



بسم الله الرحمن الرحيم

∞∞∞∞

تم رفع هذه الرسالة بواسطة / حسام الدين محمد مغربي

بقسم التوثيق الإلكتروني بمركز الشبكات وتكنولوجيا المعلومات دون أدنى

مسئولية عن محتوى هذه الرسالة.

ملاحظات : لا يوجد





**REMEDIATION OF SOIL CONTAMINATION  
CAUSED BY BRICK INDUSTRY USING  
ELECTROKINETIC TECHNIQUE: A CASE  
STUDY OF A BRICK FACTORY IN  
AL-NAHRAWAN AREA IN IRAQ**

By

**Sarah Duraid Ahmed Zangana**

A Thesis Submitted to the  
Faculty of Engineering at Cairo University  
in Partial Fulfillment of the  
Requirements for the Degree of  
**MASTER OF SCIENCE**  
in  
**Civil Engineering – Public Works**

FACULTY OF ENGINEERING, CAIRO UNIVERSITY  
GIZA, EGYPT  
2022

**REMEDIATION OF SOIL CONTAMINATION  
CAUSED BY BRICK INDUSTRY USING  
ELECTROKINETIC TECHNIQUE: A CASE  
STUDY OF A BRICK FACTORY IN  
AL-NAHRAWAN AREA IN IRAQ**

By

**Sarah Duraid Ahmed Zangana**

A Thesis Submitted to the  
Faculty of Engineering at Cairo University  
in Partial Fulfillment of the  
Requirements for the Degree of  
**MASTER OF SCIENCE**  
in  
**Civil Engineering – Public Works**

Under the Supervision of

**Prof. Dr. Mona M. Galal El-Din**

**Dr. Safwat Mahmoud Safwat**

Professor of Sanitary &  
Environmental Engineering  
Public Works Department  
Faculty of Engineering  
Cairo University

Associate Professor of Sanitary &  
Environmental Engineering  
Public Works Department  
Faculty of Engineering  
Cairo University

FACULTY OF ENGINEERING, CAIRO UNIVERSITY  
GIZA, EGYPT  
2022

**REMEDIATION OF SOIL CONTAMINATION  
CAUSED BY BRICK INDUSTRY USING  
ELECTROKINETIC TECHNIQUE: A CASE  
STUDY OF A BRICK FACTORY IN  
AL-NAHRAWAN AREA IN IRAQ**

By

**Sarah Duraid Ahmed Zangana**

A Thesis Submitted to the  
Faculty of Engineering at Cairo University  
in Partial Fulfillment of the  
Requirements for the Degree of  
**MASTER OF SCIENCE**  
in  
**Civil Engineering – Public Works**

Approved by the  
Examining Committee

---

**Prof. Dr. Mona M. Galal El-Din**

(Thesis Main Advisor)

---

**Dr. Safwat Mahmoud Safwat**

(Advisor)

---

**Dr. Minerva Edward Matta**

(Internal Examiner)

---

**Prof. Dr. Maha Mostafa El Shafei**

(External Examiner)

Professor of Sanitary & Environmental Engineering  
Housing and Building National Research Center

FACULTY OF ENGINEERING, CAIRO UNIVERSITY  
GIZA, EGYPT  
2022

**Engineer's Name:** Sarah Duraid Ahmed Zangana  
**Date of Birth:** 1 / 09 / 1988  
**Nationality:** Iraqi  
**E-mail:** [kanz\\_m2002@yahoo.com](mailto:kanz_m2002@yahoo.com)  
**Phone:** 001101618708  
**Address:** 21 Gamaa St. Giza, Egypt  
**Registration Date:** 01/03/2020  
**Awarding Date:** / /2022  
**Degree:** Master of Science  
**Department:** Civil Engineering – Public Works



**Supervisors:**

Prof. Dr. Mona M. Galal El-Din  
Dr. Safwat Mahmoud Safwat

**Examiners:**

Prof. Dr. Mona M. Galal El-Din	(Thesis Main Advisor)
Dr. Safwat Mahmoud Safwat	(Advisor)
Dr. Minerva Edward Matta	(Internal Examiner)
Prof. Dr. Maha Mostafa El Shafei	(External Examiner)
Professor of Sanitary & Environmental Engineering Housing and Building National Research Center	

**Title of Thesis:**

**Remediation of Soil Contamination Caused By Brick Industry Using Electrokinetic Technique: A Case Study of the Brick Factory In Al- Nahrawan Area In Iraq.**

**Key Words:**

Brick; Soil; Pollution; Electrokinetic; Heavy Metals.

