Hanaa Mohammed

# بسم اللّه الرحمن الرحيم

## مركز الشبكات وتكنولوجيا المعلومات

## قسم التوثيق الإلكتروني

Safaa Mahmoud

# جامعة عين شمس

## التوثيق الإلكتروني والميكروفيلم

## قسم

**نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها**

**علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات**

# RECOVERY OF SOME ELEMENTS FROM SOLID WASTTES PRODUCED FROM FUEL COMBUSTION IN POWER PLANTS


**Submitted By**

**Ali Ahmed Maan El-Ghanam**

B.Sc. Science, Faculty of Science, Mansoura University, 1985

Diploma of Environmental Sciences, Faculty of Graduate Studies and Environmental Research, Ain Shams University, 2009

Master of Environmental Sciences, Faculty of Graduate Studies and Environmental Research, Ain Shams University, 2015


**A thesis Submitted in Partial Fulfillment**

Of

**The Requirements for the Doctor of Philosophy Degree**

In

**Environmental Sciences**


**Department of Environmental Basic Sciences**

**Faculty of graduate Studies and Environmental Research**

**Ain Shams University**


**2022**

**APPROVAL SHEET**

# RECOVERY OF SOME ELEMENTS FROM SOLID WASTTES PRODUCED FROM FUEL COMBUSTION IN POWER PLANTS


**Submitted By**

**Ali Ahmed Maan El-Ghanam**

B.Sc. Science, Faculty of Science, Mansoura University, 1985

Diploma of Environmental Sciences Faculty of graduate Studies and Environmental Research, Ain Shams University, 2009

Master of Environmental Sciences Faculty of graduate Studies and Environmental Research, Ain Shams University 2015


**This thesis Towards a Doctor of Philosophy Degree in Environmental Sciences has been Approved by** :

| Name | Signature |
|---|---|
| **1.Prof. Dr. Mostafa Mohamed Hassan Khalil**<br>Prof. of Inorganic and Analytical Chemistry<br>Faculty of Science Ain Shams University | ………………………… |
| **2. Prof. Dr. Taha Abd El Azim Mohamed Abd El-Razek**<br>Prof. of Environmental Chemistry Faculty of graduate Studies and Environmental Research Ain Shams University | |
| **3.Prof.Dr.Hanan Saied Abd Elrahman**<br>Prof. of Waste Chemistry National Research Center | …………… |
| **4. Dr.Ashraf Ibrahim Shehata Hafez**<br>Central Chemical Labs.Water treatment department<br>Egyptian Electricity Holding Company | ………………………… |

**2022**

# RECOVERY OF SOME ELEMENTS FROM SOLID WASTTES PRODUCED FROM FUEL COMBUSTION IN POWER PLANTS


**Submitted By**

**Ali Ahmed Maan El-Ghanam**

B.Sc. Science, Faculty of Science, Mansoura University, 1985

Diploma of Environmental Sciences, Faculty of Graduate Studies and Environmental Research, Ain Shams University,2009

Master of Environmental Sciences, Ain Shams University, 2015


**A thesis Submitted in Partial Fulfillment of**
**The Requirements towards a Doctor of Philosophy Degree**
**in**
**Environmental Sciences**

Under the Supervision of:


1. **Prof. Dr. Taha Abd El Azim Mohamed Abd El-Razek**

Prof. of Environmental Chemistry Faculty of Graduate Studies and Environmental Research

Department of Environmental Basic Sciences

Ain Shams University

2. **Dr. Ashraf Ibrahim Shehata Hafez**

Water treatment department Central Chemical laboratory

Egyptian Electricity Holding Company.


**2022**

# Acknowledgement

*At First, I thank* **God** *for being giving me the power to complete this work and all his gifts along my life.*

*My thanks due to* **Dr. Taha A.Azim M.A.Razek,** *Professor of Environmental Chemistry Dept. of Env. Basic Science-Institute of Environmental Studies and Research, Ain Shams University, for his valuable supervision, guidance, encouragement and all facilities given through the whole thesis and his continuous encouragement and scientific discussion for the obtained data.*

*I would like to express my sincere gratitude and appreciation to the supervisor of the present work,* **Dr. Ashraf Ibrahim Shehata Hafez,** *water Treatment Department., Center Chemical lab. Egyptian Electricity Holding Company, for his great effort in planning this research, his kind care during the progress of this work and his sincere encouragement and finishing of this work*

*Thanks to all staff and members of water division department and all members of the central chemical labs for their help and co-operation.*

# ABSTRACT

This thesis composed of two sections, the first is laser characterization of furnace bottom residue (FBR) while the second addressed methods of metal recovery especially vanadium and nickel.

