IMPACT OF BRICK KILN OPERATION TO THE DEGRADATION OF SOIL QUALITY OF AGRICULTURAL LAND

KAMRUL HASAN

DEPARTMENT OFAGROFORESTRY AND ENVIRONMENTAL SCIENCE

SHER-E-BANGLA AGRICULTURAL UNIVERSITY,

DHAKA-1207

JUNE, 2018

IMPACT OF BRICK KILN OPERATION TO THE DEGRADATION OF SOIL QUALITY OF AGRICULTURAL LAND

BY

KAMRUL HASAN

REGISTRATION NO. 11-04274

A Thesis
Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE
IN
AGROFORESTRY AND ENVIRONMENTAL SCIENCE

SEMESTER: JANUARY -JUNE, 2018

Approved by:

Dr. Nazmun Naher	**Abdul Halim**
Professor	Assistant Professor
Supervisor	**Co-Supervisor**

Prof. Dr. Nazmun Naher
Chairman
Examination Committee

DEPARTMENT OF AGROFORESTRY AND ENVIRONMENTAL SCIENCE
Sher-e-Bangla Agricultural
University (SAU) Sher-e-
Bangla Nagar, Dhaka-1207

CERTIFICATE

*This is to certify that the thesis entitled “**IMPACT OF BRICK KILN OPERATION TO THE DEGRADATION OF SOIL QUALITY OF AGRICULTURAL LAND”** submitted to the **Faculty of Agriculture,** Sher-e-Bangla Agricultural University (SAU), Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGROFORESTRY AND ENVIRONMENTAL SCIENCE**, embodies the results of a piece of bona fide research work carried out by **KAMRUL HASAN, Registration no. 11-04274** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dr. Nazmun Naher
Professor
Supervisor

Dated: June, 2018
Dhaka, Bangladesh

DEDICATED TO

MY

BELOVED PARENTS

ACKNOWLEDGEMENTS

All the praises, gratitude and thanks are due to the omniscient, omnipresent and omnipotent ***Allah*** *who enabled me to pursue education in Agriculture discipline and to complete this thesis for the degree of Master of Science (MS) in Agroforestry and Environmental Science.*

I wish to express my sincere appreciation, profound gratitude and best regards to my supervisor and Chairman, ***Prof. Dr. Nazmun Naher****, Dept. of Agroforestry and Environmental Science, Sher-e-Bangla Agricultural University, Dhaka, for her guidance and supervision in carrying out the research work, continuous inspiration, constructive comments and encouragement during my research work and guidance in preparation of manuscript of the thesis. I am grateful to my co-supervisor* **Abdul Halim,** *Assistant Professor, Department of Agroforestry and Environmental Science,SAU. for his valuable advice, constructive criticism and factual comments in upgrading the research with all possible help during the research period and preparation of the thesis.*

I would like to express my deepest respect and boundless gratitude to my honorable teachers of the Department of Agroforestry and Environmental Science, Sher-e-Bangla Agricultural University, Dhaka, for their valuable teaching, sympathetic co-operation and inspirations throughout the course of this study and research work.

Here I also would like to acknowledge laboratory and field staffs for their active help during the research period.

I am indebted to my last but not least profound and grateful gratitude to my beloved parents, friends and all of my relatives for their inspiration, blessing and encouragement that opened the gate of my higher studies in my life.

The Author

June, 2018

SAU, Dhaka

IMPACT OF BRICK KILN OPERATION TO THE DEGRADATION OF SOIL QUALITY OF AGRICULTURAL LAND

ABSTRACT

Brick kiln is a big environmental issue in terms of agricultural production. The soil of brick kiln less productive compare to soil far from brick kiln. The aim of the study is to assess the impact of brick kiln operation for soil quality degradation in different area of Kurigram. The study was conducted with 24 soil samples collected from six brick kiln and adjacent agricultural field at Kurigram district. The study reveals that brick kiln industrial activity affected the soil characteristics and degraded soil quality. The results indicated that burning of soils significantly decreased the average pH values of soils both in surface and subsurface soil. The Organic matter content of the samples recorded from 0.250 to 0.920 in the burnt soil and from 0.290 to 1.055 in the unburnt soil for surface soil and for subsurface soil 0.210 to 0.740 and 0.206 to 0.705 in burnt and unburnt soil respectively. The total N content in the surface soil ranged from 0.023 to 0.100% and 0.029 to 0.123% in the burnt and unburnt soil, respectively. In case of subsurface soil, the nitrogen content in burnt and unburnt soil ranged from 0.020% to 0.068% and 0.023% to 0.073% respectively. The available P content of the samples in surface soil were within the range of 9.85 to 10.10 ppm in the burnt soil and of 17.40 to 21.90 ppm in the unburnt soil. In subsurface soil the range were from 8.60 to 13.10 for burnt soil and from 11.00 to 19.00 ppm for unburnt soil. The level of exchangeable potassium content in burnt soil ranged from 0.092 to 0.363 meq100g^{-1} in surface soil and 0.083 to 0.113 meq100g^{-1} in subsurface soil. In case of unburnt soil near the brick field the range is from 0.190 to 0.518 meq100g^{-1} in the surface soil and from 0.102 to 0.412 meq100g^{-1} in subsurface soil. The EC of burnt soil were ranged from 9.8 to 32.2 dsm^{-1} for surface soil and from 5.3 to 13.2 dsm^{-1} for subsurface soil. For the unburnt soil near brick field were from 13.4 to 36.1 dsm^{-1} for surface soil and from 8.5 to 24.6 dsm^{-1} for subsurface soil. All the chemical properties of soil decreased in burnt soil of brick kiln than the unburnt agricultural field. The chemical properties also decreased with increasing depth. The study reaves that brick burning near agricultural field is detrimental for soil fertility. The burning of enormous C, N and S not only degrade the agricultural soils but also contributing to the changes in the global climate.

LIST OF CONTENTS

CHAPTER	TITLE	PAGE NO.
	ACKNOWLEDGEMENTS	i
	ABSTRACT	ii
	LIST OF CONTENTS	iii
	LIST OF TABLES	v
	LIST OF FIGURES	vi
	LIST OF PLATES	Vii
	LIST OF ABBREVIATIONS AND ACRONYMS	viii
	LIST OF APPENDICES	ix
1	**INTRODUCTION**	**1-3**
2	**REVIEW OF LITERATURE**	**4-13**
2.1	Chemical properties and nutrient status of burnt and unburnt soil	4
2.2	Heavy metal concentration in soils	9
2.3	Environmental impact of Brick kiln operation	10
3	**MATERIALS AND METHODS**	**14-23**
3.1	Study area	14
3.1.1	Site Selection	14
3.1.2	Location	14
3.2	Abiotic characteristics	16
3.2.1	Climate	16
3.2.2	Characteristics of soil	17
3.3	Biotic characteristics	17
3.3.1	Characteristics of vegetation	17
3.4	Sampling Period	17

LIST OF CONTENTS (Contd.)

CHAPTER	TITLE	PAGE NO.
3.5	Sampling design	18
3.6	Sample Collection	18
3.7	Sample Preparation	21
3.8	Soil Sample Analysis	21
3.8.1	Textural class	21
3.8.2	Soil PH	21
3.8.3	Soil Organic matter (OM) content	22
3.8.4	Determination of Nitrogen (N) in soil sample	22
3.8.5	Determination of Phosphorus (P) in soil sample	22
3.8.6	Determination of Potassium (K) in soil sample	23
3.8.7	Electrical Conductivity (EC)	23
3.8.8	Zinc (Zn) and Cupper (Cu) determination	23
3.9	Statistical Analysis	23
4	**RESULTS AND DISCUSSION**	**24-41**
4.1	Soil pH	24
4.2	Organic matter (OM)	27
4.3	Nitrogen contents (N)	29
4.4	Phosphorus availability (P)	31
4.5	Exchangeable potassium (K)	33
4.6	Electrical conductivity (EC)	35
4.7	Available Copper (Cu)	37
4.8	Available Zinc (Zn)	39
5	**SUMMARY AND CONCLUSION**	**41-45**
6	**REFERENCES**	**46-50**
	APPENDIX	**51-54**

LIST OF TABLES

TABLE	TITLE	PAGE NO.
1	Name and location of brick field	16
2	OM values in the surface soil (0-15 cm) in different brick kiln in the experimental area	28
3	OM values in the surface soil (15-30 cm) in different brick kiln in the experimental area	28
4	N values in the surface soil (0-15 cm) in different brick kiln in the experimental area	30
5	N values in the surface soil (15-30 cm) in different brick kiln in the experimental area	30
6	Cu values in the subsurface soil (0-15 cm) in different brick kiln in the experimental area	38
7	Cu values in the subsurface soil (15-30 cm) in different brick kiln in the experimental area	38
8	Zn values in the subsurface soil (0-15 cm) in different brick kiln in the experimental area	40
9	Zn values in the subsurface soil (15-30 cm) in different brick kiln in the experimental area	40

LIST OF FIGURES

FIGURE	TITLE	PAGE NO.
1	A schematic map of study site and sample collation point in the Kurigram district in Bangladesh	15
2	pH values in the surface soil (0-15 cm) in different brick kiln in the experimental area	25
3	pH values in the surface soil (15-30 cm) in different brick kiln in the area	26
4	P values in the surface soil (0-15 cm) in different brick kiln in the experimental area	32
5	P values in the surface soil (15-30 cm) in different brick kiln in the experimental area	32
6	K values in the surface soil (0-15 cm) in different brick kiln in the experimental area	34
7	K values in the surface soil (15-30 cm) in different brick kiln in the experimental area	34
8	EC values in the surface soil (0-15 cm) in different brick kiln in the experimental area	36
9	EC values in the surface soil (15-30 cm) in different brick kiln in the experimental area	36

LIST OF PLATES

PLATE	TITLE	PAGE NO.
1	Plate a, b, c, d showing the overview of a brick field and soil collection from the brick kiln and adjacent field	19
2	Plate e, f, g, h showing soil collection in unburnt agricultural field near the brick kiln	20

LIST OF APPENDICES

APPENDIX	TITLE	PAGE NO.
I	pH values in the surface soil (0-15 cm) in different brick kiln in the experimental area	51
II	pH values in the surface soil (15-30 cm) in different brick kiln in the experimental area	51
III	P values in the surface soil (0-15 cm) in different brick kiln in the experimental area	52
IV	P values in the surface soil (15-30 cm) in different brick kiln in the experimental area	52
V	K values in the surface soil (0-15 cm) in different brick kiln in the experimental area	53
VI	K values in the subsurface soil (15-30 cm) in different brick kiln in the experimental area	53
VII	EC values in the surface soil (0-15 cm) in different brick kiln in the experimental area	54
VIII	EC values in the subsurface soil (15-30 cm) in different brick kiln in the experimental area	54

LIST OF ABBREVIATION AND ACRONYMS

AEZ	Agro-Ecological Zone
OM	Organic matter
Burnt soil	Soil collected from the brick kiln
Unburnt soil	Soil collected from the agricultural field far from brick kiln
EC	Electrical conductivity
pH	Potential of Hydrogen
N	Nitrogen
P	Phosphorus
K	Potassium
ha	Hector
µ	Average
cm	Centimeter
m	meter
%	Percent
^0C	Degree Celsius
FAO	Food and Agriculture Organization
PM	Parts Per Million

CHAPTER I

INTRODUCTION

Urbanization and industrialization in developing countries has created a demand for construction activities, which resulted in the fast growth of the brick-making industry. The brick industry is considered a small/cottage industry and there is only seasonal employment opportunity despite an enormous amount of investment (GEFONT, 2007). In conjunction with the urbanization, brick industries are rapidly increasing and migrations of people into the city areas pressurize to produce more brick. As a result, more and more brick kilns are being built. Bricks are the most important building material in housing development and are used as basic construction material in vogue of urbanization. The removal of topsoil for urban uses mainly for brick-making is growing rapidly due to the tremendous growth in urbanization and industrialization in many developing countries. Unfortunately, brick kilns are mostly situated on fertile agricultural land, as brick manufacturers need silty clay loam to silty clay soils with good drainage conditions (Mukherjee *et al.*, 2013). Bangladesh's population growth and increasing affluence have contributed to increased construction and demand for building materials. Though bricks are the main construction material in Bangladesh, their production, mostly in the form of widely dispersed single small kilns, contribute substantially to poor air quality and poor community health (Brunekreef and Holgate, 2002; Cohen *et al.,* 2005; Guttikunda *et al*., 2013; Ostro, 2004 and Pope *et al.,* 2002). During the dry season when they operate (normally November to April) contribute an estimated 40% of the 2.5 micron particulate matter ($PM_{2.5}$) in the air in Dhaka and throughout Bangladesh (Guttikunda *et al*., 2013 and Hossain *et al.,* 2007). Statistical modeling suggests that the air pollution generated by brick kilns results in between 530 and 5000 premature adult deaths annually in Dhaka alone (Croitoru and Sarraf, 2012 and Guttikunda and Khaliquzzaman, 2014).