**Summary:**

In this thesis, polluted soil with heavy metals (Pb, Cd, V, Ni, Cu, Zn, Cr) and S is being treated to remove the pollutants from it by the electrokinetic methods. The experimental setup consisted of electrodes placed in the soil and connected to electric power source. Twelve experiments were conducted. The following parameters were studied: the type of electrode, voltage, distance between the electrodes, and the use of electrolytes. The removal rates of heavy elements by electrokinetic method differed from one experiment to another, but they proved to be effective in removing pollutants from the soil. The electrokinetic process was found to be a successful process to reduce the concentration of soil contaminants including heavy metals (Pb, Cd, V, Ni, Cu, Zn, Cr) and S, when using stainless steel and graphite electrodes. The best electrode for removing Pb, Cd, Cr and S was found to be the graphite electrode, while the best electrode to remove V, Zn, Cu and Ni was stainless steel.

## **Disclaimer**

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Sarah Duraid Ahmed

Date:    /    / 2022

Signature:

## Dedication

To from the first drop of water I drank from his river

To from the first atom of air I inhaled from him

... My beloved country, **Iraq**

To my support, my hope and my life

... my **father** and **mother**

To whom do I draw my energy and strength

... my **sister** and my **brothers**

With my love...

**Sarah**

2022

## Acknowledgments

There is no doubt that the completion of this work would not be possible without the grace of Allah, then the help, support and motivation of many important people.

First, I would like to thank my thesis main advisor **Prof. Dr. Mona M. Galal El-Din**. When I ran into a trouble spot or had a question about my research or writing I asked her. She consistently allowed this thesis to be my ownwork, but steered me in the right direction whenever she thought I needed it. I am gratefully indebted to her and thankful for her valuable comments on this thesis.

I would like to express my sincere gratitude to **Dr. Safwat Mahmoud Safwat** for his help, support and inspiring discussions. I would also like to acknowledge him as the second reader of this thesis. I would like to thank him as he was involved in my experimental work for this thesis. Without his participation and advice, the thesis could not have been successfully conducted.

I must express my very profound gratitude to my sister **Dr. Suzan Duraid and Dr. Abbas Ali Saleh, Dr. Faris Al-Aany, Dr. Khalid Zaher, Yousef Ibrahim, Eng. Zainab Zamel and Eng. Saja Hashem** to providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them.

I would like to express my thanks to **Prof. Dr. Husam Alden Ahmed Abd Al Fatah** dean of the Faculty of Engineering at Cairo University without him, I would not have completed my studies. I am very grateful to him. Thank you

Finally, I dedicate my sincere thanks and gratitude to **Director General Consultant Engineer Essa Al-Fayad** who encouraged and supported me and made me walk the path of success until I achieved my dreams and ambitions to complete my studies. Thank you.

Thank You  
Sarah



# Table of Contents

<b>Disclaimer.....</b>	<b>i</b>
<b>Dedication.....</b>	<b>ii</b>
<b>Acknowledgments.....</b>	<b>iii</b>
<b>Table of Contents.....</b>	<b>iv</b>
<b>List of Tables.....</b>	<b>vii</b>
<b>List of Figures.....</b>	<b>viii</b>
<b>Nomenclature.....</b>	<b>x</b>
<b>Abstract.....</b>	<b>xii</b>
<b>Chapter 1: Introduction.....</b>	<b>1</b>
1.1 Introduction.....	1
1.2 Problem Statement.....	2
1.3 Objectives.....	2
1.4 Thesis Organization.....	3
<b>Chapter 2: Literature Review.....</b>	<b>4</b>
2.1. Soil Quality.....	4
2.1.1. Introduction.....	4
2.1.2. Soil contamination by heavy metals.....	4
2.1.3. Soil Contamination with Heavy Metals.....	5
2.1.3.1. Lead.....	5
2.1.3.2. Cadmium.....	6
2.1.3.3. Vanadium.....	6
2.1.3.4. Chromium.....	7
2.1.3.5. Other Heavy Metals.....	8
2.1.3.5.1 Mercury.....	8
2.1.3.5.2 Copper .....	8
2.1.3.5.3 Nickel.....	9
2.1.3.5.4 Zinc.....	9
2.1.3.6. Sulfur.....	10
2.1.4. Technologies Utilized for Soil Remediation.....	10
2.1.4.1 Phytoremediation.....	11
2.1.4.2 Isolation and Containment.....	11
2.1.4.3 Bioremediation.....	11
2.1.4.4 Soil Flushing.....	11
2.1.4.5 Soil Washing.....	11
2.1.4.6 Electrokinetic.....	12
2.2. Electrokinetic Remediation.....	12
2.2.1. Introduction.....	12
2.2.2. Effects of Potential Difference in electrokinetic remediation .....	13
2.2.3. Effect of electrodes on electrokinetic remediation.....	15
2.2.3.1. The electrode materials.....	15

