soil sample. In vegetable samples, the concentration values of Mn ranged from 0.04 mg/L to 0.08 mg/L and Fe ranged from 0.3 mg/L to 0.53 mg/L. The concentration values of Cu are 0.06 mg/L to 0.08 mg/L and the WHO standard of Cu is 0.73 mg/L. The concentration values of Cd were found 0.02 mg/L in all vegetable samples and the WHO values of Cd is 0.1 mg/L. The concentration values of Pb ranged from 0.02 mg/L to 0.03 mg/L and the WHO value of Pb is 0.3 mg/L. The concentration value of Zn, Cd and Pb were found below the WHO limits. The elemental concentrations of soil and vegetable samples are shown in Table (3) and the comparison of heavy metal concentrations in soil and vegetable samples are shown in Figure (8) and Figure (9). The transfer factor values of Mn, Fe and Zn were found below 1. Whereas the transfer factor value of Pb was found 1 in all samples. The transfer factor values of Cu were found below 1 except for V-2. The transfer factor value of Cd was found exceed 1 except for V-3. The comparison of Trans Factor values for vegetables samples are shown in Table (4) and Figure (10).

Table 2. Elemental concentrations of soil and vegetable samples (EDXRF results)

Elements	Elemental Concentrations (mass%)					
	S-1	V-1	S-2	V-2	S-3	V-3
Mn	0.16	0.08	0.23	0.04	0.52	0.17
Fe	18.6	0.69	21.6	0.87	26.8	0.97
Ni	0.08	0.05	0.05	0.1	0.06	0.08
Cu	0.04	0.04	0.03	0.07	0.04	0.04
Zn	0.34	0.17	0.26	0.19	0.26	0.16
As	0.01	ND	0.01	ND	0.02	ND
Pb	0.13	0.003	0.06	ND	0.1	ND

ND–Not Detected

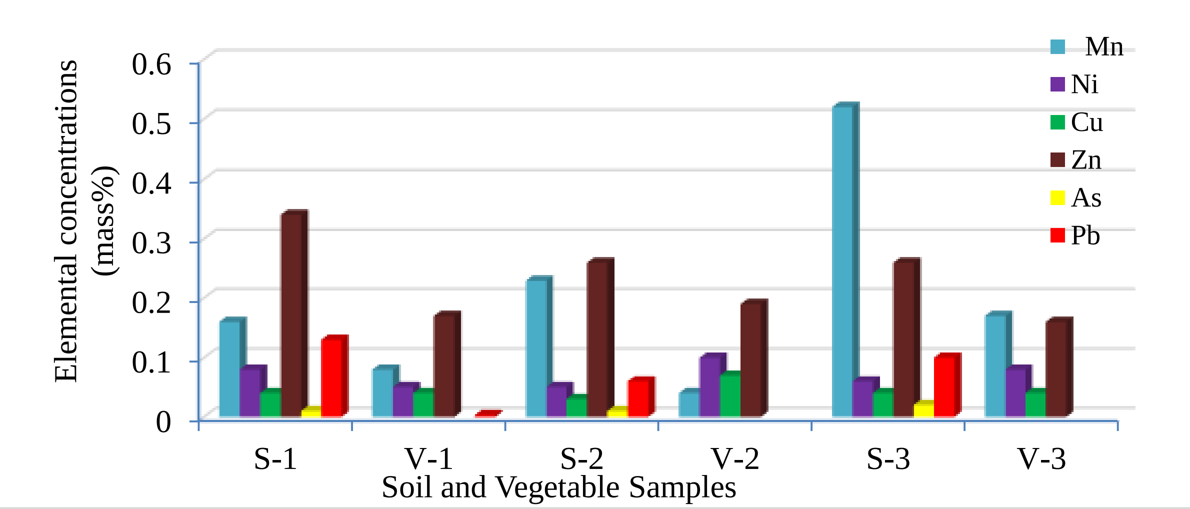

Figure 6. The comparison of elemental concentrations in soil and vegetable samples