In addition to air quality problems, brick production impacts agricultural production by utilizing fertile topsoil from agricultural lands (Brunel *et al.,* 2011 and Kathuria and Balasubramanian, 2013) and releasing toxins, including heavy metals, that influence agricultural productivity (Skinder *et al*., 2014) and threaten food security (Lal, 2013).

Topsoil, the upper surface of the earth's crust, is a naturally deposited material that mixes rich humus with minerals and composted material. It is one of the earth's most vital resources, because it contains all the essential chemical, physical and biological components for growing plants (Tucker *et al.*, 1995 and Rai *et al.*, 2009). It represents a delicate nutritional balance that provides food for many of the animals on earth, either directly in the form of plant material or indirectly in the form of products from animals that eat plants (Rai *et al.*, 2009). But topsoil degradation and environmental pollution are the most serious problems in the world today as a result of natural or anthropogenic factors, because of their adverse effects on agriculture and the life on earth (Eswaran *et al.,* 1999 and Khan *et al.,* 2007).

Brick burning is one of the principal agents of topsoil degradation (Rahman and Khan, 2001). The brick kiln operation over the years covers not only the neighboring area of vegetation with layers of brick dust, but also consistently dissipates heat all around. It alters the physicochemical properties and habitats of nearby soil by destroying the topsoil nutrient elements (macronutrients such as C, H, O, N, P, K, Ca, Mg and S, and micronutrients such as B, Cu, Fe, Mn, Mo and Zn) and soil biota (Gupta and Narayan, 2010 and Imtiaz *et al.*, 2010). Moreover, emission of gaseous pollutants and ash significantly affect the human health and vegetation (Gupta and Narayan, 2010). Brick kilns also have adverse effects on biodiversity and biogeo-chemical cycling (Khan *et al.,* 2007).

Brick kilns are destroying large area of land every year especially in Bangladesh where bricks are made by collecting topsoil from agricultural land. It increased into 5000 ha during the 1998 to 1999 period in different pockets of brick fields (Rahman and Khan, 2001). These affected areas are expanding rapidly due to the increase in brick production (IUSS, 2002). There are about 6,000 brick manufacturers in Bangladesh which produce about 18 billion pieces of brick a year. Many of them do not have proper license and the local government authorities do not have necessary resources to keep track of the fields (Rahman, 2012). The urbanization and the demand of brick manufacturing have resulted in change of the land used pattern from the good agricultural land turned into agriculturally unproductive lands around several growing cities of the developing world (Kathuria, 2007). Indigenous soil knowledge, concerns about environmental quality, wisdom and economic uses of soils are, therefore, very essential for long-term protection of soil resources (Warkentin, 2002 and Ekosse *et al.,* 2006). The objective of the study was, especially on soil nutrient status of agricultural land around the brick field area.

Objectives

1. To determine the different chemical properties of the sample soil and
2. To ascertain and examine the land quality degradation through brick field in the study area.

CHAPTER II

REVIEW OF LITERATURE

2.1 Chemical properties and nutrient status of burnt and unburnt soil

Bisht *et al.* (2015) reported that quality of soil in terms of heavy metal content and nutrient content was directly proportional to the distance from the kiln; that is, the quality of soil increased with increasing distance. The study was carried out by determining the physicochemical characteristics of soil, soil fertility, and heavy metal contamination of soil. During the entire study period in Nepal, water absorptivity of soil ranged from 2.4 to 3.3 mg/L, pH varies from 5.885 to 7.64, and organic carbon content and organic matter varied from 0.277 to 0.93%, from 0.477% to 1.603%, respectively. Nutrient content, that is, sulfate and nitrate concentration, in the soil ranged from 0.829 to 3.764 mol/L and from 0.984 to 29.99 mol/L, respectively. The concentrations of heavy metals (chromium and lead) were within permissible limit, although the levels were higher in soil at 50 m and decrease farther from brick kiln. However, the physical parameters and nutrient content were deficient in soil at 50 m while increasing gradually at distances of 100 m and 150 m.

Brick burning alters the physicochemical properties and habitats of nearby soil by destroying the topsoil nutrient elements (macronutrients such as C, H, O, N, P, K, Ca, Mg and S, and micronutrients such as B, Cu, Fe, Mn, Mo and Zn) and soil biota (Gupta and Narayan, 2010 and Imtiaz *et al.*, 2010).

The brick-kilns are mostly situated on fertile agricultural land and moreover the process of digging soil from agricultural field for Brick industry is frequently accompanied by severe soil erosion, and destruction of mixed vegetation cover and grazing lands. Further transportation of raw materials for brick industry that is soil leads to environmental pollution by mixing of dust particles in the atmosphere along with CO_2 accumulation during burning of fresh bricks was stated by Jerin *et al.* 2017.

Biswas *et al.* (2018) revealed that 40–80% reduction in crop production and 40–70% reduction in income due to soil removal. The loss of the soil reduces agricultural yields leading to both short-term and longer-term impacts on crop production that influence the country's food security. Soil degradation is an important threat to sustainable agriculture. In Bangladesh, brick production contributes to soil loss as the country relies on clay-rich soil for brick making. An in-depth understanding of why farmers sell soil and the corresponding impacts on agricultural productivity is critical for developing and implementing new policies for utilizing alternate materials and methods in Bangladesh and other areas that continue to rely on fired clay bricks as their primary building material. A team of anthropologists conducted 120 structured interviews and 20 in-depth interviews in two different geographical areas in Bangladesh to understand the incentives for and impacts of selling soil. The primary reason farmers sold soil was pressure from neighboring farmers who had previously sold soil. Once neighboring property owners had sold soil, then farmers felt they needed to sell their soil to level their land with the neighboring plot to avoid future production loss. Short-term monetary gain from selling soil was also a strong motivator helping farmers manage acute financial crises. In addition, farmers are frequently compelled to sell soil for brick making because of coercive practices by brick-owners and their soil brokers.

A study was conducted to evaluate the changes in soil properties due to the impacts of brick kiln in the vicinity of the Kirtonkhola River, Barisal. During the entire study period, moisture content of soil ranged from 18.77% to 56.49%; bulk density and particle density varies from 0.23 - 0.53 g/cm3 and 1.11 - 3.15 g/cm3 , respectively; soil porosity varies from 60.36% to 88.14%; pH varies from 6.98 to 8.85 and organic carbon content varies from 0.22% to 1.4%.The pH of the soil decreased with increasing distance from the kiln; moisture content and organic carbon increased with distance; particle density was more or less in ideal condition for plant growth but bulk density and porosity indicates poor soil structure which is unfavorable for plant (Rajonee *et al.,* 2018).

The agricultural production in the soil close to the brick kiln was lesser than the same soil far from brick kiln. The Electrical Conductance (EC) was found almost double in the soil samples close to the brick field than the soil samples far from brick field. The organic matter content in the soil sample close to the brickfield was significantly lower than that of the far soil sample. The mean values of total N, available P and S were also significantly lower in the soil samples close to the brick kiln, 0.05%, 12.4, and 8.36 ppm respectively in the close soils, while 0.06%, 24.6, and 11.7 ppm respectively in the far soil. There were no significant changes observed in the other elements. The study was conducted to assess the impact of brick kiln operation to Bangladesh, during the period of July to December 2013 by Islam *et al.* (2017).

Kathuria (2007) stated that unfortunately, brick kilns are mostly situated on fertile agricultural land, as brick manufacturers need silty clay loam to silty clay soils with good drainage conditions. The urbanization and the demand of brick manufacturing have resulted in change of the land used pattern from the good agricultural land turned into agriculturally unproductive lands around several growing cities of the developing world

The agricultural production in the soil close to the brick kiln was lesser than the same soil far from brick kiln. The Electrical Conductance (EC) was found almost double in the soil samples close to the brick field than the soil samples far from brick field. The organic matter content in the soil sample close to the brickfield was significantly lower than that of the far soil sample. The mean values of total N, available P and S were also significantly lower in the soil samples close to the brick kiln, 0.05%, 12.4, and 8.36 ppm respectively in

the close soils, while 0.06%, 24.6, and 11.7 ppm respectively in the far soil. There were no significant changes observed in the other elements. These study was conducted at Singair of Kalihati upazila in Tangail, Bangladesh, during the period of July to December 2013 by Rahman *et al.* (2015).

Gupta *et al.* (2010) found that the working brick kiln site, which experienced exposure to industrial activity for short term, showed highest total plant biomass (349-812g m -2), and higher mean soil organic C (0.77%), total N (0.05%) and moisture content (2.75% in summer). In contrast, the abandoned brick kiln site, which witnessed long-term disturbance, had highest belowground biomass (179- 253g m -2) with relatively poor soil resources (mean soil organic C (0.20%), total N (0.05%)). Belowground biomass of plant communities significantly declined with increasing soil organic C and total N. Higher species diversity was found at sites with low as well as high plant biomass. Thus, this study revealed that long-term brick kiln industrial activity affected the soil characteristics, and concomitantly the structure of plant biomass (particularly the belowground), and species diversity. Brick kiln sites in an Indian dry tropical peri-urban region, differing in the period of exposure to industrial activity and distance from the brick baking center, were investigated seasonally for their impact on plant biomass (aboveground and belowground), diversity structure and soils. A total of 72 angiospermic plant species distributed over 25 families were recorded across different sites and seasons.

A study was conducted with the selected soil profile of burnt (soil around brick kilns) and unburnt (agricultural land) soils in the Dinajpur, Rangpur, Rajshahi, Khulna and Patuakhali districts to evaluate the effects of brick kilns on soil degradation and environmental pollution by Khan *et al.* (2007). They found that The pH values of the unburnt soils increased as a function of the soil depth for Rangpur, Khulna and Patuakhali, while decreased for the soil profiles in Dinajpur. Burning of soils significantly ($p<0.05$)

decreased the average pH values of soils by 0.4 pH units (7 % increase over average content = IOAC), but strikingly increased the average EC values from 0.26 to 1.77 mS/cm (592 % IOAC) and the effect was pronounced with the depth function. The average sand content of the soil profiles increased by 330%, while the silt and clay contents decreased by 49 and 40 %, respectively. The average losses arising from the burning of agricultural soils were amounted to 63% for organic matter, 56 to 86 % and 23 to 88 % for available and total N, P, K and S, respectively. This huge loss through the burning of 1 m deep soil profile, i.e. almost 3/4th of the deterioration of soil fertility is not only reducing the crop production but also polluting the associated environment and atmosphere. The burning of enormous C, N and S not only degrade the agricultural soils but also contributing to the changes in the global climate.

Das *et al.* (2015) stated that the land degradation scenario in terms of environmental cost of brick manufacturing is much higher than the economic returns readily available. The study has been undertaken to assess impact of brick making on the degradation of land in Khejuri where about 25- brick kilns and 23- tile fields have been developed during last 10-15 years along the adjacent location of Hijli River, Rasulpur River and tidal channels.

Jerin *et al.* (2016) surveyed with the questionnaire and found out Crop loss, decreased soil fertility and subsequent reductions in crop production. Trees around brickfields were dusted badly and water quality of nearby water bodies deteriorated because of emerged dust and ash from brickfields. Noticeable negative impacts on aquaculture were found. This study investigated environmental and socio-economic impacts of brickfields at Bagatipara Upazila of Natore district,

2.2 Heavy metal concentration in soils

The effect of brickworks emissions on heavy metal content of soil and plants around the brick kiln chimneys was studied in the year 2006 by Ismail *et al.* (2012). Two brick kilns (A and B) about 600 m away from Ring Road at Sufaid Dheri on southern side of Ring Road Peshawar were selected for this study. Cd and Cr concentration in plants for Brick kiln A and B respectively were (2.03 and 1.9, 5.76 and 3.5 mg kg-1). Concentration of heavy metals in soil (AB-DTPA extractable Cd, Cr for Brick kiln A and B respectively were (0.03 and 0.41, 0.10 and 0.08 mg kg-1). High load of dust with 23.8 to 46.0 g m-2 month-1 at 50 m distance indicated higher pollution near the brick kiln chimneys. Heavy metals in the dust samples showed that Cd and Cr are added into environment with a rate of 0.08 and 0.52 mg m -2 month-1, respectively at 50 m distance from brick kiln chimney.