2.2.3.2. Electrode configuration.....	16
2.2.3.3. Spacing between electrodes.....	17
2.2.4. Effects of electrolyte on electrokinetic remediation.....	17
2.2.5. Effects of ion exchange membrane on electrokinetic remediation.....	19
2.2.6. Overview of Previous Studies about Electrokinetic Remediation.....	19
2.2.6.1. Applications of Graphite and Stainless Steel in Electrokinetic Remediation.....	19
2.2.6.2. Heavy Metals removal using Electrokinetic Remediation.....	20
2.2.6.3. Other pollutants removal using Electrokinetic Remediation.....	21
2.3. Pollution Due to Brick Industries in Iraq.....	22
2.3.1. Introduction about Brick Industries.....	22
2.3.2. Characteristic of Polluted Soil due to Brick Industries .....	22
2.3.3. Characteristics of Polluted Air due to Brick Industries.....	22
2.3.4. Characteristics of Polluted Water due to Brick Industries.....	23
2.3.5. Ways to Reduce and Prevent Soil Pollution due to Brick Industries.....	23
2.3.5.1. Cleaner Production.....	23
2.3.5.2. Treatment of Polluted Soil.....	24
2.3.6. Case Study of the Brick Factory in Al- Nahrawan Area in Iraq.....	25
2.3.6.1. Description of Brick Factory in Al- Nahrawan Area.....	26
2.3.6.2. Environmental pollution caused by the brick factory in Al-Nahrawan...	28
<b>Chapter 3: Methodology of experimental work.....</b>	<b>30</b>
3.1. General Introduction.....	30
3.2. The Field Work: - Study Area.....	30
3.3. Geographic Location of Al-Nahrawan.....	30
3.4. Topography & Geomorphology of the study Area.....	31
3.5. The groundwater.....	31
3.6. Climate of the study area.....	31
3.6.1 Temperature.....	31
3.6.2 Rainfall.....	32
3.6.3 Relative humidity.....	32
3.7. Field Measurement of Soil Pollutants.....	33
3.8. Field Measurement of Air Pollutants.....	34
3.9. The Equipment used in Field.....	39
3.10. Soil Samples.....	39
3.11. Electrokinetic Tests.....	42
3.11.1 Reactor Setup.....	42
3.12 .Sampling.....	46
<b>Chapter 4: Results and Discussion.....</b>	<b>48</b>
4.1. Introduction.....	48
4.2. Performance of EK without electrolyte using stainless steel (St.) electrode.	48
4.2.1. Performance of stainless steel electrode in removal Pb at different V/S (v/cm).....	48

