"ASSESSMENT OF SOIL AND NUTRIENT LOSS DURING BRICK MAKING PROCESS IN WESTERN MAHARASHTRA"

by

Mr. Patle Prabhat Nandkumar
(Reg. No. : 015/099)

A Thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722, DIST.AHMEDNAGAR,
MAHARSHTRA, INDIA

in the partial fulfillment of the requirements of degree

of

MASTER OF SCIENCE IN (AGRICULTURE)

in

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

POST GRADUATE INSTITUTE,
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CANDIDATE'S DECLARATION

I hereby declare that this thesis or a part thereof has not been submitted by me or any other person to any other University or Institute for a Degree or Diploma.

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This is to certify that the thesis entitled, "**ASSESSMENT OF SOIL AND NUTRIENT LOSS DURING BRICK MAKING PROCESS IN WESTERN MAHARASHTRA",**submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **SOIL SCIENCE AND AGRICULTURAL CHEMISTRY**, embodies the results of piece of *bona fide* research work carried out by **Mr. PATLE PRABHAT NANDKUMAR,** under the guidance and supervision of **Dr. A.L. Pharande,** and that no part of the thesis has been submitted for any other university for degree or diploma.

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LIST OF ABBREVIATIONS

S_1	:	Soil excavated and used for brick making
S_2	:	Molded brick/green brick
S_3	:	Fired brick/red brick
S_4	:	Soil below the brick kiln
S_5	:	Normal agriculture soil
SAARC	:	South Asian Association For Regional Cooperation
CPCB	:	Central Pollution Control Board
NIDM	:	National Institute of Disaster Management
%	:	Per cent
ha	:	Hectare
cm	:	Centimeter
mm	:	Milimeter
m	:	Meter
et al.	:	*et alia* and others
Fig.	:	Figure
i.e.	:	that is (*Id est)*
dSm^{-1}	:	Decisyman per meter
Kg ha^{-1}	:	Kilogram per hectare
mg kg^{-1}	:	Milligram per kilogram
DTPA	:	Diethylene Triamine Penta Acetic acid
viz.,	:	Vide licet, namely
pH	:	Puissance de hydrogen
EC	:	Electrical Conductivity

O.C	:	Organic Carbon
CaCO3	:	Calcium Carbonate
N	:	Nitrogen
P	:	Phosphorus
K	:	Potassium
Ca	:	Calcium
Mg	:	Magnesium
S	:	Sulphur
Fe	:	Iron
Mn	:	Manganese
Zn	:	Zinc
Cu	:	Copper
F.C	:	Field Capacity
P.W.P	:	Permanent Wilting Point

ABSTRACT

ASSESSMENT OF SOIL AND NUTRIENT LOSS DURING BRICK MAKING PROCESS IN WESTERN MAHARASHTRA

By

MR. PATLE PRABHAT NANDKUMAR

A candidate for the degree

Of

MASTER OF SCIENCE (AGRICULTURE)

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2017

Research Guide	:	Dr. A. L. PHARANDE
Department	:	Soil Science and Agril.Chemistry

The present study entitled, “Assessment of soil and nutrient loss during brick making process in western Maharashtra”, was carried out during the year 2016-17 at the Department of Soil Science and Agricultural Chemistry, Post Graduate Institute, M.P.K.V. Rahuri with an objective to estimate soil and nutrient loss during brick making process and to study degradation of agriculture soil due to establishment of brick kiln on it. The comprehensive survey of eight districts was conducted in which, 2 brick production units (kilns) from each district of study area were visited and factory owner were interviewed with semi structured questionnaires.

Five type of samples were collected viz. Soil excavated and used for brick making process (S_1), molded or

green brick (S_2), fired or red brick (S_3), soil from below the brick kiln (S_4) and normal agriculture soil to represent entire brick making process and assess the degradation of agriculture soil.

Study and interpretation of data revealed that use of soil as raw material for brick making was responsible for tremendous loss of this precious natural resource. In study area one brick factory responsible 2030.3 tonnes of soil year^{-1} on weight basis and 0.90 ha in terms of top 15 cm layer of soil where as obvious increment was reveled 32484.8 tonnes year^{-1} of soil loss and 14.5 hectares' year^{-1} of land from sixteen brick factories under investigation.

All the physical chemical and biological properties of soil excavated for brick making (S_1) were found in normal range and revealed that good quality soil was used for brick making process. Molded brick sample (S_2) were found high in organic matter content compared to all the samples which ranged from 0.24 to 1.13 % due to addition of O.M. during molding. Huge loss of available nutrients was observed in fired brick (S_3) when compared to soil used for brick making (S_1). During brick making process available N, P, K and S were loss up to extent of 80%, 27%, 10% and 53% respectively. Total N and K were lost up to 32% and 26% whereas no significant reduction was found in terms of total P.

When soil below the brick kiln (S_4) compared to the normal agriculture soil (S_5) drastic change in physiochemical properties were observed in which bulk density of (S_4) samples increased up to 1.63 to 2.0 Mg m^{-3}. Significant increase in pH

and EC were observed with an average values of 8.15 and 3.8dSm^{-1} respectively. Considerable decrease in organic carbon, available N, P and S were observed up to extent of 51%, 60%, 22% and 30% respectively whereas available and Total K in (S_4) samples were increased up to 138.9% and 41% respectively. DTPA micronutrient content significantly decreased in (S_3) samples and considerably increased in (S_4) samples.

Present study reveals the huge loss of precious natural resource and nutrients along with degradation of agriculture soil provoked by brick making process in the study area. Issues like soil excavation for brick making, use of good quality soil for brick making and establishment of brick kiln on fertile agriculture land should be dealt with proper policy making and due responsibility for sustain agriculture in not only study area but throughout the country in near future with prime urgency.

1. INTRODUCTION

Soil is a non-renewable natural resourse as it takes more than 1000 years to create 1 cm of top soil. Soil is vital for existence of many forms of life that have evolved on our planet. The nature of the soil is an important factor influencing the productivity of various ecosystems. Healthy soil is the foundation of the food system. It produces healthy crops that in turn nourish human being and animals. Soil degradation and environmental pollution are one of the most serious threats in the world today, because of their adverse effects on agriculture and the life on earth.

The increasing world's population will put pressure on soil resources. The role of soils, their contribution and efficient maintenance regarding the quality of nature are undoubtedly important and will increase in the future. Land degradation can be considered in terms of the loss of actual or potential productivity or utility as a result of natural or anthropic factors (Eswaran, 1999).

India, which is second largest populated country in world solely depends on agriculture for feeding this increasing population. India's per capita land availability for agriculture has shrunk to 0.3 hectare per farmer compared to over 11 hectares in developed countries. As per current estimate about 175 million hectares, out of total geographical area of 328 million hectares in India is subjected to soils erosion and degradation. With the growing population and their increasing needs in various sectors, land use patterns are undergoing a qualitative change in which the areas under the net cropped

land and forest land is gradually shrinking putting India's food security in question.

Very fertile, well textured (loamy) alluvial soils are extensively used for brick making process. Top fertile soil from agriculture land is excavated for brick making which is the permanent loss of soil. The brick kiln unit itself occupies considerable land area and is subjected to high temperature making it unfit for agricultural activities. Brick making process is yet not considered as a soil degradative process as losses incurred during brick making are not yet estimated in terms of soil and nutrient loss. As soil is a non-renewable resource the fast depletion of arable land thus caused due to brick making is a matter of concern to India and especially Maharashtra regarding food security, agriculture development and environmental pollution.

The brick industry competes for resources with other sectors, which poses a significant challenge to the sector such as top soil or land which could be used for agriculture. As a result of soil desurfacing by brick kilns the soil fertility is affected. Urbanization is one of the most important reasons for decreasing agriculture land which require bricks. Especially in western Maharashtra, which is the national capital region, construction activity is on the peak and for this requirement for the bricks has increased at great level.

Maharashtra is third most urbanized state as 42.4 % of its population enumerated as urban compared to 27.8% in India. It is also highly industrialized state of India contributing 13% of national industrial output, although agriculture continues to be the main occupation in the state. Western

Maharashtra which is known for its prosperous agriculture increasing top soil removal and soil degradation due to brick making is a matter to examine with great concern and priority for sustainable development of agriculture in the state.

A brick is a block made of clay burnt in a kiln. It is one of the primary building materials known to mankind. Traditionally, the term brick referred to unit composed of clay, but it is now used to denote any rectangular units lay in mortar. A brick can be composed of clay-bearing soil, sand and lime, or concrete materials. Bricks are produced in numerous classes, types, materials and sizes which vary with region and time period which are produced in bulk quantities. Two basic categories of bricks are fired and non-fired bricks. Fired clay bricks are one of the most important building materials in India. The Indian brick industry is unorganized with small production units.

India is the second largest producer of bricks after china with estimated annual production of 250 billion bricks a year, accounting for over 10% of the global production. There are approximately 140000 brick production units in the country producing bricks which have clustered in rural and semi-urban areas in the country. Unorganized brick kiln industries in India are not just emitting black carbon and polluting the air, they are also destroying the fertile top soil. Central Pollution Control Board (CPCB) has recognized the brick production industry as a highly resource and energy intensive and polluting industry as they are the sources of local air pollution affecting local population, agriculture and vegetation; at a global scale they also contribute to climate change.

Brick making process in India is characterized by traditional firing technologies, reliance on manual labour and low mechanization rate. The brick making process in this area is dominantly depend on single raw material which is the precious agriculture soil producing same type of product; solid clay bricks which are predominantly used for construction widely.

During brick making process the clay is mined and stored in the open. This makes the clay soft and removes unwanted oxides. This clay is then mixed with water to get the right consistency for molding. Mixing is done manually with hands and feet. Sometimes animal driven pug mills are used; this process is known as tempering. A lump of mix is taken, rolled in sand and slapped into the mould. Initially moulds were made of wood, now metal moulds are used. Sand is used so the brick does not stick to the mould. The mould is emptied onto the drying area, where the bricks are arranged in a herring bone pattern to dry in the sun. Every two days they are turned over to facilitate uniform drying and prevent warping. After two weeks they are ready to be burnt. Then the green bricks are arranged in a kiln and insulation is provided with a mud pack. Fire holes left to ignite the kiln are later sealed to keep the heat inside. This is maintained for a week. Firing like other operations also depends on the knowledge and experience of the brick maker. After the kiln is disassembled, the bricks are sorted according to colour. Colour is an indication of the level of burning. Over burnt bricks are used for paving or covering the kiln while slightly under burnt bricks are used for building inner walls or burnt once again in the next kiln. (www.ecobrick.in)

SAARC energy centre forecasted that 6.6% annual growth rate in construction activity would increase the annual demand for walling material to around 500 billion brick and equivalent masonry units by 2030. So it is quite evident that India requires massive quantities of construction material over the next two decades. The bulk of building material is presently derived from locally available clay, soil, sand and gravel. So, in future these statistics shows overwhelming pressure on soil resources. (Maithel, 2013)

Thus with the view of above to study losses and negative impacts on soil provoked by brick making a present study was undertaken with following objectives. The present assessment regarding loss of soil and nutrient accompanied by degradation of agriculture land can be an eye opening study for future policy making.

1] To estimate soil loss during brick making process.
2] To assess the nutrient loss during brick making process.
3] To study the effect of brick field on degradation of soil properties.

2. RIVIEW OF LITERATURE

In this chapter, an attempt has been made to represent a brief review of research information in relation to consequences of brick making with prime focus on soils. Till recently, meager attention was given to permanent soil loss due to brick making. In India and abroad, related study on role of brick industry on resource depletion and degradation is at an initial stage and literature in this connection is very scanty.