Achakzai *et al*. (2017) studied heavy metals present in agricultural soil adjacent to functional Brick Kilns in Rawalpindi and found out that the concentrations of all studied metals were above the permissible limits especially at agriculture soil located adjacent to brick kilns. However, at few sites the concentrations were found below the permissible limits. The results of study showed that brick kilns have great potential of deteriorating the quality of environment so, it is recommended that the monitoring of soil and plants around brick kilns should be carried out on regular basis in order to develop control measures to prevent the impacts of heavy metals pollution.

2.3 Environmental impact of Brick kiln operation

Jerin *et al.* (2016) run a questionnaire survey at selected community members living at or near brick field areas with the aim to assess impacts of brick fields on air, water, soil, vegetation as well as socio-economic conditions. Trees around brickfields were dusted badly and water quality of nearby water bodies deteriorated because of emerged dust and ash from brickfields. Noticeable negative impacts on aquaculture were found. Except few, a majority of the respondents were suffering from various diseases like eye irritation, skin diseases, and respiratory problems. Despite creating work opportunities for local people, brick fields of the study area adversely affected the environment and social economy.

The oxidation of pyrite (FeS_2) takes place in a stepwise approach with an initial release of SO_2 around 450°C from brick making raw material with an additional increase in temperature and the subsequent emission of sulfates occurs as SO_2 (Banerjee *et al*., 1980 and Junge, 1992 and Sanders, 1995).

Skinder *et al*. (2014) said in their studies that Brick manufacturing is the fastest-growing industrial sector in many countries (like china, India, Bangladesh and Pakistan) and among the top three sectors, along with vehicle exhaust and resuspended road dust, contributing to the air pollution and health problems in Dhaka (Bangladesh). The total emissions from the brick manufacturing in the Greater Dhaka region, to produce 3.5 billion bricks per year has been estimated about 23,300 tons of particulate matter having aerodynamic diameter < 2.5 µm (PM2.5), 15,500 tons of sulfur dioxide (SO_2), 302,000 tons of carbon monoxide (CO), 6,000 tons of black carbon (BC) and 1.8 million tons of carbon dioxide (CO_2). Emission of individual air pollutant from brick kilns varied significantly during a firing batch (seven days) and between kilns. Average emission factors per 1,000 bricks were 6.35 to 12.3 kg of CO, 0.52 to 5.9 kg of SO_2 and 0.64 to 1.4 kg of particulate matter (PM). Presently sulphur dioxide (SO_2), oxides of nitrogen (NOx) and suspended particulate matter (SPM) are the main issue pertaining to air pollution problems in developing countries, where it contributes both to urban pollution and to regional acid depositions.

Skinder *et al*. (2014) studied and revealed that all the pollutants SOx, NOx , RSPM, NRSPM and SPM (sum of RSPM and NRSPM) were crossing the limits prescribed by National Ambient Air Quality Standards (NAAQS) during the operational phase of brick kilns. Further, the air quality index (AQI) was calculated and the study sites were categorized from severe to high pollution including residential areas which is of most concern in respect to health conditions of the local people. Inter correlations of SOx, NOx, RSPM, NRSPM and SPM showing very strong correlations ($p < 0.01$) with each other indicated that their sources are the same i.e. brick kilns. This is the first type of study that has been undertaken where mushrooming of brick kilns (more than 15 brick kilns just in 2 km diameter) is deteriorating the air quality. Although industrialization is very important for the development of a country, this is a bitter fact that it speeds up the process of environmental degradation as was observed at the Panzan village of district Budgam in Jammu and Kashmir state (India).

Monga *et al.* (2012) found that mean respirable dust exposure in firing section was the highest (19.51 mg/m3) while mean respirable dust exposure in mixing and molding section was the lowest (10.08 mg/m3). The objective of this cross-sectional study was to investigate the prevalence and determinants of respiratory symptoms and their association with occupational dust exposure among the brick kiln workers. Brick kiln workers are exposed to dust particles and are susceptible to multiple pulmonary complications. Problems like asthma, chronic obstructive pulmonary symptoms, and silicosis are more common among them. As brick kiln industry is an unorganized sector, so it was decided to evaluate the respiratory symptoms and lung capacities in these workers and compare them with controls.

Air pollution has local as well as global impacts. Both living and non-living organism are facing the adverse effect of pollution. Plant health is affected by air pollution because pollutants like fluorine, lead, and mercury damage the plants. Acid rain, fog formation, bio-diversity loss etc. are the negative impacts for air pollution in environment. Industrialization is the major reason for acid rain because industries emits sulphur dioxide and oxides of nitrogen, which combines with water vapour in the atmosphere and forms mild acids. When it comes to the earth as rain, we call it acid rain. It causes extensive damage to plant lives, buildings and contaminate of lakes and rivers (EPA, 2012).

Fog is another phenomenon whose effect can extend to nearby areas. Due to air pollution, ratio of fog formation is accelerating. This fog can damage normal transportation systems, reduce the growth of crops due to decrease of sunlight. Bio-diversity of different areas can degrade due to air pollution because all these chemical components are affects the organisms (WHO, 2011).

As we understand that brick kilns are one of the major sources for air pollution. So, as environmental rules, brick kilns should not be set up on arable lands and minimum three kilometers distance away from any housing area, reserve forest, and educational institution. However, no rule is maintaining for setup brick kilns. As a result brick kilns produces black smoke which ultimately move away the species which are involved pollination process. This ultimately declines the agricultural and farming production (Islam, 2012).

The effects of brick kilns have both long term and short-term impacts in the environment. In short term the vegetation process hampers, crops production decreases, plants fruits falls down etc. and long term impacts are ozone depletions, global warming, photochemical smog's, land fertility decreases, ground water level down etc. (Pokhrel and Lee, 2011).

For the brick production, top soil is removed from the land and it takes between 25 to 30 years for those lands to be fertile as earlier. The period can be longer if vast quantities of toxic wastes such as in the form of carbon monoxide and sulphur oxide will mix into the land. On average each kiln burn 350 tons of woods a year, so more kilns means having a devastating effect on the forests (Morley, 2012).

Brick kiln removes on an average of 1500 MT of soil per ropani (0.05 ha) per year. Burning soil decreases the soil pH making it acidic, increase sand and decrease the clay content. It has serious impacts on soil physical, biological, and chemical properties resulting sharp declination in soil fertility and productivity. Moreover, it removes organic matters and makes the soil incapable for crop cultivation. Local farmers have already experienced that, their visibility reduced for brick kilns pollution. For saving their life, they wanted to stop the brick kilns or adapt scientific technologies to the brick kilns to reduce pollution. 80% of them had strong view to adopt new technology as soon as possible for reduce pollution. Some of the respondents told us that, for the old pattern of brick kilns human were suffering more than modern brick kilns area. They also shared us that along with their health problem, they were facing less food production, shortage of ground water; all types of plants nearby brick kilns were in exhausted condition. So, it is clear from people perception that people living nearby brick kilns are suffering more and they feel the adverse effect of air pollution.

CHAPTER III

MATERIALS AND METHODS

3.1 Study area

3.1.1 Site Selection

The selection of the brick kilns was based on the production capacity and nearness to agricultural lands based on the fact that the study comprised of determination of contamination in cropped land.

3.1.2 Location

This study was conducted at Ulipur, Kurigram and Rajarhut upazila in Kurigram district, during the period from July, 2018 to November, 2018. The study area was situated at 25°23' and 26°14' north latitudes and in between 89°27' and 89°54' east longitudes at an altitude of 38 meter above the sea level (Bangladesh Population Census 2001). The population is 2,069,273 (2011 national population census). This district is surrounded by Cooch Behar district of India in the north, Gaibandha district of Bangladesh in the south, Assam state of India in the east and, Lalmonirhat and Rangpur districts of Bangladesh in the west. There are 11 upazilas and 72 unions and 1872 villages in Kurigram. The study was carried out to estimate the soil degradation at 6 different brick kiln.

Figure 1. A schematic map of study site and sample collation point in the Kurigram district in Bangladesh

Table 1: Name and Location of Brick field

Short Name	Full Name	Location
MMB	Md. Mollah Bricks	Ananda Bazar, Kurigram
SAB	Sahidul Abed Bricks	Ulipur, Kurigram
MJHB	Md. Jahidul Hasan Bricks	Kurigram
GMB	Golam Mostofa Bricks	Jatiner hut, Kurigram
MBU	Mollah Bricks Ulipur	Nazimkhan bazar, Rajar hut
SFU	Sobu Forhad Ulipur,	Ulipur, Kurigram

3.2 Abiotic characteristics

3.2.1 Climate

The climate in Bangladesh is typically tropical; mild winter (October to March); hot, humid summer (March to June); humid, warm rainy monsoon (June to October). Pleasant climate exist yearlong except some heavy rain during the rainy season (June–September) in Kurigram. Although there are some heavy rainfalls during the rainy season, water is usually flowing quickly to the middle to southern part of Bangladesh, as this district is quite higher (approx. 13 meter) than sea level. Summer is embedded with rainy season and quite hot (mostly 30–35 °C). As soon as the rainy season is over, winter comes. In winter (October–February) minimum temperature is not less than 2 °C and some days are foggy and sun cannot be seen until mid-day during that days. From March, weather is warm and spring comes followed by autumn and our traditional major rice Harvesting season until May. The climatic data were collected from secondary sources (http://www.myweather2.com).

3.2.2 Characteristics of soil

The soil of the experimental site is a medium high land belongs to the general soil type, Non-calcareous Alluvium under the Agro Ecological Zone (AEZ) 2, The Active Tista Floodplain. This region includes the active floodplains of Teesta, Dharla and Dudkumar rivers. It has complex patterns of low, generally smooth ridges, inter-ridge depressions, river channels and cut-off channels. The area has irregular patterns of grey stratified, sands and silts. They are moderately acidic throughout and parent alluvium is rich in minerals. Four general soil types occur in the region; of which, Non-calcareous Alluvium predominates. Organic matter content is low and CEC is medium. Soil fertility level, in general, is low to medium. There also have unstable char land throughout the district.

3.3 Biotic characteristics

3.3.1 Characteristics of vegetation

From the ancient time, Kurigram is a land of agriculture and produces rice, jute, wheat, tobacco, potato, vegetables etc. for driving the economy of the Kurigram district. During winter season the ground water level usually goes down, farmers use the Brahmaputra river water in irrigation to cultivate high yielding varieties of rice and other crops to keep economy sustainable. Several cold storages add value to the economy of this district by preserving agricultural produces during summer season.

3.4 Sampling Period

Soil samples were collected from the selected plot during the period from July, 2018 to November, 2017.

3.5 Sampling design

Approximately 30 cm deep pits were dug for burnt and unburnt natural soils at a distance of about 35-45 m from the brick kilns where the soil had usually been collected. From the agronomic point of view, the topsoil to a depth of 100 cm are very important in terms of nutrient dynamics and degradation of soil fertility. Accordingly, the soils in each profile were sampled and analyzed at intervals of 0 to a depth of 30 cm. The bulk samples obtained from each section were stored in the field moist conditions by putting the soil samples into polyethylene bags in an airtight box immediately prior to laboratory analysis.

3.6 Sample Collection

Twelve man-made profiles of burnt soil obtained by staking the soils in open air at the boundary or periphery of each brick kilns were studied. They consisted of remnants in the brickfields and had been subjected to heating at 400 to 1000 °C temperatures. The studied twelve unburnt soils profiles nearby the boundary of the above mentioned brick kilns consisted mostly soils in agricultural lands. The studies were carried out during the dry seasons of 2017 to 2018. A total of 24 samples were randomly collected from ten different points of the study area. Twelve samples were from area which was close to the brick kiln (named as burnt soil in the manuscript). Another Twelve samples were collected from far area of the brick kiln where, apparently no change in crop production was observed as said by the local farmers (named as unburnt soil in our all discussions). The samples were collected from the depth of 0-15 cm and 15-30 cm by auger from each point and mixed thoroughly to make composite sample. Samples were placed in sealed polythene bags and then transported to the laboratory for preparation and analysis.