4.2.2. performance of stainless steel electrode in removal Cd at different V/S (v/cm).....	49
4.2.3. performance of stainless steel electrode in removal V at different V/S (v/cm).....	50
4.2.4. performance of stainless steel electrode in removal S at different V/S (v/cm).....	51
4.2.5. performance of stainless steel electrode in removal Zn, Cr, Ni and Cu at different V/S (v/cm).....	52
4.2.6. Variation of pH when using stainless steel electrode and without electrolyte.....	54
4.2.7. Variation of Electrical Conductivity when using stainless steel electrode and without electrolyte.....	55
4.3. Performance of EK without electrolyte using graphite (Gr) electrode.....	56
4.3.1. performance of graphite electrode in removal Pb at different V/S (v/cm).....	56
4.3.2. performance of graphite electrode in removal Cd at different V/S (v/cm).....	57
4.3.3. performance of graphite electrode in removal V at different V/S (v/cm).....	58
4.3.4. performance of graphite electrode in removal S at different V/S (v/cm).....	59
4.3.5. Performance of graphite electrode in removal Zn, Cr, Ni and Cu at different V/S (v/cm).....	60
4.3.6. Variation of pH when using graphite electrode and without electrolyte....	62
4.3.7. Variation of Electrical Conductivity when using graphite electrode and without electrolyte.....	63
4.4. Performance of EK with electrolyte using stainless steel electrode.....	64
4.4.1. Performance of stainless steel electrode in removal Pb, Cd, V and S at V/S= 5 v/cm.....	64
4.4.2. Performance of stainless steel electrode in removal Zn, Cr, Ni and Cu at V/S= 5 v/cm.....	65
4.5. Performance of EK with electrolyte using graphite electrode.....	66
4.5.1. Performance of graphite electrode in removal Pb, Cd, V and S at V/S= 3.75 v/cm .....	66
4.5.2. Performance of graphite electrode in removal Zn, Cr, Ni and Cu at V/S =3.75 v/cm.....	67
4.6. Comparison between different experiment.....	68
4.7. Morphology of electrodes used in electrokinetic treatment.....	70
4.7.1. SEM Stainless steel electrode in EK process.....	70
4.7.2 SEM of Graphite electrodes in EK process.....	71
4.8. Cost Analysis .....	72
4.9. Comparison with other research results.....	74
<b>Chapter 5: Conclusion and Recommendations.....</b>	<b>75</b>
5.1 Conclusion.....	75
5.2. Recommendations for future research.....	76
<b>References.....</b>	<b>77</b>

## List of Tables

Table 2.1. Vanadium-exposed workers' symptoms ( $V_2O_5$ ).....	7
Table 3.1. Concentration for the average of the soil samples from Al-Nahrawan / compound bricks factories in ppm.....	33
Table 3.2. Concentration results for the least polluted soil from Al-Nahrawan area in ppm.....	33
Table 3.3. Local and global standard of some air pollutants.....	36
Table 3.4. Concentrations of TSP &PM in the studied area for September-2020 ( $\mu g/m^3$ ).....	36
Table 3.5. Concentrations of TSP&PM in the studied area for December-2020 ( $\mu g/m^3$ ).....	36
Table 3.6. Concentrations of TSP&PM in the studied area for March-2021 ( $\mu g/m^3$ ).....	37
Table 3.7. Concentrations of TSP&PM in the studied area for June-2021 ( $\mu g/m^3$ ).....	37
Table 3.8. Gases concentrations measurements in the sites of studied area (ppm) in September period 2020.....	37
Table 3.9. Gases concentrations measurements in the sites of studied area (ppm) in December period 2020.....	38
Table 3.10. Gases concentrations measurements in the sites of studied area (ppm) in March period 2021.....	38
Table 3.11. Gases concentrations measurements in the sites of studied area (ppm) in June period 2021.....	38
Table 3.12. Figure of the equipment (devices) used in field.....	39
Table 3.13. Soil characteristics before the tretment.....	42
Table 3.14. Tools and materials utilized in the experiment.....	42
Table 3.15. Variable parameters for EC experiments.....	45
Table 4.1. Comparison between different operating conditions.....	68
Table 4.2. Energy Consumption Cost During Electrokinetic Remediation.....	73
Table 4.3. Comparison with other paper and research results.....	74