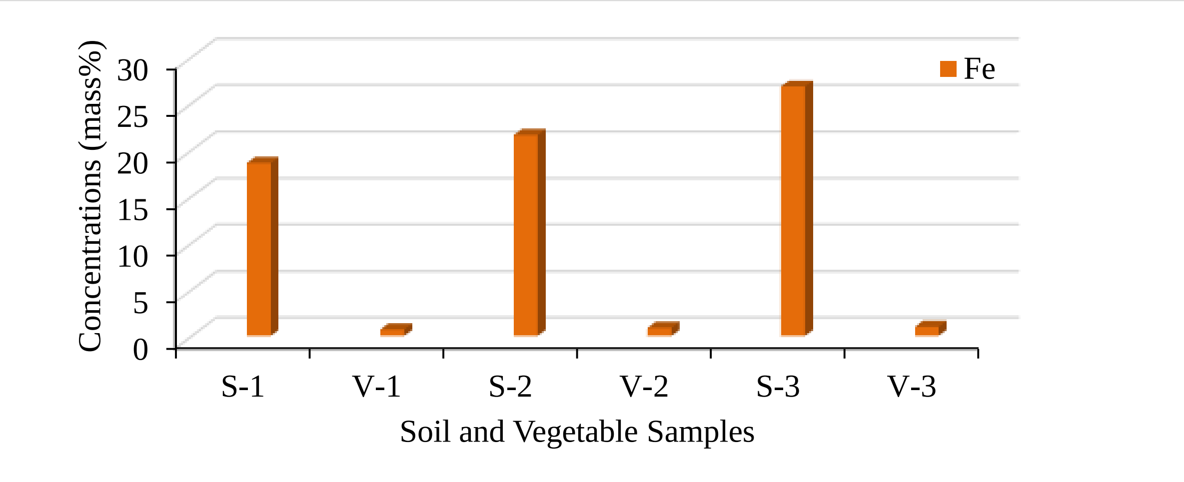

Figure 7. The comparison of iron concentrations in soil and vegetable samples

Table 3. Elemental concentrations of soil and vegetable samples (AAS results)

Elements	Elemental Concentrations (mg/L)					
	S-1	**V-1**	**S-2**	**V-2**	**S-3**	**V-3**
Mn	2.23	0.05	2.57	0.04	3.07	0.08
Fe	39.64	0.3	39.95	0.39	42.14	0.53
Cu	0.08	0.07	0.05	0.08	0.07	0.06
Zn	1.14	0.17	1.12	0.23	1.1	0.18
Cd	0.01	0.02	0.01	0.02	0.02	0.02
Pb	0.03	0.03	0.02	0.02	0.03	0.03

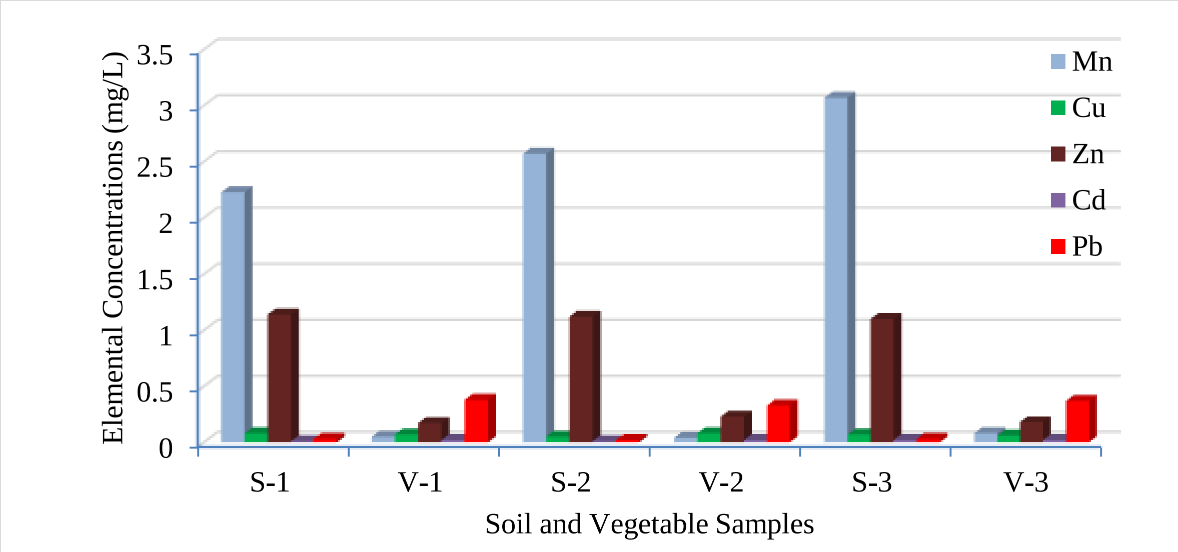

Figure 8. The comparison of heavy metal concentrations in soil and vegetable samples