Since review of literature forms a linkage between the past and present research work related to problem which helps an investigation to draw a satisfactory conclusion. Hence, a few potential research works pertaining to present research had been reviewed under following subhead as very limited literature available on this aspect.

2.1 Present scenario of brick industry in India:-

Kathuria (2007) reported that 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. Often, many farmers are forced to sell soil for brick making because their neighbors have sold soil which leaves a 4 to 6' deep gap at the surface levels between those who sold soil and those who did not.

Hedge *et al.* (2011) reported that excessive demand for construction material like bricks and sand in developing

countries like India causing huge soil degradation at alarming rate. Study revealed that loss of surface soil, nutrient losses, crop yield losses and soil erosion is taking place due to soil and sand extraction.

Kumar *et al.* (2015) carried out study in Telangana state regarding role of brick industry in degradation of land and stated that increased urbanization and industrialization in developing countries has created a huge demand for construction activities, which in turn has resulted in the fast growth of the brick-making industry. They also observed that 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.

Noll (2015) investigated socio-ecological impact of brick kilns by analyzing a cluster of 9 kilns in Mumbai metropolitan region with material and energy flow analysis. The study shows that the brick industry in study area affects the food production by depleting soil from agriculture areas for urban construction.

Bhushan *et al.* (2016) reported as per the information provided by All India Brick Manufacturers Association to them that, there are around 1,21,000 registered brick kilns in India. They also estimated that at present 75% of the market constitutes of fired clay bricks.

2.2 Effect of brick making on different soil properties: -

Chen and Li (2003) investigated changes in soil carbon and nutrients due to brick manufacturing. Five samples from different adobes and bricks were collected from a local brick factory. They measured the soil C and other nutrient contents in adobes and bricks and observed more than 80% of C, N and S were lost during brick making while soil phosphorus had no significant change during brick making.

Khan *et al.* (2005) conducted study on soil around brick kilns with selected soil profiles in comparison with unburnt agriculture soils in western part of Bangladesh. The average losses arising from the burning of agricultural soils amounted to 63% for organic matter, 56 to 86 % and 23 to 88 % for available and total N, P, K and S respectively. The pH values increased about 0.4 units and EC values increased 0.26 to 1.77 dS cm^{-1}. The average sand content of the soil profiles increased by 330%, while, the silt and clay contents decreased by 49 and 40 %, respectively.

Karaman *et al.* (2006) investigated effect of firing temperature on physical properties of clay bricks. He noted that silica changes its crystal form at 573°C and fired brick turn red due to oxidation of ferrous silicate at 550°C. At this temperature dehydroxylation takes place and carbonaceous organic matter starts to burn off. His study also revealed that increase in firing temperature result in greater weight loss up to 15%, increase in bulk density whereas, water absorption of brick on firing drastically reduced.

Salek (2007) studied the effect of brick fields on some chemical properties of soil at Birganj of Dinajpur in Banglsdesh with experiment conducted with ten soil samples collected from five brick fields and near agriculture fields. The study reveals that the activities carried out in brick fields for preparation of brick decreased available N, P, K and S in brick fields as compared to agriculture field. The study indicates that preparation of brick fields for manufacturing of bricks in general is detrimental for sustainable soil fertility.

Gollany *et al.* (2012) conducted study to determine the effect of desurfacing and topsoil depth on soil properties and corn yield under field study conducted for five years. Result shows that a reduction in top soil depth drastically reduce corn yield grown on desurfaced soil as much as 49% grain yield and 23% of total yield. Research also highlights the negative impact of desurfacing on soil properties.

Ismail (2012) carried out research work to compare the nutrients status of some selected brick fields soil and agriculture fields and found that the Brick fields were responsible for decreasing soil nutrients status; it also depleted fertility and productivity of soil. Most of the nutrients were comparatively higher in agricultural fields than those of brick field soils (except S, K & Na) as well as surface soils than those of subsurface soils. The overall results indicated that the brick fields were responsible for decreasing soil nutrients status.

Saviour and Stalin (2012) analyzed physiochemical parameters and cations like Cu^{2+}, Mn^{2+}, Fe^{2+}, and Zn^{2+} from mined soil areas and found that concentration exceeds the

permissible limit. They also reported that ex-mined soil has high heavy metal pollution potential.

Yadav (2013) conducted study for assessment of soil degradation due to brick kiln industry by using satellite imagery coupled with soil analysis and field study. He reported that repeated heating by brick industry had reduced soil fertility. He reported high decline in total N, P, and K as low as 0.161%, 0.101%, and 0.011% due to thermal effect of brick kiln. The fertile acidic soil has changed to infertile alkaline soil in study area. His study also reveals the negative impact on soil physical properties such as moisture holding capacity, texture and bulk density.

Noll (2015) reported that average weight of fired brick in study area is 2.12 kg while, average grain size distribution of analyzed green brick sample were 12.9% gravel,19.1% sand 38.4% silt and 29.7% clay. According to his research 1,196.24kg of soil is consumed per produced tones of bricks. He reported the high significance of soil as a raw material for brick production and illustrated the net export of a crucial resource from agriculture area and watershed for the urbanization in Mumbai metropolitan region.

2.3 Soil desurfacing and degradation of soil due to brick making process: -

Grewal and Kuhad (2002) described the extent of desurfacing in Haryana (India) with its impact on soil productivity and concluded that soil desurfacing by brick kilns for brick making is on exponential increase and a threat to soil

protection and soil productivity. The study points out that desurfacing of farm lands for brick industry is another source of soil degradation. Thousands of hectares of lands are losing their productive potential due to unscientific extraction of soils. Rapid restoration of soil productivity and management of desurfaced soils is of great concern for country like India and warrants due attention from all concerned.

Abdalla *et al.* (2012) studied the effect of red brick production on land use in Sudan by interviewing 49 kiln owners using semi detailed questionnaires. Study showed that rapid expansion of red brick making is a key factor shaping urban land use. Study shows brick making occurs on most fertile agriculture soils along river banks in study area responsible for their degradation which were fertile agriculture soils.

Singh *et al.* (2014) mapped and identify desurfaced soils in Rohtak and Jhajjar districts of Haryana, India using remote sensing and concluded that removal of surface soil for brick resulted in substantial areas of low quality land. The land is incapable of productive use without some form of remediation.

Suraj and Neelakantan (2014) evaluated the impact of clay mining on the hydrological ecosystem in central Kerala using spatial data, collateral data and field based data. Study highlights the excavation of soil for brick making as severe threat of soil erosion and land degradation. Soil profile study in research area reveals good quality alluvial soil is mined for brick making.

3. MATERIAL AND METHODS

The present investigation entitled “Assessment of soil and nutrient loss during brick making process in western Maharashtra” was carried out at eight districts of western Maharashtra and analysis of soil sample was carried out at the Department of Soil Science and Agriculture Chemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri during period from November 2015 to April 2017. For conducting study on a scientific investigation, methodology is an important part. It helps to collect valid and reliable information and to arrive at a meaningful conclusion.

With this view the details of material used and methods adapted during the course of investigation are presented in this chapter under following heads.

3.1 Location

The study was conducted in eight districts of western Maharashtra under Pune and Nashik division. The preparatory survey was conducted with view to locate license holder brick industries in concerned district with local help. From each district 2 factories were selected for sample collection and the brick factory owners were interviewed using a semi detail questionnaire from January-April 2016. Factory locations were recorded using hand held Geographical Positioning System (GPS; Trimble Pathfinder, Sunnyvale, CA, USA). During the survey, detail information about the source of soil used for brick making and location of river or lake is also collected from the concerned owner of the factory. The detailed information about districts, notation for each location, name of village or city, GPS

Table 1: Location of 16 brick factories under study:-

Sr. No	District	Location	Notation	GPS location of brick kiln		Name of brick factory owner
				Longitude	Longitude	
1	Ahmednagar	Sangamner	A1	19°34'52.0"N	74°15'44.1"E	Mr. Baban Abhang
2	Ahmednagar	Shrirampur	A2	19°40'01.7"N	74°38'45.2"E	Mr. Ravindra Ingale
3	Dhule	Mahindale	B1	20°53'39.6"N	74°45'02.0"E	Mr. Vijay Thansekar
4	Dhule	Chittod	B2	20°87'97.5"N	74°74'79.4"E	Mr. Sunil Patil
5	Nashik	Manmad	C1	20°21'73.9"N	74°42'26.8"E	Mr. Sanjay Shinde
6	Nashik	Dahegaon	C2	20°16'44.6"N	74°26'27.9"E	Mr. Ramesh Kadnor
7	Pune	Miraj	E1	16°48'47.5"N	74°38'41.9"E	Mr.Dipak Hulwan
8	Pune	Bamni	E2	16°49'08.2"N	74°36'28.9"E	Mr.Manoj Kumbhar
9	Sangli	karhad	F1	17°14'08.4"N	74°07'15.7"E	Mr. Shankar Khabale
10	Sangli	Patan	F2	17°22'58.9"N	73°55'06.5"E	Mr. Dinkar Dhamankar
11	Satara	Pandharpur	G1	17°41'50.7"N	75°20'03.5"E	Mr. Damu Yedge
12	Satara	Takligursala	G2	17°44'47.9"N	75°20'54.6"E	Mr. Vikas Ganpule
13	Solapur	Sarnobatwadi	H1	16°41'01.8"N	74°16'24.3"E	Miss. Sunita Bhoite
14	Solapur	Uchgaon	H2	16°41'37.9"N	74°16'30.8"E	Mr.Rahul Mandwe
15	Kolhapur	Shirur	D1	18°50'04.6"N	74°24'29.7"E	Mr. Pravin Basane
16	Kolhapur	Indapur	D2	18°06'04.5"N	75°00'14.3"E	Mr. Dhyanesh kumbhar

location, and name of the brick factory owner were mentioned in table 1.

3.2 Climate and Soils

Maharashtra state has been divided into 9 agro-climatic zones based on rainfall, soil type and the vegetation. Eight districts under present investigation mainly fall under the four agro-climatic zones as mentioned below, the brief details about name of zone, climate prevailing and soil types were presented in table 2.

Table 2: Agro-climatic zones with climate and soil type-

Sr. no.	Agro-climatic Zone	Temperature (°C)		Rainfall (mm)	Soil type	Location of study area
		Max	Min			
1	Western Ghat [No.3]	29-39	13-20	3000 to 4000	Light laterite & reddish brown, Distinctly acidic, Poor fertility, Low P & K.	Some part of Kolhapur, Satara.
2	Transition Zone-1 [No.4]	28-35	14-19	700 to 2500	Reddish brown to black, pH 6-7. Well supplied in N and P & K.	Most of Kolhapur, and some part of Pune, Nashik Satara.
3	Transition Zone-2 [No. 5]	34-40	15-21	700 to 1200	Grayish black soils, Moderately alkaline pH 7.4-8.4, fair in NPK.	Most part Nagar, Sangli, Dhule, Solapur, Sangli
4	Scarcity Zone [No. 6]	36-42	14-18	Less than 750	The soils are vertisol, montmorilonite clay, Low in N, medium in P and high in K.	Most part of Nagar, Sangli, Dhule, Solapur, Sangli

Among all these four zones the maximum area of 8 districts under investigation mostly dominated by transition zone-2 and scarcity zone. (Source: NIDM)

Table 3. Schedule of research work

Sr.No	Particulars of research work	Period
1.	Collected preliminary data and information regarding brick production units in selected 8 districts for study.	Feb-March 2016
2.	Visited to the brick production units.	April - May 2016
3.	Collected initial soil sample collection before brick making starts.	April – May 2016
4.	Collected information and soil samples from owner of brick production kiln.	April - June 2016
5.	Collected final soil sample after brick making process.	June 2016
6.	Crushed of brick samples and soil sample grading and sieving with 2 mm and 5 mm sieve.	July 2016
7.	Analysed for DHA and OC %	Aug 2016
8.	Analysed of physical and chemical properties of samples.	Aug –Dec 2016
9.	Analysed other parameters	Jan-Feb 2017
10.	Statistical analysis done	March 2017

3.4 Type of samples

For studying nutrient loss followed by degradation of agriculture soil, five types of soil samples were confirmed for sampling which represented the whole brick making process. The sample types given notation like S_1, S_2.....S_5 for easy understanding and classification. The details of sample types collected from each of sixteen brick factories were explained below

S_1 Excavated soil either from river bed or agriculture land which is transported to brick factory which is used further for brick making.