(a)

(b)

(c)

(d)

Plate 1: Plate a, b, c, d showing the overview of a brick field and soil collection from the brick kiln and adjacent field

(e)

(f)

(g)

(h)

Plate 2: Plate e, f, g, h showing soil collection in unburnt agricultural field near the brick kiln

3.7 Sample Preparation

The composite samples were air dried and sieved through a 2 mm sieve and then 500 gm each sample were stored for chemical analysis. There were three replication for each sample.

3.8 Soil Sample Analysis

Collected soil samples were analyzed for both physical and chemical properties and the soil sample were analyzed using the standard techniques as follows:

3.8.1 Textural class

Mechanical analysis of soil samples was done by hydrometer method (Bouyoucos, 1926) and the textural class was determined by plotting the values for % sand, % silt and % clay to the Marshall's triangular co-ordinate following USDA system (Marshall, 1962)

3.8.2 Soil pH

The soil pH was determined by glass electrode pH meter at a soil: water ratio of 1:2.5 as described by Jackson (1985).

3.8.3 Soil Organic matter (OM) content

The organic carbon (OC) of the soil samples was determined by Walkley and Black's wet oxidation method as outlined by Jackson (1985). The (OM) content was calculated by multiplying the content of organic carbon by Van Bemmelen's factor 1.73 (Piper, 1950).

3.8.4 Determination of Nitrogen (N) in soil sample

Total N in the soil was determined by semi-micro Kjeldahl method by digesting soil sample with concentrated H_2SO_4 and catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Se = 10:1:0.1). The N in the digest was estimated by distillation with 40% NaOH followed by titration of the distillate trapped in boric acid with 0.01N H_2SO_4 (Page *et al.*, 1982).

3.8.5 Determination of Phosphorus (P) in soil sample

Available P was extracted by Olsen's method $SnCl_2$ as reducing agent. The extract was estimated colorimetrically following the blue color method and was analyzed by a spectrophotometer at 660 nm wavelength (Black *et al.*, 1965)

3.8.6 Determination of potassium (K)

Extracted by neutral ammonium acetate and determined directly by flame photometer (Black, 1965) at the wave length of 766.5 to 769.5 nm.

3.8.7 Electrical Conductivity (EC)

The EC was measured by digital EC meter, HM digital meter (Model 831E) in 1:5 of soil water suspension (Biswas and Mukherjee, 1987).

3.8.8 Zinc (Zn) and Cupper (Cu) determination

The Zn and Cu were measured with the help of Atomic Absorption Spectrophotometer (AAS) followed the procedure of McLaren *et al.* (1984).

3.9 Statistical Analysis

After laboratory analysis of the samples, data were analyzed using Statistical Package for Social Sciences (SPSS 14.0) and Microsoft office *excel* 2010.

CHAPTER IV

RESULTS AND DISCUSSION

The results of the status of different physical and chemical component of soil collected from different areas of Kurigram district have been discussed in the following headlines in this chapter. Soil pH, OM (organic matter), available nitrogen, phosphorus, potassium, EC (electrical conductivity) etc. were studied. The following headlines are the results and discussion:

4.1 Soil pH

The pH values of the samples of surface soil (0-15 cm) ranged from 5.10 to 5.53 in the burnt soils and from 5.57 to 5.97 in the unburnt soils (Figure 2). All kinds of crops are grown well in the range of 5.6-7.3, because all types of essential nutrients are available in this range (SRDI, 2009). The study found that the unburnt soil pH is suitable for crop cultivation. The brick kiln operation decreases the pH of surrounding soil (Khan *et al*., 2007), the study found the comparatively lesser burnt soil pH than the unburnt soil in the surface soil. The pH in 15-30 cm depth ranged from 4.19 to 5.35 in the burnt soil near brick kiln and 4.59 to 5.79 in unburnt soil near agricultural field.

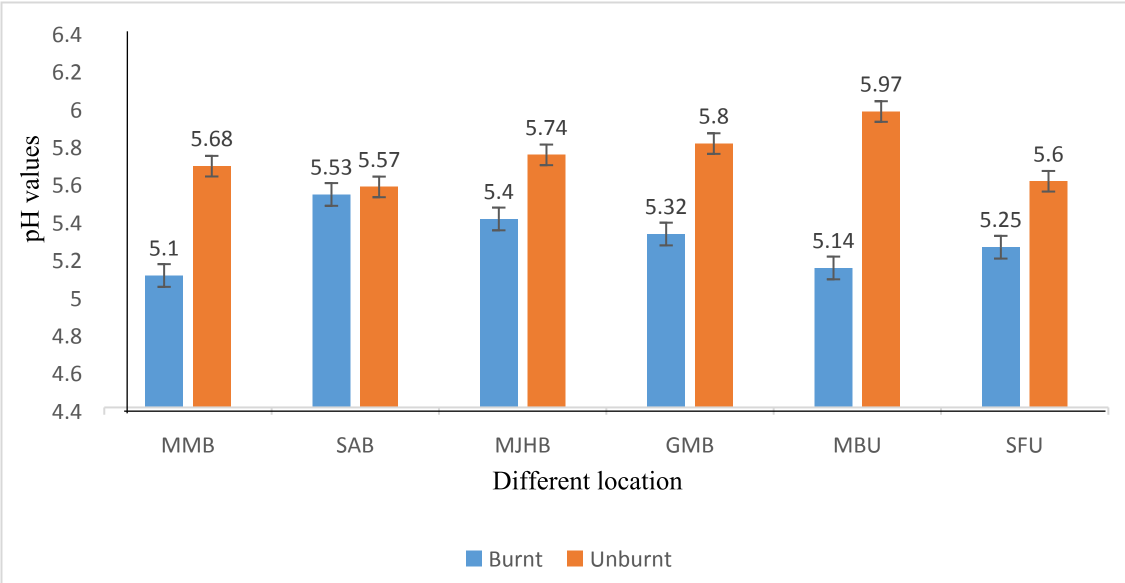

Figure 2. pH values in the surface soil (0-15 cm) in different brick kiln in the experimental area (MMB- Md. Mollah Bricks, SAB- Sahidul Abed Bricks, MJHB- Md. Jahidul Hasan Bricks, GMB- Golam Mostofa Bricks, MBU- Mollah Bricks Ulipur, SFU- Sobu Forhad Ulipur; Burnt-Brick kiln soil and Unburnt-Agricultural field soil; SD for burnt- 0.16 and unburnt-0.14)

The pH values in the profiles of the unburnt and burnt soils decreased with increasing depths. The highest pH values marked at SAB for the burnt where for unburnt the highest was marked at SAF brick field. The average pH values for surface soil was 5.29 and 5.73 in burnt and unburnt soil respectively. For the subsurface soil 4.75 and 5.03 for burnt and unburnt soil respectively. Standard deviation (SD) of surface soil was 0.16 and 0.14 for burnt and unburnt soil respectively. For the subsurface soil the SD values was 0.50 and 0.45 in burnt and unburnt soil respectively. pH of the study location marked acidic.

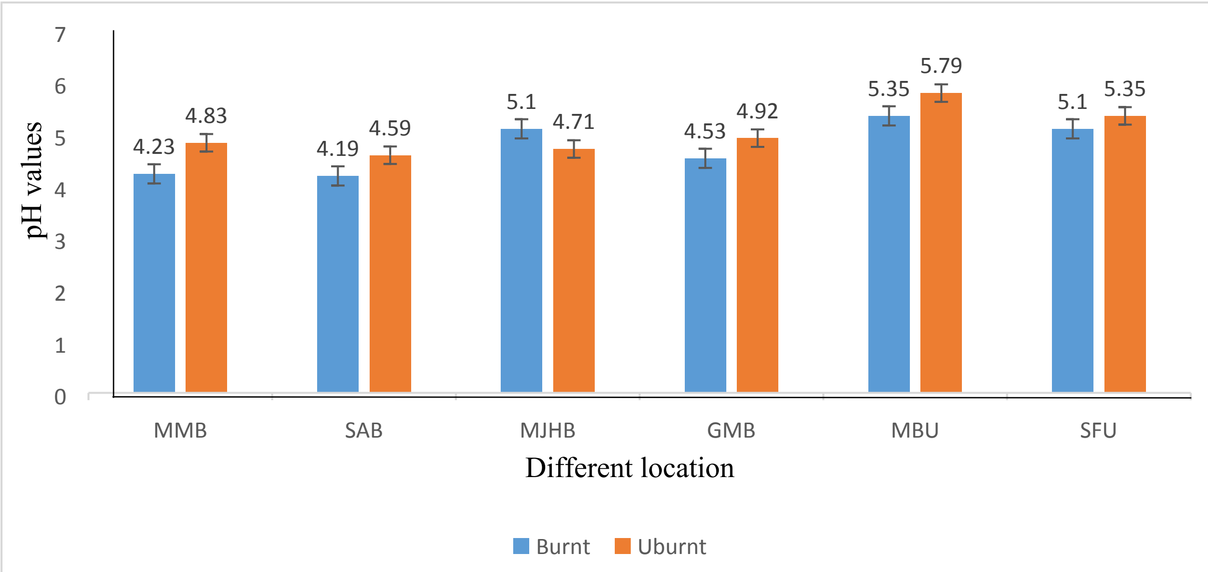

Figure 3. pH values in the surface soil (15-30 cm) in different brick kiln in the experimental area (MMB- Md. Mollah Bricks, SAB- Sahidul Abed Bricks, MJHB- Md. Jahidul Hasan Bricks, GMB- Golam Mostofa Bricks, MBU- Mollah Bricks Ulipur, SFU- Sobu Forhad Ulipur; Burnt-Brick kiln soil and Unburnt- Agricultural field soil; SD for burnt- 0.50 and unburnt-0.45)

Brick field use plenty of field around it to store soil for making the brick. So agricultural unburnt soil were collected from a distant as there were no agricultural field new the brick kiln. From the study it was revealed that pH in surface soil lower in the burnt area. Farmers use plenty of fertilizer like Gypsum, TSP, MOP, Urea etc. which accumulate in the surface and increase the pH compared to the subsurface soil in the area. The data of pH for surface and subsurface soil were showed in Appendix- I and II.

4.2 Organic matter (OM)

Organic matter values from burnt and unburnt soil in surface and subsurface soil are shown in (Figure 4 and 5). Highest OM value was observed in surface soil (0-15cm) and lower in the subsurface soil (15-30cm) for both burnt and unburnt soil. Similar result was also observed by Sood and Kanwar (1986), Mondal (1998) and Fakir (1998). The OM content of the samples recorded from 0.250 to 0.920 % in the burnt soil and from 0.290 to 1.055% in the unburnt soil for surface soil (0-15 cm) and for subsurface soil 0.210 to 0.740 and 0.206 to 0.705 in burnt and unburnt soil respectively. Highest OM value for burnt and unburnt soil was observed in MBU brick field and lowest in SAB for both surface and subsurface soil. The Higher organic carbon value for surface soil in unburnt area near the brick kiln was (1.055%) observed in MBU location and lowest (0.290%) was observed in SAB bricl kiln. Total highest value also found in this MAB brick field for the surface soil. For the subsurface soil highest (0.705%) was found in MBU location and lowest (0.206%) was observed in the SAB brick kiln. Standard deviation (SD) of surface soil was 0.27% and 0.30% for burnt and unburnt soil respectively. For the subsurface soil the SD values was 0.19% and 0.18% in burnt and unburnt soil respectively. Soil OM is a reservoir for plant nutrients, enhances water holding capacity, protects soil structure against compaction and erosion, and thus determines soil productivity (Martius *et al.,* 2001). The study found that the OM content of the agricultural land around the brick field area was decreasing day by day due to the burning of surface and subsurface soil. Similar result was also observed by Khan *et al*. (2007). Higher organic matter was found in unburnt soil near the brick kiln for both surface and subsurface soil. May be decrease of OM content in the brick kiln soil was due to the head and deposition of brick waste. Also soil, crop, and the management practice was different from farmer to farmer in different experimental location. This OM content variation might be for different management parctice and different soil texture in different location.