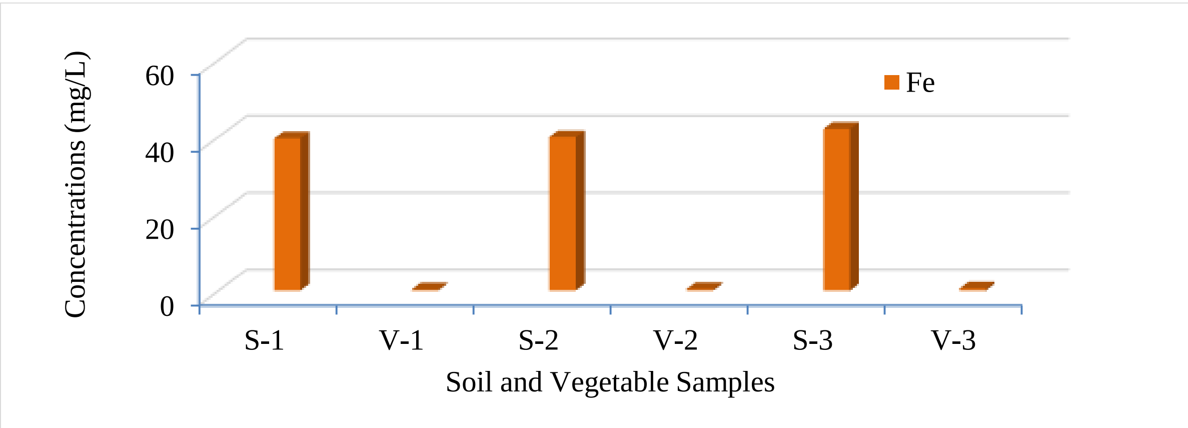

Figure 9. The comparison of iron concentrations in soil and vegetable samples

Table 4. The comparison of Trans Factor values for vegetables samples

Elements	TF (V-1)	TF (V-2)	TF (V-3)
Mn	0.02	0.01	0.03
Fe	0.01	0.01	0.01
Cu	0.9	1.2	0.9
Zn	0.12	0.2	0.2
Cd	2	2	1
Pb	1	1	1

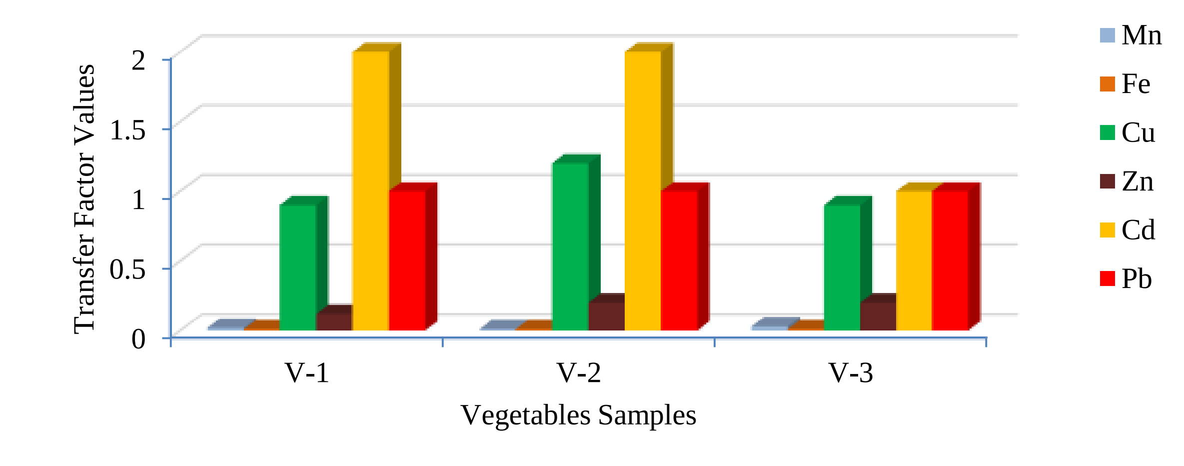

Figure 10. The comparison of Trans Factor values for vegetables samples

Conclusion

In the present study, according to EDXRF analysis, the elemental concentrations in soil samples are in order of Fe>Zn>Mn>Pb>Ni>Cu>As while the elemental concentrations in the vegetable samples are in order of Fe>Zn>Ni>Mn>Cu>Pb. Whereas the concentration of As was not found in all vegetable samples.

According to the AAS analysis, the concentration of Cr, Cu, Zn, Cd and Pb in soils and vegetable samples were found within the range of WHO standards, whereas the concentration of Mn was found slightly exceed WHO value in soil samples S-3. The transfer factor value of Pb was found 1 in all samples whereas the transfer factor value of Mn, Fe and Zn was found below 1. Moreover, the transfer factor values of Cu and Cd were found greater than 1. The findings emphasize the importance of regular monitoring and sustainable agricultural practices to migrate heavy metal contamination in food crops.

Acknowledgments

We would like to acknowledge with deepest gratitude to Dr Nyein Wint Lwin, Professor and Head, Department of Physics, University of Mandalay, for her kind permission, invaluable advice and encouragement and providing all the departmental facilities. We also thankful to Dr San Yu Swe, Professor, Department of Physics, University of Mandalay, for her kind suggestions and invaluable advice in this research.

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