S_2 Molded / Unfired / Green brick.

S_3 Fired / Red brick.

S_4 Surface soil sample (22.5 cm) below the brick kiln.

S_5 Surface soil sample from cultivable agricultural land around 100-meter distance from brick industry.

These symbols (i.e. S_1, S_2....S_5) for specific sample type were frequently used in further literature for most of tables and texts.

3.5 Sample collection and processing

Proper methods were adapted and strict care was taken during the collection of soil sampling as result of the investigation solely depends on accurate sampling.

S_1 soil which is collected from different resources is piled in the production unit. So 7-8 random sample from different different piles were collected and mixed well on a paper. After mixing a composite sample was taken.

S_2 and **S_3** four to five brick randomly selected from the stack and crushed them separately with iron hammer and

ground brick sample were collected, fresh moist molded brick sample is also collected and placed separately from the working area of kiln for estimating biological properties.

S_4 and **S_5** these samples were collected by routine soil sample collection procedures.

All samples were placed into the well labeled sealed polythene bags and brought back to the laboratory and all 80 samples (16 kiln x 5 samples) were ground with wooden mortar and pestle. Then samples were sieved with 2 mm and 5 mm sieve and stored in cotton bags for further analysis of physical, chemical and biological properties of soil.

3.6 Data collection:

For present investigation, we personally visited all 16 brick factories in 8 districts and also owner of each brick factory was interviewed by semi structured questionnaire. The data collected from respondents included general information such as name, year of establishment of industry, source of material added during molding etc. Along with formulated questions another extra information or facts was observed during brick making process, such data also added to strengthen the research.

We tried hard to get actual number of brick industries running in specific districts but due to some constrains and limitation, this data could be made available. In our study we also observed that brick industries are not on radar of government bodies yet and there is no any trustworthy statistical data is available to them. Data collected during survey with objective to estimate soil loss is presented in table no. 4.

Table 4 Questionnaires for soil loss and mean weights of green and fired bricks

Sr No.	Location	No. of bricks produced per year (Lakhs)	Total soil used in terms of no of trolleys#	Total no years since factory started	Mean weight^ of green brick (kg)	Mean weight ^ of fired brick (kg)
1	A1	6	300	31	2.52	2.23
2	A2	8	400	18	4.94	4.71
3	B1	2.5	175	11	2.46	2.00
4	B2	1.5	80	14	2.71	2.25
5	C1	0.75	50	31	2.51	2.20
6	C2	3	150	41	2.43	2.07
7	D1	5	130	4	2.07	1.73
8	D2	7	180	8	2.45	2.14
9	E1	35	3000	18	2.75	2.45
10	E2	17	900	21	2.45	2.02
11	F1	8	600	10	3.42	3.10
12	F2	18	1400	22	2.46	2.14
13	G1	2	80	12	2.38	1.79
14	G2	2.5	90	4	2.51	2.05
15	H1	4	250	20	4.74	4.21
16	H2	6	350	8	5.07	4.03
	Average	7.9	508.5	17	3	2.57
	Total	126.2	8135		47.95	41.19

(#:- As per the answer given by the factory owners and some discussion with transport experts conclusions were made that one tractor trolley approximately can hold 10-12 tons soil and one dumper truck can hold 20-25 tons of soil i.e. twice the trolley so with this view some observations of dumper are mentioned in terms trolleys only for uniformity in study)

(^:- From each brick kiln under study we took 4 random green (molded/unfired) bricks and fired bricks from different storage

lots for weighing. Then each weight is taken by pocket weighing machine followed by arithmetic mean)

(Notations for location which are used frequently in most of tables:- 1] Ahmednagar : A, 2] Dhule : B, 3] Nashik : C, 4] Pune : D, 5] Sangli : E , 6] Satara : F , 7] Solapur : G, 8] Kolhapur : H respectively.)

3.7 Soil loss due to brick making:

Data obtained from quaternaries was utilized for approximate soil loss due to brick making process. Two approaches were utilized for quantifying soil loss. In first approach soil loss in terms of tones of soil used based on the brick produced per year by individual brick factory. In second soil loss in terms of hectares of top 15 cm soil per year. Soil loss in both the approaches were quantified for average of 16 brick factory i.e. for single brick factory and for all total 16 brick factory followed by increasing trend of 100, 1000 and 100000 brick factories. This soil loss is calculated with the help of generalized quantitative assumption generated through survey and questionnaires data as statistical data regarding total no of brick factories in specific districts was not available due to some constrains.

3.7 (a) Soil loss in terms of tonnes of soil

Total Soil Loss from N no factories (tonnes) =

$$\{ \sum^{i}_{n=1} (Xa.Ya + Xb.Yb + \ldots\ldots Xn.Yn) \} \times 10^{-3} \ldots\ldots\ldots\ldots \text{where,}$$

Xa= no. of bricks produced for i^{th} factory or kiln

Xb= weight of brick from i^{th} factory in Kg

3.7 (b) Soil loss in terms of hectares of soil (15 cm layer)

$$\left\{ \sum_{n=1}^{i} \frac{(Xa.Ya + Xb.Yb.+\ldots\ldots\ldots Xn.Yn.)}{2.24 \times 10^6} \right.$$

where; Xa = no of bricks produced per year by specific factory (lakhs)

Yb = average weight of fired brick by specific factory

a,b,c …n= specific brick factory

3.8 (a) Gain or loss in nutrient or specific soil property due to brick making process

Gain or loss in any nutrient concentration or specific soil property was calculated by considering average value for S_1 (soil excavated for brick making) as basis for comparison with S_2 (green brick) and S_3 (fired brick) i.e. result obtained for S_2 and S_3 were compared with S_1 to calculate overall gain or loss in any soil property. Denoted by (*) in further tables.

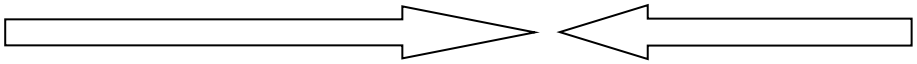
3.8 (b) Degradation of agriculture soils by brick making

Degradation of agriculture soil influenced by brick burning was calculated in terms of gain or loss in any nutrient concentration or specific soil property by considering average value of S_5 (normal agriculture soil near brick field) as basis of comparison with S_4 (soil below brick kiln). Denoted by (#) in further tables.

Same methodology and trend was followed in further tables for different parameters to calculate % gain and % loss from S_1 to S_2, S_3 and from S_5 to S_4. S_1 and S_5 were considered as

100%. Example is presented and elaborated in following table for organic C content in different soil samples.

Sample ⇨ / Location ⇩	S_1	S_2	S_3	S_4	S_5
All 16 location data	0.14-0.56	0.24-1.13	0-.08	.06-0.43	.017-0.57
Average	0.38	0.63	0.04	0.19	0.38
Gain/Loss	*	G 0.25	L 0.34	L 0.20	#
% G / % L	*	G 66.3	L 90.5	L 51.8	#



3.9 Pot culture experiment

To assess capacity of different samples to support plant growth a separate pot culture experiment was conducted in wire house at Department of Soil Science and Agril. Chemistry, M.P.K.V., Rahuri, during November 2016 in which five different types of soil samples collected during sample collection utilized as medium for plant growth. Plastic pots having 2.5 -3 kg capacity were taken and filled with 2 kg of samples. 50 seeds of wheat were sown per pot and visual observation and photographs were taken on 15 days after sowing.

Sr. No	Particular	Details
1.	Name of crop	Wheat
2.	Variety	Fule Netravadi
3.	Treatments	5 (S_1, S_2, S_3, S_4 and S_5)
4.	Replications	4 (Locations)
5.	Seed rate	50 seeds per plot
6.	Sowing date	15 November

3.10 Method of analysis:

Soil samples were analyzed for physical, chemical and biological properties by adopting standard methods of analysis (Table 5, Sr. No. A, B and C)

Table 5. Standard methods adopted for soil physical and chemical analysis

Sr. no.	Particular	Method	Reference
A.	**Physical Properties:**		
1.	Soil texture	International pipette method	Piper (1966)
2.	Bulk density	Clod method	Blake and Hartage (1986)
3.	Soil color	Colour chart	Munsell color Chart (1975)
4.	Available water content	Pressure plate and pressure membrane apparatus	Richards (1941)
B.	**Chemical Properties:**		
1.	pH (1:2.5)	Potentiometric	Jackson (1973)
2.	EC (1:2.5) dS m^{-1}	Conductometry	Jackson (1973)
3.	Organic Carbon (%)	Wet oxidation	Nelson and Sommer (1982)
4.	Free $CaCO_3$ (%)	Acid neutralization	Alison and Moodier (1965)
5.	Total N	Macro-Kjeldahl	Keeny and Nelson(1982)
6.	Total P	Modified procedure of Chang and Jackson	Peterson and Corey(1966)
7.	Total K	H_2SO_4,$HClO_4$ and HF digestion	Jackson (1973)
8.	Available N (kg ha^{-1})	Alkaline permanganate	Subbiah and Asija (1956)

9.	Available P (kg ha^{-1})	0.5 M $NaHCO_3$ (pH 8.5) Ascorbic acid	Watanabe and Olsen (1965)
10.	Available K (kg ha^{-1})	1 N *N* NH_4OAc	Knudsen and Peterson (1982)
11.	Available S (kg ha^{-1})	Calcium Chloride extraction method	Williams and Steinberg(1959)
12.	DTPA extractable micronutrient Fe, Mn, Zn, Cu	Atomic absorption spectrophotometer	Lindsay and Norvell (1978)
C.	**Biological Properties:**		
1.	Dehydrogenase activity (DHA)	Spectophotometry	Casida *et al.* (1964)

3.11 Statistical Analysis:

The data generated after the chemical and physical observations recorded for soil and brick samples as per the scheduled program mentioned above was statistically analyzed by adopting ANOVA: Single factor as suggested by Panse and Sukhatme (1985).

4. Result and Discussion

The study was conducted in 8 districts of western Maharashtra followed by analysis of samples at Department of Soil Science and Agricultural Chemistry, MPKV, Rahuri 2016-17 with view to assess the soil and nutrient loss during the brick making process along with assessment of degradation of agriculture land. The result obtained and observation recorded are presented and discussed in this chapter.