Table 2. OM Values (%) in the surface soil (0-15 cm) in different brick kiln in the experimental area

Sampling point	Burnt	Unburnt
MMB	0.465	0.490
SAB	0.250	0.290
MJHB	0.560	0.610
GMB	0.395	0.410
MBU	0.920	1.055
SFU	0.890	0.930
Mean	0.58	0.63
SD	0.27	0.30

Table 3. OM Values (%) in the surface soil (15-30 cm) in different brick kiln in the experimental area

Sampling point	Burnt	Unburnt
MMB	0.340	0.335
SAB	0.210	0.206
MJHB	0.530	0.520
GMB	0.450	0.445
MBU	0.740	0.705
SFU	0.630	0.625
Mean	0.483	0.473
SD	0.192	0.184

4.3 Nitrogen contents (N)

The total N content in the surface soil (0-15 cm) ranged from 0.023 to 0.100% and 0.029 to 0.123% in the burnt and unburnt soil, respectively. In case of subsurface soil (15-30 cm), the nitrogen content in burnt and unburnt soil ranged from 0.020% to 0.068% and 0.023% to 0.073% respectively (Table 4 and 5). Highest (0.123%) Nitrogen content observed in SAF location at unburnt surface soil and lowest (0.020%) nitrogen content observed in location MJHB at burnt subsurface soil. The average total N content for surface soil was found 0.06% in the burnt and 0.07% in the unburnt soils. For the subsurface soil the average value is 0.04% for burnt soil and 0.05%for unburnt soil. Standard deviation (SD) of surface soil was 0.03% and 0.03% for burnt and unburnt soil respectively. For the subsurface soil the SD values was 0.017% and 0.018% in burnt and unburnt soil respectively. According to BARC (1997), the standard level of total N in soil is 0.32%. Regarding the report of SRDI (2009), the N values of Kurigram agricultural soil ranged from 0.013 to 0.150%. The nitrogen content decreased in lower depth. It was observed that nitrogen content was higher in surface soil the subsurface soil for both burnt and unburnt soil. In the study area the range of total nitrogen was far below the critical range of nitrogen. Low organic matter content and burning of soil by heat was the reason for that. Lower value of N is due to loss of organic carbon which contains nitrogen and nitrogen fixing micro-organisms in soil (Rai *et al*., 2009). Most of the soil of Bangladesh contained nitrogen below critical level stated by Portach and Islam (1984).

It is found from the result that nitrogen content decreased in subsurface soil. Hossain *et al.* (2003) also found the similar result that all the soil were deficient in nitrogen content.

Table 4. N Values (%) in the surface soil (0-15 cm) in different brick kiln in the experimental area

Sampling point	Burnt soil	Unburnt soil
MMB	0.037	0.040
SAB	0.045	0.049
MJHB	0.023	0.029
GMB	0.087	0.090
MBU	0.095	0.099
SFU	0.100	0.123
Mean	0.064	0.072
SD	0.033	0.037

Table 5. N Values (%) in the surface soil (15-30 cm) in different brick kiln in the experimental area

Sampling point	Burnt soil	Unburnt soil
MMB	0.054	0.059
SAB	0.035	0.038
MJHB	0.020	0.023
GMB	0.060	0.065
MBU	0.048	0.050
SFU	0.068	0.073
Mean	0.047	0.051
SD	0.017	0.018

4.4 Phosphorus availability (P)

The available P content of the samples in surface soil (0-15 cm) were within the range of 9.85 to 10.10 ppm in the burnt soil and of 17.40 to 21.90 ppm in the unburnt soil. In subsurface soil (15-30 cm) the range were from 8.60 to 13.10 for burnt soil and from 11.00 to 19.00 ppm for unburnt soil (Figure 4 and 5). The highest value of phosphorus were found 21.90 ppm and 19.00 ppm for surface and subsurface soil in burnt and unburnt soil respectively. The lowest phosphorus content at surface and subsurface soil were found 9.85 ppm and 8.60 ppm at MMB brick field. The lower amount (8.60) of P was found in burnt soil than the unburnt soil, suggested the negative impact of brick burning on the surface and subsurface soil P content. It will be reported on the standard level of P for crop cultivation that is 21 ppm (BARC, 1997). The SRDI (2009) reported that the available P values of Kurigram district agricultural soil ranged from 0.90 to 1.67 ppm. Thus, the study revealed that the P content in the study area was relatively higher than the finding of SRDI.

The research found that phosphorus content were higher in surface soil then subsurface soil. Higher (21.90 ppm) phosphorus value was found in surface soil then those of subsurface soil at the location GMB. The lowest phosphorus value was recorded (8.60 ppm) at subsurface soil.

Average phosphorus content for surface were 15.26 ppm and 19.26 ppm at burnt and unburnt soil respectively. For the subsurface soil 10.85 ppm for burnt and 16.45 ppm for unburnt soil. Standard deviation (SD) of surface soil was 0.111 $meq100g^{-1}$ and 0.120 $meq100g^{-1}$ for burnt and unburnt soil respectively. For the subsurface soil the SD values was 0.010 $meq100g^{-1}$ and 0.107 $meq100g^{-1}$ in burnt and unburnt soil respectively.

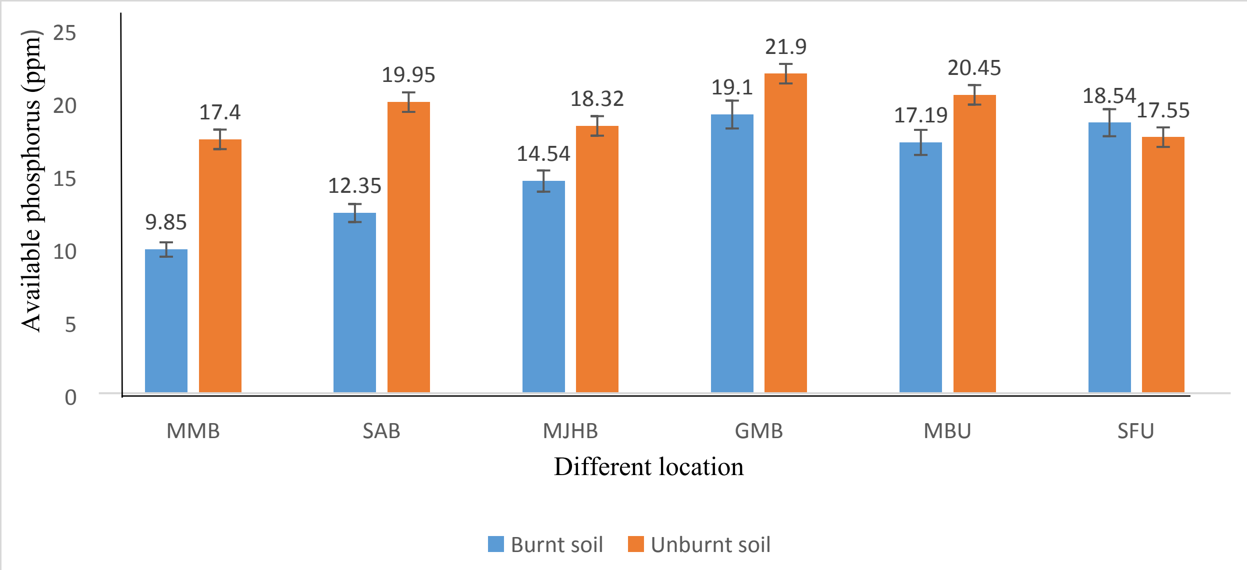

Figure 4. P values in the surface soil (0-15 cm) in different brick kiln in the experimental area.; Burnt- Brick kiln soil and Unburnt- Agricultural field soil; SD for burnt- 0.111 meq100g^{-1} and unburnt- 0.120 meq100g$^{-1)}$

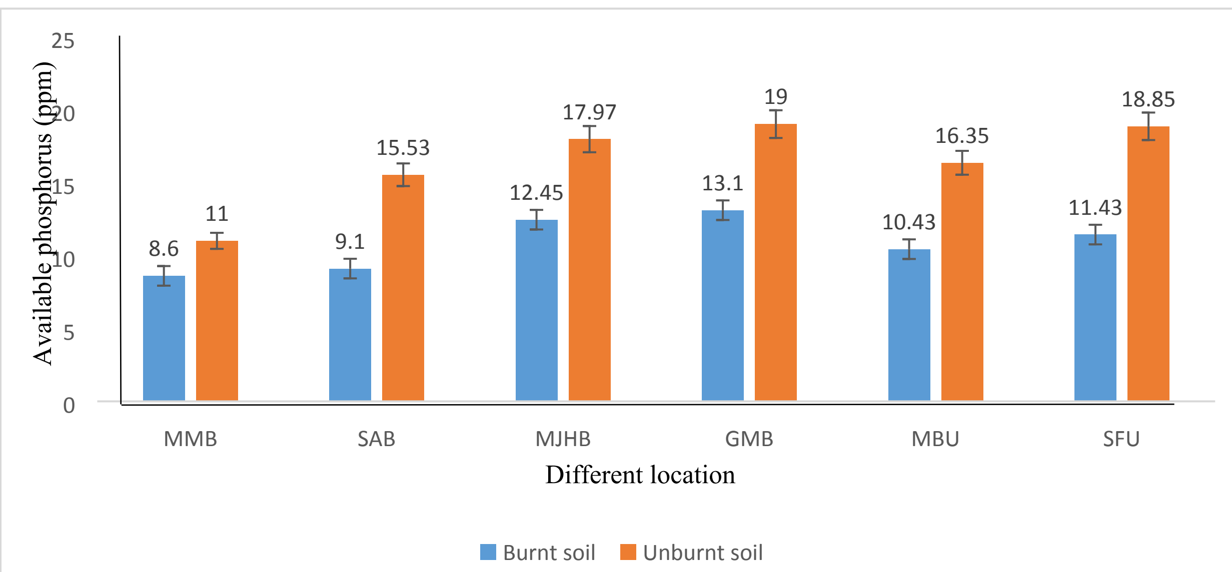

Figure 5. P values in the surface soil (15-30 cm) in different brick kiln in the experimental area. Burnt- Brick kiln soil and Unburnt- Agricultural field soil; SD for burnt- 0.010 meq100g^{-1} and unburnt- 0.107 meq100g^{-1})

4.5 Exchangeable potassium (K)

The results on exchangeable potassium content in burnt and unburnt soil are shown in (Figure 6 and 7). The level of exchangeable potassium content in burnt soil ranged from 0.092 to 0.363 meq100g^{-1} in surface soil and 0.083 to 0.113 meq100g^{-1} in subsurface soil. In case of unburnt soil near the brick field the range is from 0.190 to 0.518 meq100g^{-1} in the surface soil and from 0.102 to 0.412 meq100g^{-1} in subsurface soil. The maximum potassium value at surface and subsurface soil were found to be 0.518 meq100g^{-1} and 0.412 meq100g^{-1} at SFU brick field. The lowest potassium value at surface and subsurface soils were recorded to 0.092 meq100g^{-1} at MJHB brick field and 0.097 meq100g^{-1} at GMB brick field respectively.

The potassium value in unburnt soil ranged from 0.190 to o.518 meq100g^{-1} at surface soil and from 0.102 to 0.412 meq100g^{-1} at subsurface soil. The maximum 0.518 meq100g^{-1} were found at location SAF for surface soil and for the subsurface soil the maximum 0.412 found at SAF brick field also. The average K values for surface soil was 0.213 meq100g^{-1} and 0.343 meq100g^{-1} in burnt and unburnt soil respectively. For the subsurface soil 0.098 meq100g^{-1} and 0.272 meq100g^{-1} for burnt and unburnt soil respectively. Standard deviation (SD) of surface soil was 0.111 meq100g^{-1} and 0.120 meq100g^{-1} for burnt and unburnt soil respectively. For the subsurface soil the SD values was 0.010 meq100g^{-1} and 0.107 meq100g^{-1} in burnt and unburnt soil respectively.

From the study it was revealed that the potassium content was high in unburnt soil then in the burnt soil. The exchangeable potassium was found to be higher in surface soil than that of subsurface soil. Eaqub and Zaman (1987), Hossain *et al.* (2003) and Zaman and Nuruzzaman (1995) also found the similar result.