**First section:** The goal of this section was to investigate the existence of heavy elements locally found in nine different samples of fuel power plant residues and to pay attention to the mining industry towards exploration recycling of these reserves. An optimized fast detection system based on an orthogonal double-pulse laser-induced plasma spectroscopy (ODPLIPS) system for quantitative analysis of valuable heavy metals like vanadium (V) and nickel (Ni) content in fuel power plant residue (PPR) was successfully developed. Those metals were taken from the PPR as a solid waste residue for industrial recycling. The investigated composition analysis by employing the calibration of the LIPS scheme is established on the registered collection spectra of the plasma flare generated by the laser beam in air pressure. We prepared standard matrices in a known concentration in the PPR sample to draw the standard calibration curves for each element, as well as by utilizing a tactic based on the intense lines emission of the elements of interest as quantitative analysis. These heavy elements that exist in the PPR were exactly identified using the energy dispersive X-ray (EDX) and an orthogonal double-pulse-LIPS (ODPLIPS) systems. By using the ODPLIPS excitation technique, the intensity of both spectral lines Ni(II) 221.65 and V(II) 294.45 nm were enhanced by nearly 4 and 5 times, respectively at laser pulse energy (LPE) ratio (E2/E1 = 3) as compared to the SP signal that could help the analytical performance of the LIPS system in terms of increasing sensitivity and reducing self-absorption effects for PPR pellets. Several experimental parameters of ODPLIPS geometry like the periodic interval between the data acquisition and the excitation pulse laser (ICCD gate delay, td = 200 ns), the LPE ratio (E2 = 3 times E1) and the inter-pulse separation between the couple laser pulses ($\Delta t$ = 800 ns) have been optimized to improve the SNR and sensitivity of our detection system and to achieve the best detection limit. The calibration curves were employed to quantify the Ni and V concentration that exists in the PPR samples. Furthermore, the LIPS outcome accuracy in evaluating the V and Ni concentration in PPR was validated using an inductively coupled plasma-optical emission spectrometry (ICP-OES) system. The predicted LIPS out- comes were found in complete harmony with the ICP-OES outcomes. The predictable limit of detection of our ODPLIPS system for V and Ni heavy metals was observed to be about 12.58, and 14.75 mg/kg, respectively. The proposed protocols elucidated that the brilliant profit of ODPLIPS for identifying valuable V and Ni metals present in the PPR sample and for examining the quality and purity of recovering metal manufactures.

**Second section:** Solid waste residue generated in power stations that use heavy oil as the source of fuel poses a threat to the environment due to the presence of some heavy metals. At the same time, these metals include vanadium and nickel can be recovered and recycled. In this work vanadium and nickel were recovered from solid waste residue (Furnace bottom sediments FBS) collected from the bottom of steam boiler. Four samples were selected and collected from different boilers. Solid samples were grinded to convert them to powdered form and sieved in 200 µm. The grinded samples were used for recovery. The recovery of vanadium and nickel was conducted in two stages. A first stage was acidification of the grinded (FBS) using 30 % sulfuric acid (dissolution of FBS) followed by alkali metal precipitation. The second stage is similar to first stage on the remaining solids from first stage. Determination of vanadium and nickel were conducted by two techniques, (EDX) and (ICP technique). The effect of some operational parameters (liquid/solid, leaching, temperature, mixing time, acid and alkali concentrations) on the recovery of V and Ni was investigated. Conditions of precipitation of V and Ni from alkali solutions were established. The effect of different amount of ammonium hydroxide/ammonium chloride which gives deferent pH value from (2 to 10) at different temperatures (25, 40, 60, and 80) ºC were investigated. The maximum recovery of vanadium reached 96.3% at (pH 3.5),Nickel recovery was 95.8% at (pH 9.5)for reaction time 4 h.

**Keywords**

LIPS • Recycling metals, Power plant residue, ICP, Furnace bottom sediments, Solid waste, Heavy fuel oil, Vanadium, Nickel

# List of Abbreviations

| | | |
|---|---|---|
| Al | : | Aluminum |
| ASTM | : | American Standard Methods |
| EDX | : | Energy dispersive X-ray |
| FBS | : | Furnace bottom sediments |
| Fe | : | Iron |
| FGD | : | Flue gas desulfurization |
| ICP | : | Inductive coupled plasma |
| ICP-OES | : | Inductively coupled plasma-optical emission Spectrometry system. |
| LPE | : | Laser pulse energy |
| Na | : | Sodium |
| Ni | : | Nickel |
| ODP | : | Orthogonal double-pulse |
| ODPLIPS | : | Orthogonal double-pulse laser-induced plasma spectroscopy |
| S | : | Sulfur |
| Si | : | Silicon |
| td | : | Time delay |
| TGA | : | Thermo gravimetric analysis |
| V | : | Vanadium |
| Zn | : | Zink |

# List of Contents

# List of Tables

# List of Figures