4.1 Assessment of soil loss during brick making process.

Table 6. Observations from 16 brick factories under study

Data of 16 brick factories under study	No. of bricks produced per year (Lakhs)	Total soil used in terms of no of trolleys/year	Total no years since factory started	Mean weight of green brick(Kg)	Mean weight of fired brick (Kg)
Total	126.25	8135	--	47.95	41.19
Average	7.89	508.5	17	3	2.57

Data obtained from questionnaires was utilized for calculating approximate soil loss due to brick making process. Two approaches were utilized for quantifying soil loss. In first approach soil loss in terms of tones of soil used was calculated based on the brick produced per year by individual brick factory. In second, soil loss in terms of hectares of agriculture land comprising only top 15 cm soil layer per year. Soil loss in both the approaches were quantified for average of 16 brick factory i.e. for single brick factory and for all total 16 brick factory followed by increasing trend of 100,1000 and 100000 brick factories. This soil loss is calculated

with the help of generalized quantitative assumption generated through survey and questionnaires data, as statistical data regarding total number of brick factories in specific districts were not available due to some constrains.

4.1(a) Soil loss in terms of tonnes of soil

From table 6.

Mean weight of fired brick = 2.57 kg.....(1)

Total bricks produced / year/ factory = 7.9 lakhs.....(2)

Total bricks produced / year /16 factories = 126.4 lakhs ...(3)

By using following formula;

Total Soil Loss from N number of factories (tonnes) =

$\{ \sum^{i}_{n=1} (Xa.Ya=+Xb.Yb+.....Xn.Yn) \} \times 10^{-3}$.....where,

Xa= no. of bricks produced for i^{th} factory or kiln

Xb= weight of brick from i^{th} factory in Kg

❖ Soil loss from single brick factory = $790000 \times 2.57 \times 10^{-3}$

= 2030.3 tonnes $year^{-1}$....(A)

Hence on an average single brick factory is responsible for 2030.3 tonnes of soil loss per year as only soil was used as raw material for brick making at all the brick factories under study area.

❖ Soil loss from 16 brick factories = $12640000 \times 2.57 \times 10^{-3}$

= 32484.800 tonnes $year^{-1}$

Hence on an average only 16 brick factories under investigation were responsible for 32484.80 tonnes of soil loss which is very tremendous loss of soil which in turn a precious natural resource.

❖ Soil loss from 100 brick factories = (A) x 100

= 2030.3 x 100

= 203030 tonnes $year^{-1}$

❖ Soil loss from 100000 brick factories =203030000 tonnes $year^{-1}$

If increasing trend of number of brick factories were included in above calculations the soil loss was piling up at proliferating rate.

4.1(b) Soil loss in terms of hectares of soil (15 cm layer)

It is evident that the weight of top 15 cm layer from one-hectare soil in field is equal to 2.24 x 10^6 kg ha^{-1} (Millar and Turk, 2002). By using this relation an attempt was made to quantify soil loss in terms of hectares of agriculture soil.

➢ Total soil loss by brick factories in hectares (top 15 cm layer) $year^{-1}$=

$$\left\{ \sum_{n=1}^{i} \frac{(Xa.Ya + Xb.Yb.+\ldots\ldots\ldots Xn.Yn.)}{2.24 \times 10^6} \right.$$

where; Xa = no of bricks produced per year by specific factory (lakhs)

Yb = average weight of fired brick by specific factory

a,b,c …n= specific brick factory

- Average soil loss from single brick factory (hectares year^{-1}) =

$$= \frac{7.9 \times 2.57}{22.4}$$

= 0.90 hectare year^{-1}…..(B)

- Soil loss from 16 brick factories under investigation =

$$= \frac{\text{Total brick produced from 16 kilns X Average weight of fired birick}}{22.4}$$

$$= \frac{126.4 \times 2.57}{22.4}$$

= 14.5 hectares year^{-1}

- Soil loss from 100 brick factories = (B) x 100

= 0.90 x 100

= 90 hectares year^{-1}

- Soil loss from 100000 brick factories = (B) x 100000

= 90,000 hectares year^{-1}

With this approach, also if increasing trend of number of brick factories were considered and included in above calculations the soil loss was piling up at proliferating rate.

4.2 Effect of brick making process on different physical properties of soil

The physical properties of different soil samples collected from all 16 brick kilns under study *viz.*, texture, bulk density, soil colour, available water content at 1/3rd and 15 bar are presented in table 7 to 10 and discussed under following subheads.

4.2.1 Soil texture

The texture of soil used for brick making (S_1), soil below the brick kiln (S_4) and soil from agriculture field (S_5) was presented in Table 7 as % of sand, silt and clay respectively. Texture of green bricks (S_2) and fired bricks (S_3) were omitted as it varies with impact force applied for breaking and solely depends on the crushing power applied.

The sand, silt and clay percent in soil used for brick making (S_1) was found in the range of 19 to 37 %, 33 to 53 % and 21 to 36 % respectively. Most of the samples were silt loam to silty clay loam in texture as good texture soil is used for brick making process for better binding and strength to bricks. The sand, silt and clay present in agriculture soil samples near brick kiln (S_5) were in range 10 to 40 %, 31 to 55 %, and 25 to 48 % respectively, which varied considerably location to location.

The texture of samples of soil below the brick kiln (S_4) was in range 31 to 61, 23 to 48 and 09 to 30 respectively. A sharp decline in clay and silt content was observed in these samples. The increased sand content is due to accumulation of sand in top layer migration of clay to subsoil horizons, structural transformation of

clay during burning of bricks in kiln and its impact and accumulation on surface soil below the kiln. Similar results of increased sand content and decreased clay percent was reported by (Khan *et al.*, 2005) in soil samples collected around brick kilns in western part of Bangladesh.

Table 7. Percentage of sand silt and clay in different samples

		Soil texture								
		Sample Type								
Location		**S_1**			**S_4**			**S_5**		
Sr No.	Area	Sand (%)	Silt (%)	Clay (%)	Sand (%)	Silt (%)	Clay (%)	Sand (%)	Silt (%)	Clay (%)
1	A1	35	44	21	59	23	18	10	55	35
2	A2	29	46	25	52	32	16	16	41	43
3	B1	30	41	29	43	33	24	21	39	40
4	B2	34	35	31	31	39	30	26	49	25
5	C1	32	39	29	57	34	9	20	44	36
6	C2	26	44	30	44	32	24	38	35	27
7	D1	23	52	25	51	29	20	29	41	30
8	D2	37	40	23	38	34	28	13	39	48
9	E1	25	45	30	49	27	24	30	41	29
10	E2	29	43	28	47	38	15	34	31	45
11	F1	34	42	24	39	48	13	21	38	41
12	F2	19	53	28	31	43	26	15	46	39
13	G1	32	37	31	42	38	20	40	34	26
14	G2	31	33	36	36	43	21	16	39	45
15	H1	31	44	25	61	25	14	27	44	29
16	H2	34	37	29	39	34	27	35	31	34
	Average	30.1	42.2	27.8	44.9	34.5	20.6	24.4	40.4	35.8
	Range	19-37	33-53	21-36	31-61	23-48	9-30	10-40	31-55	25-48

4.2.2 Bulk density

The data related to bulk density of different soils are presented in table 8. Bulk density of soil used for brick making was ranged from 1.32 to 1.65 Mg m^{-3} with the mean of 1.46 Mg m^{-3}. The bulk density of green and red bricks was in range of 1.88 to 2.40 Mg m^{-3} and 2.24 to 2.60 Mg m^{-3} respectively with mean value of 2.16 Mg m^{-3} and 2.44 Mg m^{-3}. The result shows gradual increase in bulk density in transformation of normal soil to green brick due to compaction in molding and further its conversion to red brick and exclusion of water and air due to burning. The high B.D. values may be due to the fact that we get high BD values when done on small clods but in reality BD values less as we do not take account of cracks. Similar results were also reported by (Karaman *et al.,* 2006) under their investigation on effect of firing temperature on physical properties of clay bricks.

Bulk density of agriculture soil near brick field ranged from 1.29 to 1.67 Mgm^{-3} with mean value of 1.48 Mg m^{-3} which normally attributed to agriculture soils for optimum crop growth.
Bulk density of soil below brick kiln increased with 21.7% as compared to normal agriculture soil and ranged from 1.63 to 2.00 Mg m^{-3} with mean value of 1.80 Mg m^{-3}. This is due to continuous compaction effect exerted by the weight of bricks stacked into the kiln for burning and various heavy operations on that soil.

Table 8 Effect of brick making on bulk density of soil

Sr. No	Location	Soil bulk density (Mg m^{-3}) Sample type				
		S_1	S_2	S_3	S_4	S_5
1	Nagar A1	1.55	2.31	2.42	1.85	1.45
2	Nagar A2	1.49	2.25	2.52	1.81	1.37
3	Dhule B1	1.43	2.15	2.43	1.86	1.46
4	Dhule B2	1.46	2.04	2.56	1.76	1.50
5	Nashik C1	1.65	2.40	2.59	1.80	1.67
6	Nashik C2	1.45	1.96	2.25	1.65	1.47
7	Pune D1	1.44	2.15	2.60	1.63	1.59
8	Pune D2	1.48	2.16	2.33	1.84	1.46
9	Sangli E1	1.52	2.23	2.24	1.71	1.59
10	Sangli E2	1.47	2.16	2.47	2.00	1.29
11	Satara F1	1.43	1.88	2.37	1.92	1.31
12	Satara F2	1.36	2.29	2.38	1.79	1.53
13	Solapur G1	1.30	1.92	2.60	1.88	1.47
14	Solapur G2	1.35	2.21	2.48	1.76	1.40
15	Kolhapur H1	1.64	2.20	2.44	1.82	1.59
16	Kolhapur H2	1.36	2.23	2.52	1.71	1.52
	Average	1.46	2.16	2.44	1.80	1.48
	Range	1.32-1.65	1.88-2.40	2.24-2.60	1.63-2.00	1.29-1.67
	Gain/Loss	*	0.7 G	0.98 G	0.32 G	#
	% G / % L	*	47.8 G	66.8 G	21.7 G	#
	Mean	1.87				
	SEm (±)	0.03				
	CD at 5%	0.08				

[Note: (*) Gain or loss in any nutrient concentration or specific soil property was calculated by considering average value for S1 (soil excavated for brick making) as basis for comparison with S2 (green brick) and S3 (fired brick) i.e. result obtained for S2 and S3 were compared with S1 to calculate overall gain or loss in any soil property. Denoted by (*) in further tables.]

[Degradation of agriculture soil influenced by brick burning was calculated in terms of gain or loss in any nutrient concentration or

specific soil property by considering average value of S5 (normal agriculture soil near brick field) as basis of comparison with S4 (soil below brick kiln). Denoted by (#) in further tables.]

Same methodology and trend was followed in further tables for different parameters to calculate % gain and % loss from S_1 to S_2, S_3 and from S_5 to S_4. S_1 and S_5 were considered as 100%.

4.2.3 Available water content at 1/3rd and 15 bars

The data on available water content of different soil samples at 1/3rd bar (at field capacity) and at 15 bars (at permanent wilting point) are presented in table 9 and 10. Available water content of soil used for brick making (S_1) was in range of 29.6 to 34.8% and 14.6 to 19.2% at 1/3rd and 15 bars respectively, with mean values 32.3% and 16.7%. In green brick it was increased was to from 31.5 to 32.2% and 16.8 to 20.9% with mean values 34.7% and 18.9% with 7.4% and 13.1 % gain respectively. This increase may be due to the addition of organic matter like rice husk, baggasse, sorghum straw etc. during molding of green bricks which increases the water holding capacity of soil at different soil moisture tensions. In red bricks 13.29% and 31.9% loss of available moisture content was found which ranged between 23.0 to 31.6% and 8.2 to 14.1% with mean values 28% and 11.3% respectively. This loss was due to loss of organic matter during burning of red bricks and conversion of active clay into dent clay due to the high temperature burning ranging from 900-1200^{0}C.

Available water content at 1/3rd bar of soil below brick kiln and normal agriculture soil ranges from 26.1 to 32.6% and 31.5 to 35.7% with mean values of 29.5% and 33.2% respectively.