## List of Figures

Fig. 1.1. Al-Nahrawan industry region with the brick factories.....	2
Fig. 2.1: Schematic Clay Brick Production Process Flow.....	28
Fig. 2.2 :Flow chart of the steps of the production process of making bricks with the pollutants coming out of each step resulting residue.....	29
Fig. 3.1. Location of Al-Nahrawan in Baghdad Governorate.....	30
Fig. 3.2. Maximum and minimum annual rates of air temperature respectively in Baghdad city during the period 2016-2020.....	31
Fig. 3.3. Average annual rates for rainfall in Baghdad during the period (2016-2020).....	32
Fig. 3.4. Average annual rates for maximum and minimum RH in Baghdad during the period 2016-2020.....	32
Fig. 3.5. Spot7 Satellite image (with resolution 1.5m) in 26/4/2021 of Al-Nahrawan show the Location Sample.....	35
Fig. 3.6. NITON XL31 device (XRF), Thermo scientific 900 heavy metals analyzer, US-made .....	39
Fig. 3.7. Gasmet-DX4040 FTIR Gas Analyzer Version E2.04 .....	39
Fig. 3.8. AEROCET 531.....	39
Fig. 3.9 .pH meter (WTW series, inolab pH 720).....	40
Fig. 3.10. Conductivity meter (HANNA type- HI9811-5).....	40
Fig. 3.11 . Sensitive Balance (Mettler AE 166).....	40
Fig. 3.12. Flame atomic absorption (SHIMADZU, ASC-7000) (Heavy metal measurements	41
Fig. 3.13. UV( sulfate meter).....	41
Fig. 3.14. Scanning Electron Microscope (SEM) (Quanta FEG 250, FEI).....	41
Fig. 3.15. EC cell and how ions move a- with electrolytes and b- without electrolytes.....	44
Fig. 3.16. Sixteen EC experiments with different conditions.....	44
Fig. 3.17. EK Cell Setup without electrolyte chambers.....	45
Fig. 3.18. EK Cell Setup with electrolyte chambers.....	46
Fig. 4.1. The lead removal efficiency with different V/S ratio using EK with stainless steel electrodes and without electrolyte.....	49
Fig. 4.2. The cadmium removal efficiency with different V/S ratio using EK with stainless steel electrodes and without electrolyte.....	50
Fig. 4.3. The vanadium removal efficiency with different V/S ratio using EK with stainless steel electrodes and without electrolyte.....	51
Fig. 4.4. The sulfur removal efficiency with different V/S ratio using EK with stainless steel electrodes and without electrolyte.....	52
Fig. 4.5. Zn, Cu, Ni, and Cr removal efficiency at V/S 1.25 v/cm using EK with stainless steel electrodes and without electrolyte.....	53
Fig. 4.6. Zn, Cu, Ni, and Cr removal efficiency at V/S 2.5 v/cm using EK with stainless steel electrodes and without electrolyte.....	53
Fig. 4.7. Zn, Cu, Ni, and Cr removal efficiency at V/S 3.75 v/cm using EK with stainless steel electrodes and without electrolyte.....	53
Fig. 4.8. Zn, Cu, Ni, and Cr removal efficiency at V/S 5 v/cm using EK with stainless steel electrodes and without electrolyte.....	54
Fig. 4.9. Zn, Cu, Ni, and Cr removal efficiency at V/S 6.25 v/cm using EK with stainless steel electrodes and without electrolyte.....	54
Fig. 4.10. Zn, Cu, Ni, and Cr removal efficiency at V/S 7.5 v/cm using EK with stainless steel electrodes and without electrolyte.....	54
Fig.4.11. pH value at the end of experiment at various V/S value using EK with stainless steel electrodes and without electrolyte.....	55
Fig.4.12. EC value at the end of experiment at various V/S value using EK with stainless	