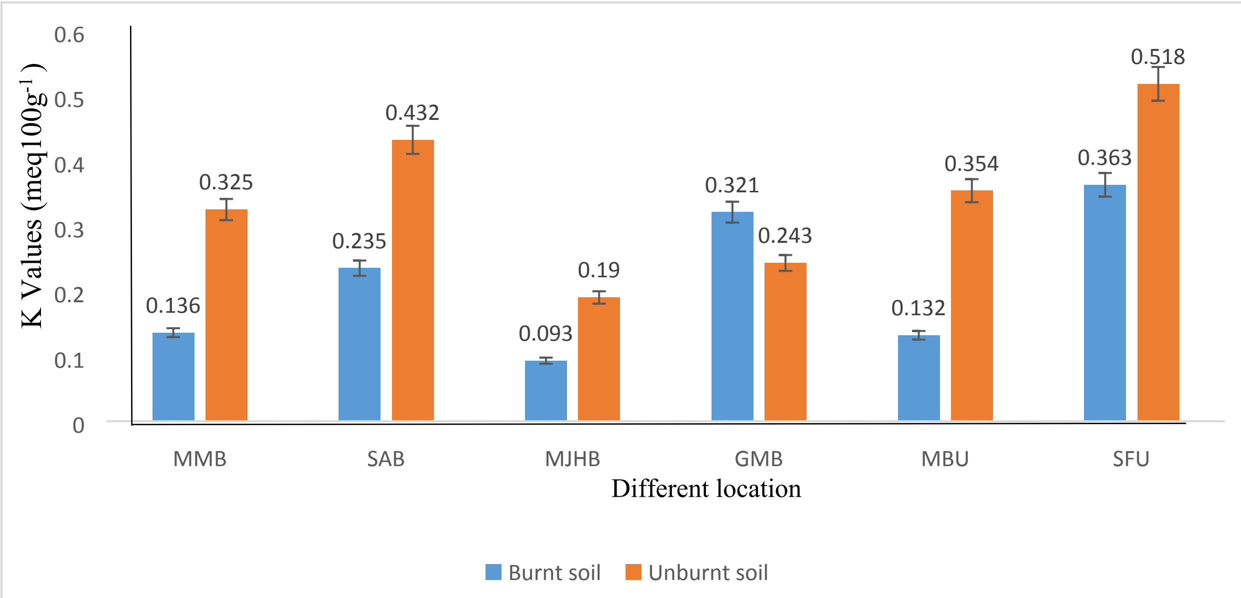

Figure 6. K values in the surface soil (0-15 cm) in different brick kiln in the experimental area. Burnt- Brick kiln soil and Unburnt- Agricultural field soil; SD, burnt- 0.111 meq100g^{-1} and unburnt- 0.120 meq100g^{-1})

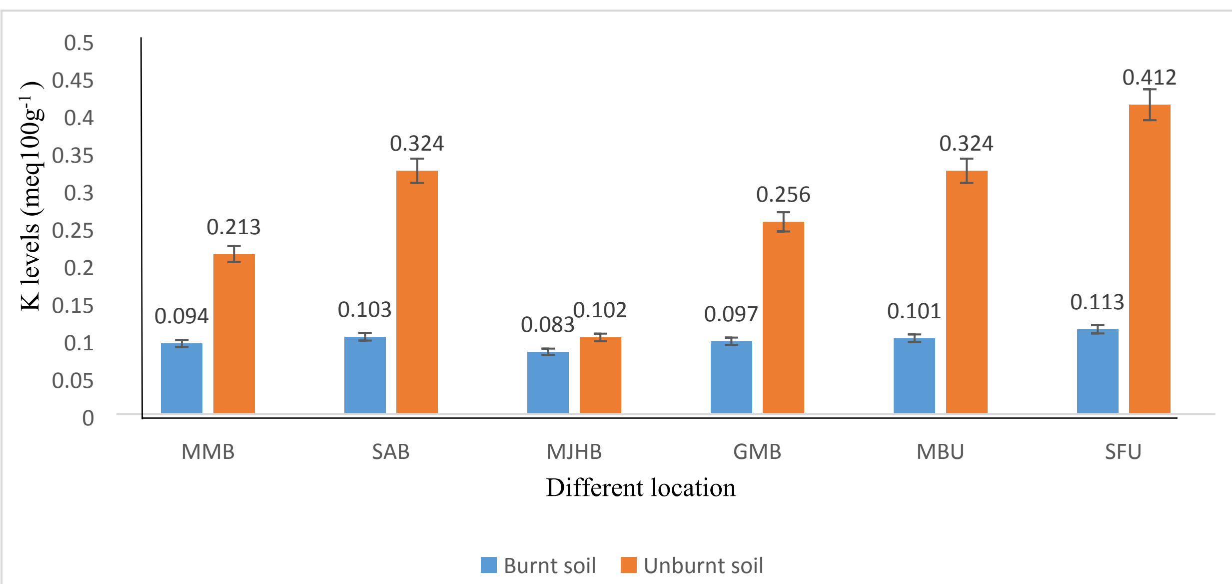

Figure 7. K values in the surface soil (15-30 cm) in different brick kiln in the experimental area. Burnt- Brick kiln soil and Unburnt- Agricultural field soil; SD, burnt- 0.010 meq100g^{-1} ,unburnt-0.107 meq100g^{-1})

4.6 Electrical conductivity (EC)

The electrical conductivity (EC) of both surface and subsurface soil are showed in Figure 8 and 9. The EC of burnt soil were ranged from 9.8 to 36.1 dsm^{-1} for surface soil (0-15 cm) and from 5.3 to 13.2 dsm^{-1} for subsurface soil (15-30 cm). For the unburnt soil near brick field were from 13.4 to 36.1 dsm^{-1} for surface soil and from 8.5 to 24.6 dsm^{-1} for subsurface soil. Highest EC values were found 34.2 dsm^{-1} at SFU brick field for unburnt soil in surface soil. The maximum EC value for burnt soil were 32.2 dsm^{-1} at SFU brick field in surface soil and the minimum value were 5.3 dsm^{-1} at SAB brick field in subsurface soil. Average EC values of surface soil were 21.62 dsm^{-1} and 24.68 dsm^{-1} for burnt and unburnt soil respectively. For subsurface soil the average EC value were 9.467 dsm^{-1} and 14.017 dsm^{-1} for burnt and unburnt soil respectively. The Standard deviation value for burnt soil was 8.409 dsm^{-1} and 3.054 dsm^{-1} for surface and subsurface soils, respectively. In unburnt agricultural field soil the Standard deviation value for EC was 9.169 dsm^{-1} for surface and 6.519 dsm^{-1} for subsurface soil.

Management practices like irrigation, fertilizer etc. were responsible for the Ec values of unburnt agricultural field. These practices helped soil to get higher accumulation of cations(+) in unburnt agricultural field. In burnt brick field soil no practices like these were happened and also the brick field contain low cation(+) bearing substances like dust, sand, brick etc. mixed with soil. Those were cause of low Ec values in burnt soils of brick field. The data of Ec for surface and subsurface soil were showed in Appendix- VII and VIII.

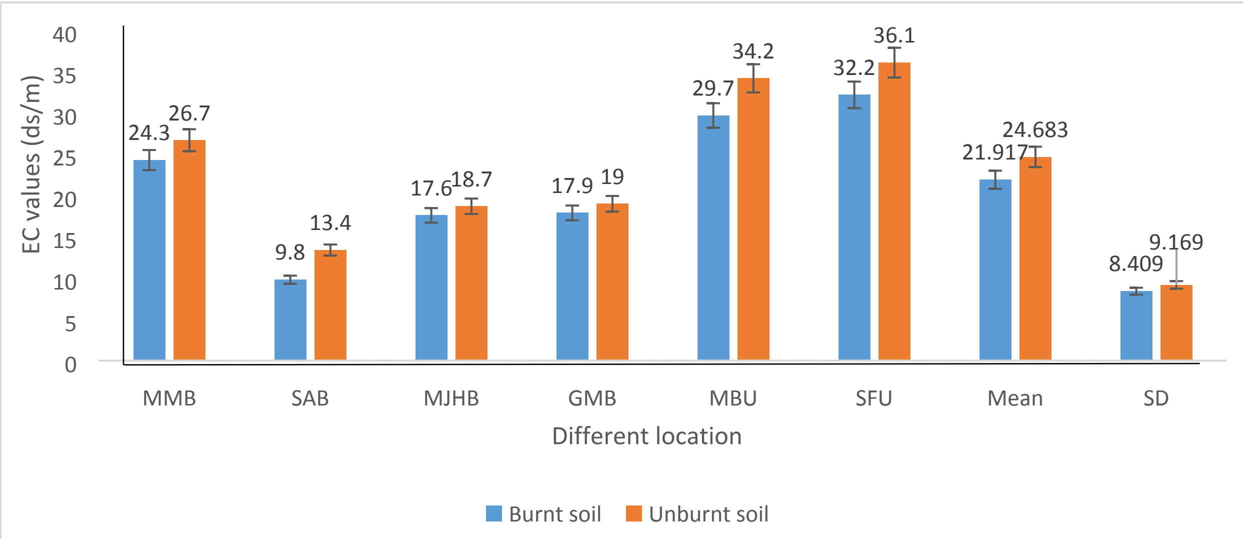

Figure 8. EC values in the surface soil (0-15 cm) in different brick kiln in the experimental area. Burnt-Brick kiln soil and Unburnt- Agricultural field soil; SD for burnt-8.409 dsm^{-1} and unburnt-9.169 dsm^{-1})

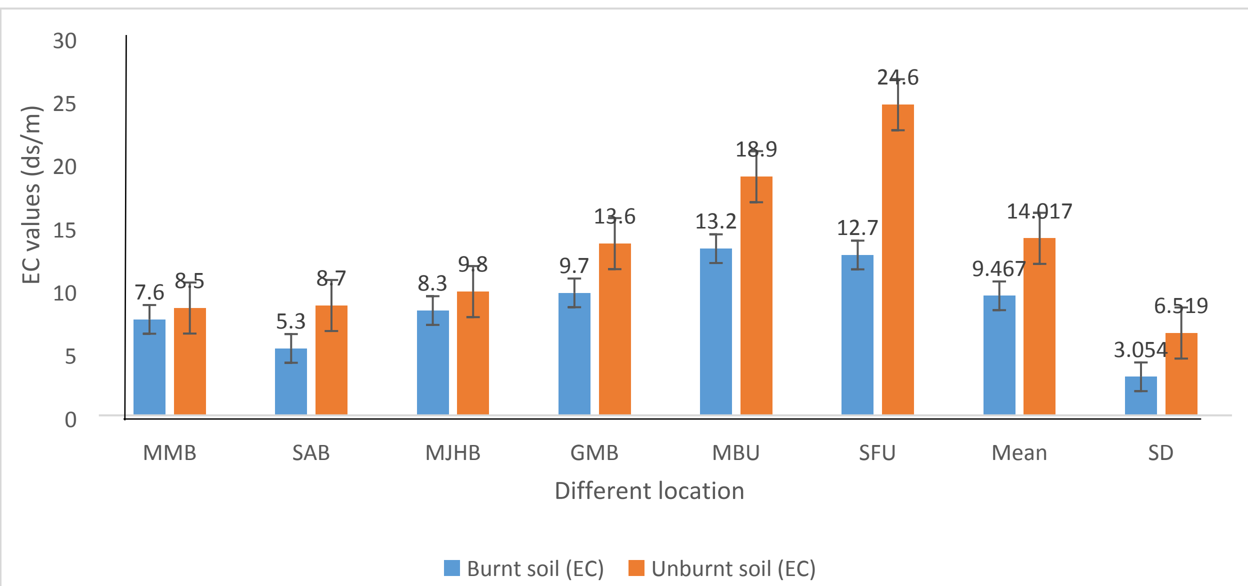

Figure 9. EC values in the surface soil (15-30 cm) in different brick kiln in the experimental area. Burnt-Brick kiln soil and Unburnt- Agricultural field soil; SD for burnt- 3.054 dsm^{-1} and unburnt- 6.519 dsm^{-1})

4.7 Available Copper (Cu)

The total Cu content for surface soil (0-15 cm) was recorded ranging from 0.082 to 0.088 ppm in the burnt soil and from 0.090 to 0.098 ppm in the unburnt soils. For subsurface soil the range was from 0.071 to 0.079 ppm for burnt soil and from 0.080 to 0.089 ppm for the unburnt agricultural field (Table 6 and 7). Maximum Cu 0.098 ppm was found at MBU brick field for surface soil in unburnt agricultural field. For subsurface soil the maximum Cu 0.089 ppm was found at MBU location. In burnt soil maximum Cu content was 0.088 ppm in surface soil and 0.079 ppm was at subsurface soil in the location MBU brick field. Minimum Copper value 0.071 ppm was found at MMB location for the subsurface soil. For the surface soil the minimum Cu value 0.082 was found at MMB brick field in burnt soil.