At 15 bar it ranged from 11.2 to 18.7% and 12.4 to 20% with mean of 15.3% and 17.6% respectively. The decreased in available water content in soil below brick kiln may be due to the increased sand content with significant decrement in clay content and loss of organic matter due to burning of brick kiln.

Table 9 Moisture content at 1/3rd bar of as influenced by brick making process

Sr No.	Location	Moisture content at 1/3 bar (%)				
		Sample type				
		S_1	S_2	S_3	S_4	S_5
1	Nagar A1	33.0	36.8	23.0	28.8	32.4
2	Nagar A2	31.3	32.3	26.9	28.0	31.9
3	Dhule B1	34.8	37.2	30.3	32.5	35.5
4	Dhule B2	32.9	36.3	29.5	30.6	32.1
5	Nashik C1	33.5	35.0	29.0	30.1	32.0
6	Nashik C2	32.0	34.8	31.3	32.0	32.5
7	Pune D1	32.1	35.1	27.6	28.2	34.1
8	Pune D2	30.2	33.5	28.9	29.6	32.5
9	Sangli E1	32.6	35.0	25.4	26.1	34.0
10	Sangli E2	29.6	33.3	26.7	28.5	31.5
11	Satara F1	34.6	35.1	31.6	27.3	35.7
12	Satara F2	33.1	35.4	29.8	30.6	32.5
13	Solapur G1	31.1	33.5	24.7	27.8	33.5
14	Solapur G2	30.3	31.5	27.1	29.8	32.7
15	Kolhapur H1	33.5	35.9	27.5	32.6	34.7
16	Kolhapur H2	31.9	34.2	28.5	30.2	34.2
	Average	32.3	34.7	28.0	29.5	33.2
	Range	29.6-34.8	31.5-37.2	23.0-31.6	26.1-32.6	31.5-35.7
	Gain/Loss	*	G 2.41	G 4.29	G 3.69	#
	% G / % L	*	G 7.46	G 13.2	G 11.1	#
	Mean	31.54				
	SEm (±)	0.44				
	CD at 5%	1.24				

Table 10 Moisture content at 15 bars of as influenced by brick making process

Sr No.	Location	Moisture content at 15 bar (%)				
		Sample type				
		S_1	S_2	S_3	S_4	S_5
1	Nagar A1	17.81	18.91	12.77	16.12	19.23
2	Nagar A2	14.55	19.64	9.09	12.38	12.35
3	Dhule B1	16.26	18.16	11.03	15.47	18.12
4	Dhule B2	14.91	16.79	13.19	14.07	16.38
5	Nashik C1	16.37	19.52	14.08	15.33	17.29
6	Nashik C2	15.52	19.13	8.21	15.18	18.02
7	Pune D1	17.32	19.32	12.01	13.37	13.97
8	Pune D2	14.74	18.21	8.3	12.81	19.17
9	Sangli E1	18.39	20.18	10.67	16.87	17.13
10	Sangli E2	17.21	18.19	13.29	15.79	18.86
11	Satara F1	19.15	19.46	10.63	11.22	16.42
12	Satara F2	17.01	17.33	13.66	15.55	19.97
13	Solapur G1	18.11	19.58	12.58	18.71	18.52
14	Solapur G2	16.52	18.37	9.81	18.21	18.93
15	Kolhapur H1	17.83	20.89	10.01	19.31	19.48
16	Kolhapur H2	15.01	17.94	12.07	13.91	17.52
	Average	16.7	18.9	11.3	15.3	17.6
	Range	14.6-19.2	16.8-20.9	8.2-14.1	11.2-18.7	12.4-20.0
	Gain/Loss	*	G 2.18	L 5.33	L 2.32	#
	% G / % L	*	G 13.0	G 31.9	G 13.1	#
	Mean	15.94				
	SEm (±)	0.45				
	CD at 5%	1.27				

4.2.4 Soil colour

The data pertaining to soil colour of different soil samples were presented in table 11and 12**.** Soil colour of (S_1) and (S_5) were found variable in nature as great variability in source of soil collection from different locations among different districts under investigations. When green brick (S_2) was converted into red brick (S_3) the hue drastically decreased from 7.5 and 10YR to 2.5 and 5YR giving dominant reddish to yellowish red colour due to firing colour of clay brick is influenced by the chemical and mineral content of the raw material, the firing temperature and the atmosphere in the kiln. Reddish pink coloured bricks tend to be the result of high iron content whereas reddish yellow bricks are attributed to higher lime content. (www.etbricks.co.uk)

Reduction in value and chroma of colour with same hue in samples from below the brick kiln (S_4) may be due to the increased deposition of ash of burnt raw material on the surface below the brick kiln with increased sand content. The Dominant colour of (S_3) was reported red or combination of red with shade of yellow and brown colour.

Table11. Soil colour as influenced during brick making process

Sr No.	Location	Soil colour (Munsell colour chart)				
		Sample type				
		S_1	S_2	S_3	S_4	S_5
1	Nagar A1	10YR 4/3	10YR 6/3	2.5YR 7/8	2.5YR 6/4	7.5YR ¾
2	Nagar A2	10YR 4/4	10YR 6/2	2.5YR 4/8	5YR 7/2	7.5YR 4/4
3	Dhule B1	10YR 5/4	10YR 5/6	2.5YR 4/8	2.5YR 7/8	7.5YR 4/4
4	Dhule B2	10YR 4/4	7.5YR 6/4	5YR 5/8	7.5YR 7/2	10YR 3/3
5	Nashik C1	10YR 5/6	10YR 5/3	2.5YR 4/8	10YR 7/3	10YR 3/3
6	Nashik C2	10YR 5/8	10YR 5/4	5YR 4/6	10YR 6/2	7.5YR 5/6
7	Pune D1	10YR 4/3	10YR 5/3	2.5 YR 4/4	10YR 3/6	10YR 3/6
8	Pune D2	10YR 5/3	7.5YR 4/2	5YR 5/6	5YR 6/4	5YR 2.5/1
9	Sangli E1	10YR 4/4	10YR 4/4	2.5YR 4/3	7.5YR 6/4	7.5YR 4/1
10	Sangli E2	10YR 3/4	10YR 4/4	2.5YR 4/6	10YR 6/2	7.5YR 3/1
11	Satara F1	5YR 4/4	5YR 3/4	2.5YR 4/8	7.5YR 6/3	7.5YR ¾
12	Satara F2	5YR 4/4	5YR 3/3	2.5YR 5/6	2.5YR 7/2	7.5YR 3/3
13	Solapur G1	10YR 5/3	10YR 5/3	2.5 YR 5/6	5YR 6/3	2.5YR 3/2
14	Solapur G2	10YR 4/3	10YR 4/3	5YR 4/6	7.5YR 6/3	7.5YR 3/1
15	Kolhapur H1	5YR 4/4	7.5YR 4/6	2.5YR 4/8	2.5YR 5/4	2.5YR 3/1
16	Kolhapur H2	5YR 3/4	7.5YR 4/6	2.5YR 4/8	5YR 5/4	7.5YR 4/1
Note :	e.g.= 5YR ¾ then, '5YR': Hue , '3': Value, '4': Chroma					

Table12. Soil colour of different samples altered by brick making process

Sr No.	Location	Colour code as per Munsell colour chart				
		Sample type				
		S_1	S_2	S_3	S_4	S_5
1	A1	Brown	Pale brown	Light red	Light yellowish brown	Dark brown
2	A2	Dark yellowish brown	Light brownish gray	Red	Pinkish grey	Brown
3	B1	Yellowish brown	Yellowish brown	Red	Light red	Brown
4	B2	Dark yellowish brown	Light brown	Yellowish red	Pinkish grey	Dark brown
5	C1	Yellowish brown	Brown	Red	Very pale brown	Dark brown
6	C2	Brown	Dark yellowish brown	Yellowish red	Light brownish grey	Strong brown
7	D1	Brown	Brown	Reddish brown	Light yellowish brown	Dark yellowish brown
8	D2	Brown	Brown	Yellowish red	Light reddish brown	Black
9	E1	Brown	Dark yellowish brown	Reddish brown	Light brown	Dark Grey
10	E2	Dark yellowish brown	Dark yellowish brown	Red	Light brownish gray	Very dark grey
11	F1	Reddish brown	Dark reddish brown	Red	Light brown	Dark brown
12	F2	Reddish brown	Dark reddish brown	Red	Pale red	Dark brown
13	G1	Brown	Brown	Red	Light reddish brown	Very dark greyish brown
14	G2	Brown	Brown	Strong reddish brown	Light brown	Dark grey
15	H1	Reddish brown	Strong brown	Red	Reddish brown	Dark reddish gray
16	H2	Dark reddish brown	Strong brown	Red	Reddish brown	Dark gray

4.3 Change in different chemical properties during brickmaking process and degradation of agriculture soil as influenced by brick making

The change in different chemical properties such as pH, EC, organic carbon, $CaCO_3$, loss or gain in nutrient concentration such as available N, P, K, S and total N, P, K content of different soil samples along with change status of micronutrient such as Fe, Mn, Zn and Cu were presented in this section under different subheads. All this chemical properties alteration is largely influenced by different practices followed during the brick making processes.

4.3.1 Soil reaction (pH)

The data with respect to the soil pH were reported in table 13. The pH of the soil used for brick making (S_1) and green bricks (S_2) were at par with average values 7.67 and 7.46 with most of samples are slightly alkaline. The pH of red brick (S_3) was significantly increased as compared to S_1 and S_2 which ranged from 6.83 to 9.95 with average value of 8.62. This increased pH attributed to formation of hydroxides of Al and Fe formed during burning and loss of organic matter.

The pH of soil below the brick kiln (S_4) was increased as compared to normal agriculture soil (S_5) at an extent of 7.4 % which is ranges from 7.12 to 9.50 with average value of 8.15. This gradual increase in pH may be because of less buffering capacity of these soils due to disintegrated clay and minimum organic matter content. Similar results were reported by (Khan *et al.*,2005) in study conducted on burnt kiln in Bangladesh.

Table 13. Effect of brick making process on soil pH

Sr No.	Location	Soil pH (1: 2.5)				
		Sample type				
		S_1	S_2	S_3	S_4	S_5
1	Nagar A1	8.11	7.96	9.16	8.64	7.91
2	Nagar A2	8.05	8.09	8.13	8.23	8.02
3	Dhule B1	8.12	8.07	9.91	9.50	7.81
4	Dhule B2	7.62	7.64	7.79	8.21	7.98
5	Nashik C1	8.25	8.02	9.76	8.11	8.18
6	Nashik C2	7.77	7.83	7.92	8.70	7.69
7	Pune D1	7.89	7.82	8.97	7.91	7.52
8	Pune D2	7.99	7.78	8.14	8.14	7.59
9	Sangli E1	7.81	7.73	9.17	8.17	7.75
10	Sangli E2	8.05	7.81	9.95	8.16	7.37
11	Satara F1	6.76	6.52	9.06	7.25	6.59
12	Satara F2	7.11	6.61	7.68	7.66	6.93
13	Solapur G1	6.62	5.65	6.68	7.25	7.18
14	Solapur G2	8.05	7.84	9.29	8.48	8.21
15	Kolhapur H1	6.74	6.21	6.83	7.12	6.99
16	Kolhapur H2	7.92	7.76	9.46	8.84	7.82
	Average	7.67	7.46	8.62	8.15	7.58
	Range	6.62-8.25	6.52-8.09	6.83-9.95	7.12-9.50	6.59-8.21
	Gain/Loss	*	0.21 L	0.95 G	0.56 G	#
	% G / % L	*	2.69 L	12.4 G	7.44 G	#
	Mean	7.89				
	SEm (±)	0.18				
	CD at 5%	0.51				

4.3.2 Electrical conductivity (EC)

The data related to electrical conductivity of different soil samples reported in table 14. The EC of soil used for brick making ranged from0.28 to 1.51 dS m^{-1}, with average value of 0.67 dS m^{-1}. There is no significant difference between electrical conductivity of green brick and red brick samples as they ranged from 0.39 to 4.16 dS m^{-1} and 0.31 to 3.92 dS m^{-1} with average value of 1.77 dS m^{-1} and 1.84 dS m^{-1}, respecting This variation in salt content of soil may be due the variability in location from where sample were collected and difference in nature of organic matter, quality of water added during the molding process and fuel used for burning process.