steel electrodes and without electrolyte.....	56
Fig. 4.13. The lead removal efficiency with different V/S ratio using EK with graphite electrodes and without electrolyte.....	57
Fig. 4.14. The cadmium removal efficiency with different V/S ratio using EK with graphite electrodes and without electrolyte.....	58
Fig. 4.15. The vanadium removal efficiency with different V/S ratio using EK with graphite electrodes and without electrolyte.....	59
Fig. 4.16. The sulfur removal efficiency with different V/S ratio using EK with graphite electrodes and without electrolyte.....	60
Fig. 4.17. Zn, Cu, Ni, and Cr removal efficiency at V/S 1.25 v/cm using EK with graphite electrodes and without electrolyte.....	61
Fig. 4.18. Zn, Cu, Ni, and Cr removal efficiency at V/S 2.5 v/cm using EK with graphite electrodes and without electrolyte.....	61
Fig. 4.19. Zn, Cu, Ni, and Cr removal efficiency at V/S 3.75 v/cm using EK with graphite electrodes and without electrolyte.....	61
Fig. 4.20. Zn, Cu, Ni, and Cr removal efficiency at V/S 5 v/cm using EK with graphite electrodes and without electrolyte.....	62
Fig. 4.21. Zn, Cu, Ni, and Cr removal efficiency at V/S 6.25 v/cm using EK with graphite electrodes and without electrolyte.....	62
Fig. 4.22. Zn, Cu, Ni, and Cr removal efficiency at V/S 7.5 v/cm using EK with graphite electrodes and without electrolyte.....	62
Fig.4.23. pH value at the end of experiment at various V/S value using EK with graphite electrodes and without electrolyte.....	63
Fig.4.24. EC value at the end of experiment at various V/S value using EK with graphite electrodes and without electrolyte.....	64
Fig. 4.25. Pb, Cd, S, and V removal efficiency at V/S 5 v/cm no space between soil and electrode using EK with stainless steel electrodes and with electrolyte.....	65
Fig. 4.26. Pb, Cd, S, and V removal efficiency at V/S 5 v/cm space between soil and electrode = 1 cm using EK with stainless steel electrodes and with electrolyte...	65
Fig. 4.27. Zn, Cu, Ni, and Cr removal efficiency at V/S 5 v/cm no space between soil and electrode using EK with stainless steel electrodes and with electrolyte.....	66
Fig. 4.28. Zn, Cu, Ni, and Cr removal efficiency at V/S 5 v/cm space between soil and electrode = 1 cm using EK with stainless steel electrodes and with electrolyte...	66
Fig. 4.29. Pb, Cd, S, and V removal efficiency at V/S 3.75 v/cm no space between soil and electrode using EK with graphite electrodes and with electrolyte.....	67
Fig. 4.30. Pb, Cd, S, and V removal efficiency at V/S 3.75 v/cm space between soil and electrode = 1 cm using EK with graphite electrodes and with electrolyte.....	67
Fig. 4.31. Zn, Cu, Ni, and Cr removal efficiency at V/S 5 v/cm no space between soil and electrode using EK with graphite electrodes and with electrolyte.....	68
Fig.4.32. Zn, Cu, Ni, and Cr removal efficiency at V/S 5 v/cm space between soil and electrode = 1 cm using EK with graphite electrodes and with electrolyte.....	68
Fig.4.33. Comparison between different experiments.....	69
Fig.4.34. Scanning electron microscopy (SEM) micrograph of St. electrode (anode) before and after used in EK.....	71
Fig.4.35. Scanning electron microscopy (SEM) micrograph of St. electrode (cathode) before and after used in EK.....	71
Fig.4.36. Scanning electron microscopy (SEM) micrograph of Gr. electrode (cathode) before and after used in EK.....	72
Fig.4.37. Scanning electron microscopy (SEM) micrograph of Gr. electrode (anode) before and after used in EK.....	72

# Nomenclature

Abb.	INTERPRETATION
As	Arsenic
AC	Alternating current
BS	Body mill sludge
Cd	Cadmium
Cu	Copper
Cr	Chromium
CO	Carbon monoxide
CO <sub>2</sub>	Carbon dioxide
DBS	Dry bed sewage sludge
DOC	Dissolved organic carbon
DC	Direct current
EC	Electrical conductivity
EDTA	Ethylene diamine tetra acetic acid
EKPR	Electrokinetic assisted phytoremediation
EKR	Electrokinetic remediation
ECC	Energy consumption cost
EEP	Electric energy price
Gr	Graphite
Hg	Mercury
HA	Humic acid
H	High
H <sub>2</sub> S	Hydrogen sulfide
Ir	Iridium
i	Current density
KW	Kilo Watt
LCA	Life cycle analysis
LBS	Lead bearers sewage sludge
MCBP	Milted clay brick powder
mA	Milli amber
Ni	Nickel
NA	Natural attenuation
NO <sub>2</sub>	Nitrogen dioxide
Pb	Lead
PS	Polishing sludge
pH	Negative logarithm of hydrogen ion concentration
ppm	parts per million
PM	Particulate Matter (contain a proportionately larger amount of water and acid forming chemicals such as sulphate and nitrate and carbon material) [67].
PM <sub>10</sub>	Particulate Matter with size 10 µm
PM <sub>25</sub>	Particulate Matter with size 25 µm
PHC	Polycyclic hydrocarbons
RHA	Rice husk ash
RH	Relative humidity