The mean value of total Cu contents for surface soil was found 0.085 and 0.094 ppm in the burnt and unburnt soils, respectively. For subsurface soil the mean value was 0.075 and 0.084 ppm for burnt and unburnt soils, respectively. The Standard deviation value for burnt soil was 0.002 and 0.003 for surface and subsurface soils, respectively. For the unburnt agricultural soil the SD value was 0.003 for both surface and subsurface soil.

The study found that Cu contents decreased with increased depth. Lower Cu value was found in burnt brick field soil than the unburnt agricultural soil. The nutrient loss was due to the heat developed for brick burning the brick kiln operation.

Table 6. Cu Values (ppm) in the subsurface soil (0-15 cm) in different brick kiln in the experimental area

Sampling point	Burnt soil (Cu)	Unburnt soil (Cu)
MMB	0.082	0.090
SAB	0.087	0.094
MJHB	0.085	0.097
GMB	0.083	0.093
MBU	0.088	0.098
SFU	0.086	0.092
Mean	0.085	0.094
SD	0.002	0.003

Table 7. Cu Values (ppm) in the subsurface soil (15-30 cm) in different brick kiln in the experimental area

Sampling point	Burnt soil (Cu)	Unburnt soil (Cu)
MMB	0.071	0.080
SAB	0.077	0.084
MJHB	0.075	0.087
GMB	0.073	0.083
MBU	0.079	0.089
SFU	0.076	0.082
Mean	0.075	0.084
SD	0.003	0.003

4.8 Available Zinc (Zn)

The total Zn content for surface soil ranged from 2.031 to 2.090 ppm in the burnt and from 2.113 to 2.992 ppm in the unburnt soil in the study area. For the subsurface soil available Zn ranged from 2.011 to 2.070 ppm and from 2.102 to 2.537 ppm for burnt and unburnt soils, respectively (Table 8 and 9). Highest Zn content 2.090 ppm for burnt and 2.992 ppm for unburnt found at SFU location in surface soil. Maximum Zn value for subsurface soil was 2.070 ppm and 2.527 ppm for burnt and unburnt soils, respectively. For burnt soil minimum Zn value 2.011 ppm was found at SAB brick field in subsurface soil. For the surface soil the minimum Zn value was 2.031 for burnt soil. In unburnt agricultural field the lowest Zn content was 2.102 ppm at SAB location in subsurface soil.

The mean value of total Zn content for surface soil was found 2.063 and 2.59 ppm in the burnt and unburnt soils, respectively. For subsurface soil the mean value for Zn content was 2.045 and 2.295 ppm in burnt and unburnt soils, respectively. The SD value for burnt soil was 0.023 and 0.022 ppm for surface and subsurface soils, respectively. For the unburnt agricultural field soil, the SD value was 0.37 for surface soil and 0.152 ppm for subsurface soil.

In this experiment it was revealed that available Zn values lower in the burnt brick field soil than in the unburnt agricultural soil. It was due to the heat accumulate from the brick burning operation. Zn values also decreased with increasing depth.

Table 8. Zn values (ppm) in the subsurface soil (0-15 cm) in different brick kiln in the experimental area

Sampling point	Burnt soil (Zn)	Unburnt soil (Zn)
MMB	2.042	2.245
SAB	2.031	2.113
MJHB	2.057	2.453
GMB	2.085	2.784
MBU	2.074	2.951
SFU	2.090	2.992
Mean	2.063	2.59
SD	0.023	0.37

Table 9. Zn values (ppm) in the subsurface soil (15-30 cm) in different brick kiln in the experimental area

Sampling point	Burnt soil (Zn)	Unburnt soil (Zn)
MMB	2.052	2.345
SAB	2.011	2.102
MJHB	2.027	2.353
GMB	2.045	2.184
MBU	2.064	2.251
SFU	2.070	2.537
Mean	2.045	2.295
SD	0.022	0.152

CHAPTER V

SUMMARY, CONCLUSSION AND RECOMMENDATION

SUMMARY

The study was conducted to show the chemical and physical properties of soil in the six selected brick kiln and the agricultural field (35-45 m) adjacent to the brick kiln, for both surface (0-15 cm) and subsurface (15-30 cm) at Kurigram district. The samples were collected from the study area and analysed in the Laboratory of Soil Science, Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka. The comparative results of chemical and physical properties are summarized below:

The average pH values for surface soil was 5.29 and 5.73 in burnt and unburnt soil respectively. For the subsurface soil 4.75 and 5.03 for burnt and unburnt soil respectively. Standard deviation (SD) of surface soil was 0.16 and 0.14 for burnt and unburnt soil respectively. For the subsurface soil the SD values was 0.50 and 0.45 in burnt and unburnt soil respectively. pH of the study location marked acidic.

The average OM values for surface soil was 0.58% and 0.63% in burnt and unburnt soil respectively. For the subsurface soil 0.63% and 0.47% for burnt and unburnt soil respectively. Standard deviation (SD) of surface soil was 0.27% and 0.30% for burnt and unburnt soil respectively. For the subsurface soil the SD values was 0.19% and 0.18% in burnt and unburnt soil respectively. The unburnt soil contain more organic matter than the burnt soil. The OM level decreased with increased soil depth.

The average total N content for surface soil was found 0.06% in the burnt and 0.07% in the unburnt soils. For the subsurface soil the average value is 0.04% for burnt soil and 0.05%for unburnt soil. Standard deviation (SD) of surface soil was 0.03% and 0.03% for burnt and unburnt soil respectively. For the subsurface soil the SD values was 0.017% and 0.018%

in burnt and unburnt soil respectively. Total Nitrogen content in the study area were below the critical level and gradually decreased with increased depth. The unburnt agricultural field contain more N than the burnt soil of the brick kiln.

The average P values for surface soil was 15.54 ppm and 19.26 ppm in burnt and unburnt soil respectively. For the subsurface soil 10.85 ppm and 16.45 ppm for burnt and unburnt soil respectively. Standard deviation (SD) of surface soil was 3.67 ppm and 1.80 ppm for burnt and unburnt soil respectively. For the subsurface soil the SD values was 1.80 ppm and 3.00 ppm in burnt and unburnt soil respectively. The lowest phosphorus content at surface and subsurface soil were found 9.85 ppm and 8.60 ppm at MMB brick field. The lower amount (8.60) of P was found in burnt soil than the unburnt soil shown the negative impact of brick burning on the surface and subsurface soil P content. P values also decreased with increased depth.

The average K values for surface soil was 0.213 meq100g^{-1} and 0.343 meq100g^{-1} in burnt and unburnt soil respectively. For the subsurface soil 0.098 meq100g^{-1} and 0.272 meq100g^{-1} for burnt and unburnt soil respectively. Standard deviation (SD) of surface soil was 0.111 meq100g^{-1} and 0.120 meq100g^{-1} for burnt and unburnt soil respectively. For the subsurface soil the SD values was 0.010 meq100g^{-1} and 0.107 meq100g^{-1} in burnt and unburnt soil respectively. More exchangeable K were found in unburnt agricultural soil than burnt brick kiln soil.

Average EC values of surface soil were 21.62 dsm^{-1} and 24.68 dsm^{-1} for burnt and unburnt soil respectively. For subsurface soil the average EC value were 9.467 dsm^{-1} and 14.017 dsm^{-1} for burnt and unburnt soil respectively. The EC values decreased with increased depth for both burnt and unburnt soil. Higher soil salinity caused for higher EC in agricultural field.

The mean value of total Cu contents for surface soil was found 0.085 and 0.094 ppm in the burnt and unburnt soils, respectively. For subsurface soil the mean value was 0.075 and 0.084 ppm for burnt and unburnt soils, respectively. The SD value for burnt soil was 0.002 and 0.003 for surface and subsurface soils, respectively. For the unburnt agricultural soil the SD value was 0.003 for both surface and subsurface soil. It was revealed that Cu values lower in the burnt soil than the unburnt agricultural soil due to the heat developed for brick burning.

The mean value of total Zn content for surface soil was found 2.063 and 2.59 ppm in the burnt and unburnt soils, respectively. For subsurface soil the mean value for Zn content was 2.045 and 2.295 ppm in burnt and unburnt soils, respectively. The SD value for burnt soil was 0.023 and 0.022 ppm for surface and subsurface soils, respectively. For the unburnt agricultural field soil, the SD value was 0.37 for surface soil and 0.152 ppm for subsurface soil. In this study it was seen that Zn content in lower in the burnt soil than the unburnt soil. It also decreased with the increasing depth

CONCLUSION

Brick kilns are not only destroying large areas of lands, but also the organic material and nutrients in the soil. In the study area, the values of OM (0.58%) and nutrients were found very low in the burnt soil compared to the unburnt soil, while the soil pH and EC were relatively higher. The study clearly depicted that the brick kiln operation decreases the OM and essential nutrients by degrading the soil quality. From the result of this study, it can be concluded that chemical properties of soil was lower in burnt soil of brick kiln than the unburnt agricultural soil.

RECOMMENDATION

The present investigation increases awareness about the status of soil degradation and environmental pollution induced by the brick kilns operation. To minimize soil nutrients loss and soil quality degradation, the study recommends:

(i) brick fields should be built away from the productive agricultural land;

(ii) restoring organic material and nutrient status so as to offset the negative impact of brick burning operation; and

(iii) rules and regulations for the brick field management must be developed by the government and related authorities.

CHAPTER VI

REFERENCES

Achakzai, K., Khalid, S., and Bibi, A. (2017). Determination of heavy metals in agricultural soil adjacent to functional Brick Kilns: a case study of Rawalpindi. *Sci. Tech. and Dev.* **34(3)**: 122-129.

Banerjee, A. K. (1980). 5'-terminal cap structure in eucaryotic messenger ribonucleic acids. *Microbiological reviews*, *44*(2), 175.

Bangladesh Population Census (2001), Bangladesh Bureau of Statistics; Cultural survey report of Upazilas of Kurigram District 2007. pp. 23-47

BARC. (1997). Fertilizer recommendation guide. Bangladesh Agricultural Research Council. BARC Publications. Farmgate, Dhaka. Bangladesh. pp. 196.

Bhuiyan, M. M. H. (2000). Effects of forms and timing of fertilizer on the performance of the transplant aman rice cv. BINASHAIL. M. S. Thesis, Department of Agronomy., BAU, Mymensing. p. 86

Bhuiyan, N. I. (1988). Co-ordinated Project on Potassium Studies. Progress Report. BARI, Joydebpur Gazipur. pp. 1-45

Bisht, G. and Neupane, S. (2015). Impact of Brick Kilns' Emission on Soil Quality of Agriculture Fields in the Vicinity of Selected Bhaktapur Area of Nepal. *Applied and Envir. Soil Sci.* **90(1):** 43-67.

Biswas, D., Gurley, E. S., Rutherford, S., and Luby, S. P. (2018). The Drivers and Impacts of Selling Soil for Brick Making in Bangladesh. Environmental management, 1-11.

Biswas, N.K. and S.I. Mukherjee. (1987). Soil chemical analysis. Oaretic Hall of India Private Ltd. New Delhi, India.

Black, C. A. (1965). Methods of Soil Analysis. Part 1 and Part 2. Amar. Soc. Agron. Inc. Pub. Madison. Wiscosin. USA.

Bouyoucos, G. J. 1926. Hydrometer method improved for making particle size analysis of soils. *J. of Agronomy*. **54:** 4661-4665.

Brunel, I. (2011). The life of Isambard Kingdom Brunel, civil engineer. Cambridge University Press.

Brunekreef, B., and Holgate, S. T. (2002). Air pollution and health. *The lancet*, ***360*****(9341),** 1233-1242.

Chowdhury, M. M. U. (1990). To study the physical and chemical properties of four soil series of Mymensingh district. M. S. Thesis. Dept. Soil Science, BAU, Mymensingh. pp. 37-71

Croitoru, L., and Sarraf, M. (2012). Benefits and costs of the informal sector: the case of brick kilns in Bangladesh. *J. of Environ Protection*, *3*(06), 476.

Cohen, A. D. (2005). Strategies for learning and performing L2 speech acts. *Intercultural pragmatics*, *2*(3): 275-301.

Das, R. (2015). Causes and consequences of land degradation in and around the brick kilns of khejuri CD blocks over Coastal Medinipur in West Bengal. *Int. J. of Innovative Resch and Devment*, **4(2**): 257-265

Eaqub, M. and Zaman, M.W. (1987). Soil test crop response stidies for fertilizer recommendation (BAU Component) Ann. Rep. BARC. Coord. Reo. Project. P. 5.