There is significant increase in electrical conductivity observed between agriculture soil sample and sample from below the brick kiln ranging from 0.33 dS m^{-1} to 1.14 dS m^{-1} and 1.72 dS m^{-1} to 6.25 dS m^{-1} with average values 0.65 dS $m^{-1}$and 3.82 dS m^{-1} respectively. This increased salt content in sample below the brick kiln may be due to continuous accumulation of ash of coal and burning raw materials used as fuel which are salt forming material in nature unknown chemical added during process of firing bricks and absence of organic matter. Use of NaCl during firing process may also be responsible for higher EC and higher concentration of Na^{+} or its salt.

Table 14 Effect of brick making practices on electrical conductivity of different soil samples

Sr No.	Location	Electrical conductivity (dS m^{-1})(1:2.5) Sample type				
		S_1	S_2	S_3	S_4	S_5
1	Nagar A1	1.51	2.62	3.92	4.34	0.73
2	Nagar A2	1.06	2.76	1.06	3.86	0.38
3	Dhule B1	0.44	0.83	0.31	6.25	0.81
4	Dhule B2	0.61	0.44	1.42	2.98	0.29
5	Nashik C1	0.13	4.16	3.34	6.25	0.26
6	Nashik C2	0.81	0.53	1.16	4.01	1.14
7	Pune D1	0.74	0.93	1.37	2.91	0.38
8	Pune D2	0.47	2.86	3.01	5.57	0.33
9	Sangli E1	0.40	2.15	2.27	2.38	1.03
10	Sangli E2	0.28	2.64	2.89	3.76	0.91
11	Satara F1	1.01	2.31	2.68	3.31	0.48
12	Satara F2	0.81	1.76	1.38	4.91	0.63
13	Solapur G1	0.49	0.51	0.72	2.33	1.10
14	Solapur G2	0.71	1..33	1.36	4.94	0.84
15	Kolhapur H1	0.18	0.39	0.58	5.02	0.46
16	Kolhapur H2	1.14	1.68	1.99	2.89	0.68
	Average	0.67	1.77	1.84	3.82	0.65
	Range	0.28-1.51	0.39-4.16	0.31-3.92	1.72-6.25	0.33-1.14
	Gain/Loss	*	1.10 G	1.17 G	3.17 G	#
	% G / % L	*	162 G	173 G	485 G	#
	Mean	1.75				
	SEm (±)	0.23				
	CD at 5%	0.66				

4.3.3 Organic carbon (%)

The soil organic carbon content in different samples as influenced by brick making process is reported in table 15. The organic carbon % of soil used for brick making (S_1) ranged from 0.18% to 0.56% with average value 0.38% which significantly increased in molded brick (S_2) by 66.3% and ranged from0.24% to 1.13% with average value 0.65. This increment in organic carbon content in molded due addition of large quantity of locally available organic matter such as baggase, rice husk, sorghum straw etc. during the molding to get desired consistency to the soil mass. Significant loss of organic carbon observed in conversion of green brick (S_2) into fired brick (S_3) with 90.5% loss in organic carbon as it observed in range of 0 to 0.08% with average value 0.05 which is categorized as very low. This loss of soil organic C due oxidation and burning of organic matter and this biomass burning, during firing of bricks at 700-1200 ^{0}C (Kamyotra, 2007) and leads to the release of high amount of C in the form of atmospheric CO_2, aerosol and pyrogenic carbon ash in soil, (Araya, 2014).

Similar trend of decrement in soil organic carbon is observed in comparison of agriculture soil (S_5) with soil below the brick kiln (S_4). The organic carbon (%) in these samples ranged from 0.17 to 0.60% and 0.06 to 0.46% with average values 0.38% and 0.19% respectively, in which around half of organic matter reduction with average loss of 51.8%. The reason behind this reduction is that soil surface layer having immediate contact with firing clamp and impact of this prolonged high temperature during firing on to the soil below brick kiln.

Table15. Effect of brick making practices on organic carbon content of different soil samples

Sr No.	Location	Soil organic carbon (%)				
		Sample type				
		S_1	S_2	S_3	S_4	S_5
1	Nagar A1	0.18	0.24	0.06	0.09	0.26
2	Nagar A2	0.29	0.36	0.02	0.12	0.23
3	Dhule B1	0.36	0.50	0.02	0.06	0.17
4	Dhule B2	0.26	0.38	0.03	0.09	0.14
5	Nashik C1	0.14	0.42	0.08	0.18	0.41
6	Nashik C2	0.39	0.62	0.06	0.23	0.30
7	Pune D1	0.54	0.48	0.02	0.29	0.44
8	Pune D2	0.48	0.81	0.04	0.24	0.33
9	Sangli E1	0.44	0.59	0.02	0.27	0.47
10	Sangli E2	0.45	0.62	0.05	0.30	0.41
11	Satara F1	0.48	1.13	0.02	0.06	0.60
12	Satara F2	0.53	0.77	0.06	0.43	0.54
13	Solapur G1	0.56	1.01	0.00	0.12	0.39
14	Solapur G2	0.51	0.90	0.06	0.11	0.48
15	Kolhapur H1	0.18	0.74	0.02	0.21	0.57
16	Kolhapur H2	0.30	0.56	0.05	0.18	0.45
	Average	0.38	0.63	0.04	0.19	0.38
	Range	0.18-0.56	0.24-1.13	0.00-0.08	0.06-0.46	0.17-0.60
	Gain/Loss	*	G 0.25	L 0.34	L 0.20	#
	% G / % L	*	G 66.3	L 90.5	L 51.8	#
	Mean	0.32				
	SEm (±)	0.04				
	CD at 5%	0.10				

[Note: (*) Gain or loss in any nutrient concentration or specific soil property was calculated by considering average value for S1 (soil excavated for brick making) as basis for comparison with S2 (green brick) and S3 (fired brick) i.e. result obtained for S2 and S3 were compared with S1 to calculate overall gain or loss in any soil property. Denoted by (*) in further tables.

[Degradation of agriculture soil influenced by brick burning was calculated in terms of gain or loss in any nutrient concentration or specific soil property by considering average value of S5 (normal agriculture soil near brick field) as basis of comparison with S4 (soil below brick kiln). Denoted by (#) in further tables.]

Same methodology and trend was followed in further tables for different parameters to calculate % gain and % loss from S_1 to S_2, S_3 and from S_5 to S_4. S_1 and S_5 were considered as 100%.

4.3.4 Free $CaCO_3$(%)

The data on calcium carbonate status of different soil samples are presented in table 16. The calcium carbonate content of soil used for brick making (S_1) was ranged from 1.20% to 8.64% with average value 3.80%. It increased in green brick (S_2) with 18.64 % and decreased in fired brick (S_3) with 29.31% having $CaCO_3$ % ranged from 1.44 to 9.12% and 0.72 to 6.72% along with average values 4.5% and 2.7% respectively.

Significant loss 30.5% of $CaCO_3$ was observed in samples from below the brick kiln (S_4) as compared to normal agriculture soil (S_5), which ranges from 0.48 to 6.64% and 0.96 to 8.40% with average values 3.7% and 5.3% respectively. This reduction of 30.53% in $CaCO_3$ content may be due some escape of CO_2 due to heating of $CaCO_3$, a process akin to what happens in a lime kiln.

Table 16 Effect of brick making on soil $CaCO_3$ content

Sr No.	Location	Soil $CaCO_3$ equivalent (%)				
		Sample type				
		S_1	S_2	S_3	S_4	S_5
1	Nagar A1	5.52	5.76	3.48	3.96	4.80
2	Nagar A2	3.12	4.08	2.20	6.64	8.40
3	Dhule B1	8.64	9.12	6.72	5.28	7.76
4	Dhule B2	3.84	4.04	2.96	5.24	8.16
5	Nashik C1	3.60	4.24	3.16	4.08	6.84
6	Nashik C2	1.44	1.68	0.72	5.12	6.40
7	Pune D1	7.92	8.64	5.20	3.60	4.08
8	Pune D2	6.48	7.44	4.12	4.84	6.48
9	Sangli E1	1.20	2.64	2.20	4.88	7.16
10	Sangli E2	3.12	4.32	3.44	2.16	5.76
11	Satara F1	1.68	2.32	0.96	2.16	3.88
12	Satara F2	1.92	2.12	0.96	1.68	1.92
13	Solapur G1	5.52	6.20	1.44	6.40	7.68
14	Solapur G2	4.08	5.60	2.68	1.68	3.36
15	Kolhapur H1	1.44	2.40	1.48	1.24	0.96
16	Kolhapur H2	1.20	1.44	1.20	0.48	1.92
	Average	3.8	4.5	2.7	3.7	5.3
	Range	1.20-8.64	1.44-9.12	0.72-6.72	0.48-6.64	0.96-8.40
	Gain/Loss	*	G 0.71	L 1.11	G 1.63	#
	% G / % L	*	G 18.6	L 29.3	G 30.5	#
	Mean	4.01				
	SEm (±)	0.55				
	CD at 5%	1.54				

4.3.5 Available nitrogen

The data in respect of available nitrogen is presented in table 17. The available N in excavated soil used for brick making (S_1) ranged from 147.2 to 247.7 kg ha^{-1} with average value 200.5 kg ha^{-1} which is in low category. Highest available N was observed in excavated soils of Solapur district whereas lowest was in Nashik district, this variation in available N might be due to the variation in source of river alluvium and variation in mineral composition of soil which vary considerably location to location. Significant increase up to 41.6% in available N was observed in green brick (S_2) which ranged from 191.3 to 316.7 kg ha^{-1} with average value 242.1 kg ha^{-1}. This increase in available N is due to the addition of high load of organic matter in molding as most of available N in soil is present in organic form. Due to burning of organic matter available N significantly decreased up to 80.9% in fired brick samples which ranged from 15.7 to 90.9 kg ha^{-1} with average value 80.9 kg ha^{-1} which falls under very low category as per six tier system. The results are in agreement with reports of (Chen and Li, 2003) and (Yadav, 2013).

Available N was significantly reduced in samples from below the brick kiln (S_4) as compared to normal agriculture soil samples (S_5) by 60.9% with average values 34.5 to 138 kg ha^{-1} and 138 to 228.9 kg ha^{-1} having average values kg ha^{-1} and 195.2 kg ha^{-1} respectively. This is due to impact of prolonged burning on the surface of soil beneath the brick kiln with loss of organic matter as well as nitrogen in gaseous form. Similar results were also reported by (Khan *et al.,*2005) and (Salek, 2007).