Eswaran, H., R. Lal and P.F. Reich. (2001). Land degradation: An overview. In: Responses to land degradation. E.M. Bridges, I.D. Hannam, L.R. Oldeman, F.W.T. Pening de Vries, S.J. Scherr, and S. Sompatpanit (eds.). Proceedings of the 2nd international conference on land degra-dation and desertification.KhonKaen, Thailand. Oxford Press. New Delhi, India. pp. 9.

Fakir, M. S. A. (1998) Comparative studies of physical-chemical properties of hill soils and floodplain soil of Bangladesh. M. S. Thesis, Dept. Soil. Science BAU. Mymensing.

GEFONT (2007) Nepal: Labour Under the Chimney—A Study on the Brick Kilns of Nepal. Putalisadak, Kathmandu, Nepal: General Federation of Nepalese Trade Unions (GEFONT), Man Mohan Labour Building, GEFONT Plaza.

Gupta, S. and R. Narayan. (2010). Brick kiln industry in long-term impacts biomass and diversity structure of plant communities. *Curr. Sci. India.* **99(1):** 72-79.

Guttikunda, S. K. and Khaliquzzaman, M. (2014). Health benefits of adapting cleaner brick manufacturing technologies in Dhaka, Bangladesh. *Air Quality, Atmosphere and Health*. **7(1):** 103-112.

Hossain, C. F., Kim, Y. P., Baerson, S. R., Zhang, L., Bruick, R. K., Mohammed, K. A., and Zhou, Y. D. (2005). Saururus cernuus lignans—Potent small molecule inhibitors of hypoxia-inducible factor-1. *Biochemical and biophysical resch communications*, *333*(3): 1026-1033.

Hossain, A., Hossain, A.K.M.M., Rahman, M.S., Rahman, M.M. Chowdhury, M.A.M. and Khan, M.S.H. (2003). Effect of tillage Practices on Soil Properties under different Cropping Patterns. *J. Sci. Tech*. **1:** 44-48

Ismail, M., Mihammad, D., Khan, F. U., Munsif, F., Ahmad, T., Ali, S. and Ahmad, M. (2012). Effect of brick kiln's emissions on heavy metal (CD and CR) content of contiguous soil and plants. *Sarhad J. of Agril*. **28(3):** 276-328

IUSS. (2002). Soil and the environment. IUSS commission VIII. Int. Union of Soil Sci. World Congress of Soil Sci. Thailand. pp. 6.

Imtiaz, M., A. Rashid, P., Khan, M.Y. and Aslam, M. 2010. The role of micro-nutrients in crop production and human health. *Pak. J. Bot.* **42 (4):** 2565-2578.

Islam, M. S., Al Mamun, S., Muliadi, M., Rana, S., Tusher, T. R. and Roy, S. (2015). The impact of brick kiln operation to the degradation of topsoil quality of agricultural land. *AGRIVITA, J. of Agril. Sci.*. **37(3):** 204-209.

Jerin, M. F., Mondol, S. K., Sarker, B. C., Rimi, R. H. and Aktar, S. (2016). Impacts of Brick Fields on Environment and Social Economy at Bagatipara, Natore, Bangladesh. *J. of Env. Sci. and Natural Resources*. **9(2):** 31-34.

Jackson, M.L., (1985). Soil Chemical Analysis. Prentic Hall of India Pvt. Ltd., New Delhi. pp. 41-330.

Kathuria, V. (2007). Utilization of fly-ash by brick manufacturers - environmental costs vs. benefits. Research Report. Ministry of Environment and Forests. India.

Khan, H.R., Rahman, K., Rouf, A.J.M.A., Sattar, G.S., Oki, Y. and Adachi, T. (2007). Assessment of degradation of agricultural soils arising from brick burning in selected soil profiles. *Int. J. Environ. Sci. Tech.* **4 (4):** 471-480.

Karne, K., and Kumar, V. Role of Soil Brick Industry in the Degradation of Land and Environment-A Case Study of Mallaram in Nizamabad, Telangana State.

Martius, C. and Tiessen, H. and Vlek, P. (2001). Managing organic matter in tropical soils: scope and limitations. Proceedings of a Workshop. Plant and Soil Sci. Development Research Center. University of Bonn (ZEF Bonn). Germany, 7–10 June, 1999. Springer. Netherlands. pp. 236.

McLaren, R.G., R.S. Swift and B.F. Quin. (1984). EDTA extractable copper, zinc, iron and manganese in soils of the Canterbury plains. *New Zeal. J. Agr. Res.* **27:** 207-217.

Mukherjee, P., Biswas, G., and Nag, P. K. (1987). Second-law analysis of heat transfer in swirling flow through a cylindrical duct. *J. of heat transfer*, **109(2):** 308-313.

Mondol, M. Y. A. (1998) Studies on the physical properties of BAU farm soil. M. S. Thesis, Dept. Soil. Science BAU, Mymensingh.

Monga, V., Singh, L. P., Bhardwaj, A., & Singh, H. (2012). Respiratory health in brick kiln workers. *Int. J. Phys. Soc. Sci*. ***2*****(4)**: 226-44.

Mukherjee, S. and Chakraborty, D. (2013). Environmental cost of using topsoil for brick-making. In Environmental Scenario in India, Routledge. pp. 143-158.

Marshall, T. J. (1962). Mechanical composition of soils in relation to field description of texture. Commonwealth Aust. Council. Sci. Ind. Res. Melbourne, Australia, Bull. 224. P. 20.

Ostro, Bart, and World Health Organization. "Outdoor air pollution: assessing the environmental burden of disease at national and local levels." (2004).

Page, A. L., Miller, R. H., and Keeney, D. R. (1982). Methods of soil analysis, part 2. Chemical and microbiological properties, 2.

Piper, C. S. (1950). Soil and Plant Analysis (The University of Adelaide.). Inter. Sci. Pub., New York, USA.

Pokhrel, R., and Lee, H. (2011). Estimation of the effective zone of sea/land breeze in a coastal area. *Atmospheric Pollution Research*, *2*(1), 106-115.

Pope, K. L. (2002). *U.S. Patent Application 29/141,525*.

Portch, S. and Islam, M. S. (1984). Nutrient status of some important agricultural soils of Bangladesh. In proc. Of the Int. Symp. On soil test crop response correlation studies, BARK, Dhaka. pp. 98-107

Rai, A.K., B. Paul and Singh, G. (2009). Assessment of soil quality in the vicinity of subsided area in the south eastern part of Jharia Coalfield, Jharkhand, India. I*nt. J. Report Opinion*. **1 (6)**: 18-23.

Rahman, M.K. and Khan, H. R. (2001). Impacts of brick kiln on topsoil degradation and environmental pollution. Research Project Report. Ministry of Science, Information and Communication Technology. Bangladesh. pp. 210.

Rahman, M. 2012. Brickfield. Banglapedia. National Encyclopedia of Bangladesh.Asiatic Society of Bangladesh. http://en. banglapedia.org/index.php?title=Brickfield.

Rahman, M. K. and Khan, H. R. (2015). Impacts of brick kiln on topsoil degradation and environmental pollution. Project report submitted to the Ministry of Science and Information and Communication Technology, Bangladesh Secretariat (Dhaka), 210.

Rajonee, A. A. and Uddin, M. J. (2018). Changes in Soil Properties with Distance in Brick Kiln Areas around Barisal. *Open J. of Soil Sci.* **8(03)**: 118.

Sanders, C. S. (1995). *Collected papers of charles sanders peirce*. Harvard University Press.

Skinder, B. M., Pandit, A. K., Sheikh, A. Q. and Ganai, B. A. (2014). Brick kilns: cause of atmospheric pollution. *J. Pollut. Eff. Cont*. **2:** 110.

Skinder, B. M., Sheikh, A. Q., Pandit, A. K. and Ganai, B. A. (2014). Brick kiln emissions and its environmental impact: A Review. *J. of Eco. and The Natural Env*. **6(1):** 1-11.

SRDI. (1991). Land and Soil Utilization Guide. Upazila Nirdeshika Series Sadar Upazilla of Kurigram. SRDI, Dhaka, Bangladesh. pp. 50-55.

SRDI. (2001). Land and Soil Utilization Guide. Upazila Nirdeshika Series- Ulipur Upazilla . SRDI, Dhaka, Bangladesh. pp. 43-60.

SRDI. (2001). Land and Soil Utilization Guide. Upazila Nirdeshika Series Sadar Upazilla of Kurigram. SRDI, Dhaka, Bangladesh. pp. 35-52

SRDI. (2009). Land and Soil Utilization Guide. Upazila Nirdeshika Series- Ulipur Upazilla SRDI, Dhaka, Bangladesh. pp. 56-62.

Tucker, M.R., J.K. Messick and C. Stokes. 1995. Soil fertility note 14: Topsoil. North Carolina Department of Agriculture and Consumer Services (NCDA and CS).NCDA and CS Agronomic division. USA. pp. 1-2.

Warkentin, B.P. (2002). Soil and the environment, commission VIII. In: Bulletin of the International Union of Soil Science, No. 101, World Congress of Soil Science, 14-21 August. Thailand. pp. 29-32.

Zaman, M.W. and Nuruzzaman, M. (1995). Effect of long term ground water irrigation on the fertility status of Madhupur Upazilla soil in Bangladesh. *Thai J. Agril. Sci.* **28:** 64-77

http://www.myweather2.com

APPENDICES

Appendix I. pH values in the surface soil (0-15 cm) in different brick kiln in the experimental area

Sampling point	Burnt soil	Unburnt soil
MMB	5.10	5.68
SAB	5.53	5.57
MJHB	5.40	5.74
GMB	5.32	5.83
MBU	5.14	5.97
SFU	5.25	5.69
Mean	5.29	5.73
SD	0.16	0.15

Appendix II. pH values in the surface soil (15-30 cm) in different brick kiln in the experimental area

Sampling point	Burnt soil	Unburnt soil
MMB	4.23	4.83
SAB	4.19	4.59
MJHB	5.1	4.71
GMB	4.53	4.92
MBU	5.35	5.79
SFU	5.1	5.35
Mean	4.75	5.03
SD	0.50	0.45

Appendix III. P values (ppm) in the surface soil (0-15 cm) in different brick kiln in the experimental area

Sampling point	Burnt soil	Unburnt soil
MMB	9.85	17.40
SAB	12.35	19.95
MJHB	14.54	18.32
GMB	19.10	21.90
MBU	17.19	20.45
SFU	18.54	17.55
Mean	15.26	19.26
SD	3.67	1.80

Appendix IV. P values (ppm) in the surface soil (15-30 cm) in different brick kiln in the experimental area

Sampling point	Burnt soil	Unburnt soil
MMB	8.60	11.00
SAB	9.10	15.53
MJHB	12.45	17.97
GMB	13.10	19.00
MBU	10.43	16.35
SFU	11.43	18.85
Mean	10.85	16.45
SD	1.80	3.00

Appendix V. K values (meq100g^{-1}) in the surface soil (0-15 cm) in different brick kiln in the experimental area

Sampling point	Burnt soil	Unburnt soil
MMB	0.136	0.325
SAB	0.235	0.432
MJHB	0.092	0.190
GMB	0.321	0.243
MBU	0.132	0.354
SFU	0.363	0.518
Mean	0.213	0.343
SD	0.111	0.120

Appendix VI. K values (meq100g^{-1}) in the subsurface soil (15-30 cm) in different brick kiln in the experimental area

Sampling point	Burnt soil	Unburnt soil
MMB	0.094	0.213
SAB	0.103	0.324
MJHB	0.083	0.102
GMB	0.097	0.256
MBU	0.101	0.324
SFU	0.113	0.412
Mean	0.098	0.272
SD	0.010	0.107

Appendix VII. EC values (dsm^{-1}) in the surface soil (0-15 cm) in different brick kiln in the experimental area

Sampling point	Burnt soil	Unburnt soil
MMB	24.3	26.7
SAB	9.8	13.4
MJHB	17.6	18.7
GMB	17.9	19.0
MBU	29.7	34.2
SFU	32.2	36.1
Mean	21.917	24.683
SD	8.409	9.169

Appendix VIII. EC values (dsm^{-1}) in the subsurface soil (15-30 cm) in different brick kiln in the experimental area

Sampling point	Burnt soil (EC)	Unburnt soil (EC)
MMB	7.6	8.5
SAB	5.3	8.7
MJHB	8.3	9.8
GMB	9.7	13.6
MBU	13.2	18.9
SFU	12.7	24.6
Mean	9.467	14.017
SD	3.054	6.519