Table 17 Effect of brick making on soil available nitrogen

Sr No.	Location	Soil available nitrogen (kg ha^{-1})				
		Sample type				
		S_1	S_2	S_3	S_4	S_5
1	Nagar A1	188.2	203.8	47.0	65.9	197.6
2	Nagar A2	178.8	191.3	34.5	69.0	188.2
3	Dhule B1	200.7	216.4	22.0	37.6	185.0
4	Dhule B2	213.2	222.7	31.4	59.6	138.0
5	Nashik C1	147.4	244.6	43.9	75.3	228.9
6	Nashik C2	175.6	219.5	28.2	90.9	144.3
7	Pune D1	247.7	232.1	15.7	34.5	210.1
8	Pune D2	207.0	279.1	28.2	100.5	228.9
9	Sangli E1	228.9	247.7	90.9	128.6	194.4
10	Sangli E2	203.8	235.2	40.8	138.0	184.0
11	Satara F1	207.0	316.7	31.4	53.3	150.5
12	Satara F2	188.2	225.8	59.6	84.7	194.4
13	Solapur G1	238.3	304.2	12.3	53.3	207.0
14	Solapur G2	228.9	288.5	18.8	62.7	216.4
15	Kolhapur H1	166.2	225.8	50.2	87.8	232.1
16	Kolhapur H2	188.2	219.5	56.4	78.4	222.7
	Average	200.5	242.1	38.2	76.3	195.2
	Range	147.2-247.7	191.3-316.7	15.7-90.9	34.5-138.0	138.0-228.9
	Gain/Loss	*	41.6 G	162.3 L	118.9 L	#
	% G / % L	*	20.7 G	80.9 L	60.9 L	#
	Mean	150.4				
	SEm (±)	7.22				
	CD at 5%	20.4				

4.3.6 Available phosphorus

The data in respect of available phosphorus is presented in table 18. The available P in excavated soil used for brick making (S_1) was ranged from 9.0 to 29.3 kg ha^{-1} with average value 16.5 kg ha^{-1}. Highest available P was observed in excavated soils of Satara (F1) and Kolhapur (H1) locations whereas lowest was in Nagar (A2) and Nashik (C1) locations, this variation in available P might be due to the variation in source of river alluvium and variation in mineral composition of soil which vary considerably location to location. A small increase of 10.3% in available P was found in green brick samples ranging from 10.2 to 30.2 kg ha^{-1} with average value of 18.2 kg ha^{-1}. Significant decrease of 27.1% in fired brick samples as compared to excavated soil used for brick making (S_1) in which available P in fired brick samples ranged from 5.0 to 21.0 kg ha^{-1} with average of 12.1 kg ha^{-1}. The loss of available P might be attributed to loss of organic matter during firing of bricks, change in clay mineral composition and P transformations.

Available P significantly reduced in samples from below the brick kiln (S_4) as compared to normal agriculture soil samples (S_5) by 22.1% which ranged in available P content of 6.7 to 21.3 kg ha^{-1} and 15.7 to 26.7 kg ha^{-1} having average values 16.1 kg ha^{-1} and 20.7 kg ha^{-1} respectively. This could be due to impact of prolonged burning on the surface of soil beneath the brick kiln with loss of organic matter. Similar results were reported by (Salek, 2007) and (Ismail, 2012)

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Table18 Effect of brick making process on soil available phosphorus

Sr No.	Location	Soil available phosphorus (kg ha^{-1})				
		Sample type				
		S_1	S_2	S_3	S_4	S_5
1	Nagar A1	14.0	15.0	7.1	8.6	16.9
2	Nagar A2	9.0	10.2	5.0	12.1	18.1
3	Dhule B1	12.6	13.1	14.5	6.7	20.0
4	Dhule B2	18.8	19.8	13.3	14.5	15.7
5	Nashik C1	9.8	15.0	14.8	14.5	20.5
6	Nashik C2	11.4	15.5	10.7	19.3	21.4
7	Pune D1	11.2	16.7	9.3	15.0	17.6
8	Pune D2	13.6	14.0	15.5	14.5	20.0
9	Sangli E1	21.2	22.4	9.8	21.7	23.6
10	Sangli E2	20.0	21.4	17.1	20.7	25.5
11	Satara F1	24.0	24.8	9.8	17.9	26.7
12	Satara F2	21.2	22.6	16.9	21.3	23.8
13	Solapur G1	16.4	16.9	10.5	19.0	18.3
14	Solapur G2	12.4	13.1	6.2	11.4	17.1
15	Kolhapur H1	29.3	30.2	21.0	22.4	24.3
16	Kolhapur H2	19.8	21.2	11.4	16.4	21.7
	Average	16.5	18.2	12.1	16.1	20.7
	Range	9.0-29.3	10.2-30.2	5.0-21.0	6.7-21.3	15.7-26.7
	Gain/Loss	*	1.70 G	4.49 L	4.57 L	#
	% G / % L	*	10.3 G	27.1 L	22.1 L	#
	Mean	16.73				
	SEm (±)	1.20				
	CD at 5%	3.37				

4.3.7 Available potassium

The data in respect of available potassium is presented in table 19. The available K in excavated soil used for brick making (S_1) ranged from 134.4 to 459.2 kg ha^{-1} with average value 266.7 kg ha^{-1}. Highest available K in excavated soil was observed in Nagar district whereas lowest in Kolhapur district, this might be due to variation in source of river alluvium. A significant increase of 31.9% in available K was found in green brick samples ranging from 179.2 to 537.6 kg ha^{-1} with an average value 351.8 kg ha^{-1}. Small decrease of 10.2% in fired brick samples as compared to excavated soil used for brick making (S_1) in which available K in fired brick samples ranged from 123.2 to 369.6 kg ha^{-1} with an average of 239.5 kg ha^{-1}. The loss of available K might be attributed to loss of organic matter, change in clay mineral hydration status and K transformations, as exchangeable potassium bound in clay micelle and interlayer spaces transform due to the action of high temperature.

A significantly high increase in available K content was observed in samples from below the brick kiln (S_4) as compared to normal agriculture soil samples (S_5) by 139 % with average values 526.4 to 1232 kg ha^{-1} and 190.4 to 683.2 kg ha^{-1} having average values 929.6 kg ha^{-1} and 389.2 kg ha^{-1} respectively. This increase in K concentration is due to prolonged accumulation and deposition of ash on surface of soil below the kiln as ash mainly contains high amount of potassium. This ash continually deposits from kiln on surface of soil selected for establishment of kiln at every single kiln rotation due to burning of biomass and coal.

Table19. Effect of brick making process on soil available potassium

Sr No.	Location	Soil available potassium (kg ha^{-1})				
		Sample type				
		S_1	S_2	S_3	S_4	S_5
1	Nagar A1	459.2	515.2	168.0	1187	392.0
2	Nagar A2	302.4	382.4	248.8	1019	425.6
3	Dhule B1	268.8	414.4	280.0	526.4	683.2
4	Dhule B2	336.0	537.6	369.6	750.4	492.8
5	Nashik C1	246.4	257.6	235.2	873.6	313.6
6	Nashik C2	268.8	302.4	327.2	907.2	548.8
7	Pune D1	459.2	504.0	123.2	1053	336.0
8	Pune D2	324.8	492.8	247.2	929.6	257.6
9	Sangli E1	235.2	416.8	304.8	985.6	403.2
10	Sangli E2	168.0	257.6	201.6	1232	380.8
11	Satara F1	134.4	168.0	176.4	952.0	280.0
12	Satara F2	156.8	179.2	213.6	1064	190.4
13	Solapur G1	268.8	325.6	336.0	907.2	515.2
14	Solapur G2	291.2	371.2	169.6	1109	571.2
15	Kolhapur H1	212.8	235.2	224.0	660.8	235.2
16	Kolhapur H2	134.4	268.8	206.4	716.8	201.6
	Average	266.7	351.8	239.5	929.6	389.2
	Range	134.4 - 459.2	179.2 - 537.6	123.2 - 369.6	526.4 - 1232	190.4 - 683.2
	Gain/Loss	*	85.1G	27.2L	540.4G	#
	% G / % L	*	31.9G	10.2L	138.9G	#
	Mean	435.4				
	SEm (±)	32.9				
	CD at 5%	92.6				

4.3.8 Available sulphur

The data on available sulphur are presented in table 20. The available S in excavated soil used for brick making (S_1) ranged from 7.9 to 28.9 µg $g^{-1}$with an average value of 18.3 µg g^{-1} which is in sufficient category. Highest available S content was observed in soils of Kolhapur whereas lowest available S content was observed in soils of Pune region this is may be due to the variation in location to location and available S present in river alluvium in that particular location from which soil used for brick making was excavated. Significant increase up to extent of 19.2% in available sulphur was observed in green brick (S_2) which ranged from 9.63 to 30.0 µg g^{-1} with an average value 21.8 µg g^{-1}. This increase in available S is due to the addition of high load of organic matter in molding as most of available sulphur in soil is present in organic form. Due to burning of organic matter available S significantly decreased up to 53.9% in fired brick samples which ranged from 4.53 to 11.9 µg g^{-1} with an average value of 8.4 µg g^{-1}which falls under insufficient category. The results were similar with the reports of (Chen and Li, 2003) and (Yadav, 2013).

Available S was significantly reduced in samples from below the brick kiln (S_4) as compared to normal agriculture soil samples(S_5) by 30.1% with values ranging 6.23 to 18.7 µg $g^{-1}$and 7.4 to 27.8 µg g^{-1}having an average values 10.9 µg $g^{-1}$and 15.6 µg g^{-1} respectively. This is due to impact of prolonged burning on the surface of soil beneath the brick kiln with loss of organic matter. Similar results were reported by (Khan *et al.*,2005) and (Salek, 2007).

Table 20 Effect of brick making on soil available sulphur

Sr No.	Location	Soil available sulphur (µg g^{-1}) Sample type				
		S_1	S_2	S_3	S_4	S_5
1	Nagar A1	21.0	24.4	5.7	10.8	13.0
2	Nagar A2	28.9	29.5	9.1	11.9	16.4
3	Dhule B1	14.2	14.7	11.4	10.2	9.6
4	Dhule B2	10.8	17.0	6.8	7.9	11.9
5	Nashik C1	16.4	18.7	10.2	18.7	23.8
6	Nashik C2	18.1	17.6	7.4	12.5	22.5
7	Pune D1	7.9	9.6	5.1	7.4	18.1
8	Pune D2	20.4	25.5	11.9	10.8	9.1
9	Sangli E1	10.2	13.6	7.9	14.7	20.4
10	Sangli E2	11.9	27.2	4.5	6.2	10.8
11	Satara F1	28.9	30.0	7.9	11.3	27.8
12	Satara F2	19.3	22.7	9.6	7.4	9.1
13	Solapur G1	22.7	28.9	11.3	13.0	22.1
14	Solapur G2	14.7	15.3	7.9	9.1	7.4
15	Kolhapur H1	21.2	26.7	9.1	11.6	8.5
16	Kolhapur H2	26.6	28.3	9.2	11.5	19.9
	Average	18.3	21.8	8.4	10.9	15.6
	Range	7.9-28.9	9.63-30.0	4.53-11.9	6.23-18.7	7.4-27.8
	Gain/Loss	*	G 3.53	L 9.88	L 4.71	#
	% G / % L	*	G 19.2	L 53.9	L 30.1	#
	Mean	15.0				
	SEm (±)	1.34				
	CD at 5%	3.77				

4.3.9 DTPA Fe

The data pertaining to DTPA micronutrients viz. Fe are presented in table 21. The DTPA Fe in soil used for brick making (S_1) was ranged from 0.44 to 5.70 µg g^{-1} with an average value of 2.46 µg g^{-1}. The Fe content slightly increased in green brick samples (S_2) and fired brick samples (S_3) up to extent of 11.10%

and 17.05% respectively. The DTPA Fe content in (S_2) and (S_3) ranged from 0.98 to 5.93 and 1.26 to 5.59 µg g^{-1} with an average value of 2.74 µg g^{-1} and 2.88 µg g^{-1}. The increase in Fe content may be due to addition of water of diverse nature during molding and oxidation of ferrous silicate at 550^0C, (Karaman *et al.*, 2006).

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Table 21 Effect of brick making process on DTPA-Fe in soil

Sr No.	Location	DTPA Fe (µg g^{-1}) Sample type				
		S_1	**S_2**	**S_3**	**S_4**	**S_5**
1	Nagar A1	0.83	0.98	1.67	3.35	1.24
2	Nagar A2	0.90	1.15	1.26	4.64	0.45
3	Dhule B1	1.25	2.05	2.17	6.56	3.88
4	Dhule B2	1.15	1.64	1.79	3.93	2.10
5	Nashik C1	1.20	1.59	2.24	3.32	1.12
6	Nashik C2	1.94	2.04	2.23	3.79	3.84
7	Pune D1	4.21	4.00	4.29	5.97	2.90
8	Pune D2	5.37	5.49	5.59	6.71	0.68
9	Sangli E1	5.70	5.93	5.05	7.14	4.31
10	Sangli E2	2.93	2.96	3.50	5.96	2.37
11	Satara F1	1.97	2.11	2.43	3.37	1.57
12	Satara F2	2.60	2.73	2.52	2.93	2.96
13	Solapur G1	0.44	1.54	1.39	1.79	2.19
14	Solapur G2	1.97	2.29	2.05	4.74	1.15
15	Kolhapur H1	2.67	2.80	3.58	4.21	3.58
16	Kolhapur H2	4.29	4.50	4.35	8.00	5.15
	Average	2.46	2.74	2.88	4.78	2.47
	Range	0.44-5.70	0.98-5.93	1.26-5.59	1.79-8.00	0.45-5.15
	Gain/Loss	*	G 0.27	G 0.42	G 2.31	#
	% G / % L	*	G 11.1	G 17.0	G 93.5	#
	Mean	3.07				
	SEm (±)	0.38				
	CD at 5%	1.08				

The DTPA Fe content was significantly increased in samples from below the brick kiln (S_4) up to extent of 12% as compared to normal agriculture soils (S_5). The Fe content of S_4 and S_5 samples ranged from 1.79 to 8.00 µg g^{-1} and 0.45 to 5.15 µg $g^{-1}$with an average values of 4.78 µg g^{-1} and 2.47 µg g^{-1} respectively

4.3.10DTPA Mn

The data pertaining to DTPA micronutrient Mn is presented in table 22. The DTPA Mn in soil used for brick making (S_1) ranged from 1.88 to 12.69 µg g^{-1} with an average value of 5.77 µg g^{-1}. The highest Mn content in soil used for brick making was observed in Sangli district whereas lowest Mn content was observed in Ahmednagar and Satara districts this variation in micronutrient content may be attributed to variation in location, different parent material and chemical composition of river alluvium excavated for brick making. The Mn content slightly increased in green brick samples (S_2) and significantly decreased in fired brick samples (S_3) up to extent of 20.60 % and 46.50% respectively. The DTPA Fe content in S_2 and S_3 ranged from 1.21 to 12.79 µg $g^{-1}$and 0.45 to 8.61 µg g^{-1} with an average value of 6.96 µg g^{-1} and 3.09 µg g^{-1}.

The DTPA Mn content was significantly increased in samples from below the brick kiln (S_4) up to extent of 90.83% as compared to normal agriculture soils (S_5). The Mn content of (S_4) and (S_5) samples ranged from 5.26 to 16.80 µg g^{-1} and 1.33 to 8.82 µg g^{-1} with average values of 10.37 µg g^{-1} and 5.43 µg g^{-1} respectively. Similar results were reported by (Saviour and Stalin,

2012) from mined areas of brick burning for DTPA micronutrients Fe, Mn, Zn and Cu.

Table 22 Effect of brick making process on DTPA-Mn in soil

Sr No.	Location	DTPA- Mn (µg g-1)				
		Sample type				
		S_1	S_2	S_3	S_4	S_5
1	Nagar A1	3.65	4.59	0.45	6.53	1.33
2	Nagar A2	1.88	2.54	1.51	8.39	4.44
3	Dhule B1	4.44	4.43	0.54	5.26	7.99
4	Dhule B2	3.43	5.25	0.67	13.47	4.61
5	Nashik C1	1.88	1.21	1.68	9.03	2.67
6	Nashik C2	5.69	6.09	1.27	8.61	3.55
7	Pune D1	3.13	9.41	1.29	16.80	4.81
8	Pune D2	2.88	3.36	1.43	8.99	5.51
9	Sangli E1	12.69	12.79	5.81	14.10	7.09
10	Sangli E2	11.95	12.48	7.12	11.02	7.90
11	Satara F1	3.17	6.68	0.78	8.75	8.40
12	Satara F2	3.58	9.73	1.24	14.01	1.38
13	Solapur G1	10.68	8.93	8.55	11.39	8.82
14	Solapur G2	10.09	9.31	8.61	13.65	6.27
15	Kolhapur H1	7.87	8.54	5.16	8.64	6.98
16	Kolhapur H2	5.29	5.99	3.28	7.23	5.18
	Average	5.77	6.96	3.09	10.37	5.43
	Range	1.88-12.69	1.21-12.79	0.45-8.61	5.26-16.80	1.33-8.82
	Gain/Loss	*	G 1.19	L 2.68	G4.93	#
	% G / % L	*	G 20.6	L 46.5	G 90.8	#
	Mean	6.32				
	SEm (±)	0.79				
	CD at 5%	2.22				

4.3.11 DTPA Zn

The data pertaining to DTPA micronutrient Zn is presented in table 23. The DTPA Zn in soil used for brick making (S_1) ranged from 0.15 to 1.02 µg g^{-1} with an average value of 0.47µg

g^{-1}. The Zn content slightly increased in green brick samples (S_2) and significantly decreased in fired brick samples (S_3) up to extent of 23.10 % and 31.84 % respectively. The DTPA Zn content in S_2 and S_3 ranges from 0.22 to 1.13 µg g^{-1} and 0.15 to 0.76 µg g^{-1} with an average value of 0.58 µg g^{-1} and 0.32 µg g^{-1}.

Table 23 Effect of brick making process on DTPA-Zn in soil

Sr No.	Location	DTPA- Zn (µg g^{-1}) Sample type				
		S1	**S2**	**S3**	**S4**	**S5**
1	Nagar A1	0.15	0.25	0.24	0.40	0.39
2	Nagar A2	0.16	0.29	0.21	0.61	0.48
3	Dhule B1	0.24	0.26	0.17	0.28	0.12
4	Dhule B2	0.21	0.22	0.15	0.30	0.28
5	Nashik C1	0.20	0.44	0.22	0.57	0.47
6	Nashik C2	0.34	0.35	0.32	1.53	0.51
7	Pune D1	0.44	0.46	0.27	0.43	0.41
8	Pune D2	0.32	0.56	0.18	0.74	0.59
9	Sangli E1	1.02	1.13	0.27	1.78	0.60
10	Sangli E2	0.99	1.10	0.48	1.53	0.56
11	Satara F1	0.27	0.29	0.24	0.96	0.59
12	Satara F2	0.35	0.41	0.30	0.71	0.29
13	Solapur G1	0.76	0.99	0.76	1.09	0.75
14	Solapur G2	0.85	1.00	0.50	1.06	0.58
15	Kolhapur H1	0.89	0.99	0.48	1.99	0.58
16	Kolhapur H2	0.28	0.47	0.32	1.60	0.69
	Average	0.47	0.58	0.32	0.97	0.49
	Range	0.15-1.02	0.22-1.13	0.15-0.76	0.28-1.99	0.12-0.75
	Gain/Loss	*	G 0.11	L 0.15	G 0.48	#
	% G / % L	*	G 23.1	L 31.8	G 97.3	#
	Mean	0.57				
	SEm (±)	0.09				
	CD at 5%	0.24				

The DTPA Zn content was significantly increased in samples from below the brick kiln (S_4) up to extent of 97.36% as compared to normal agriculture soils (S_5). The Zn content of (S_4) and (S_5) samples ranged from 0.28 to 1.99 µg g^{-1} and 0.12 to 0.75 µg g^{-1} with average values of 0.97 µg g^{-1} and 0.49 µg g^{-1} respectively.

4.3.12 DTPA Cu

The data pertaining to DTPA micronutrient Cu is presented in table 24. The DTPA Cu in soil used for brick making (S_1) ranged from 0.61 to 4.0 µg g^{-1} with an average value of 1.86 µg g^{-1}. The Cu content slightly increased in green brick samples (S_2) and significantly decreased in fired brick samples (S_3) up to extent of 7.14 % and 47.53 % respectively. The DTPA Cu content in S_2 and S_3 ranges from 0.23 to 3.99 µg $g^{-1}$and 0.20 to 3.00 µg g^{-1} with an average value of 1.99 µg g^{-1} and 0.97 µg g^{-1}.

The DTPA Cu content was significantly increased in samples from below the brick kiln (S_4) up to extent of 94.44% as compared to normal agriculture soils (S_5). The Cu content of (S_4) and (S_5) samples ranged from 0.80 to 4.54 µg g^{-1} and 0.18 to 2.73 µg g^{-1} with average values of 2.38 µg g^{-1} and 1.23 µg g^{-1} respectively. Similar results were reported by (Saviour and Stalin, 2012) from mined areas of brick burning.

Table 24. Effect of brick making process on DTPA-Cu in soil

Sr No.	Location	DTPA- Cu (µg g-1) Sample type				
		S_1	S_2	S_3	S_4	S_5
1	Nagar A1	0.68	1.01	0.23	1.05	0.37
2	Nagar A2	1.40	1.02	0.38	1.53	0.53
3	Dhule B1	0.85	1.45	0.39	1.74	0.18
4	Dhule B2	0.61	0.46	0.20	1.12	0.42
5	Nashik C1	0.78	0.23	0.26	0.80	0.83
6	Nashik C2	0.80	0.99	0.20	1.06	0.85
7	Pune D1	1.86	2.40	0.55	2.70	1.85
8	Pune D2	1.62	2.15	0.77	2.21	1.18
9	Sangli E1	4.00	3.01	0.63	4.54	1.33
10	Sangli E2	2.96	3.39	1.63	3.77	2.61
11	Satara F1	1.52	1.35	0.41	1.43	0.47
12	Satara F2	1.22	1.42	0.45	1.51	0.41
13	Solapur G1	3.11	3.36	2.37	3.65	2.73
14	Solapur G2	3.59	3.37	3.05	4.14	1.83
15	Kolhapur H1	2.17	2.26	1.68	2.65	2.00
16	Kolhapur H2	2.56	3.99	2.37	4.27	2.05
	Average	1.86	1.99	0.97	2.38	1.23
	Range	0.61-4.0	0.23-3.99	0.20-3.00	0.80-4.54	0.18-2.73
	Gain/Loss	*	G 0.13	L 0.88	G 1.16	#
	% G / % L	*	G 7.14	L 47.5	G 94.4	#
	Mean	1.69				
	SEm (±)	0.27				
	CD at 5%	0.76				

3.3.13 Total Nitrogen

The data in respect of total nitrogen is presented in table 25. The total N in excavated soil used for brick making (S_1) ranged from 0.066 to 0.097 % with average value 0.079 %. The highest total N was observed in soils of Satara F1 and Kolhapur H1 whereas lowest Total N was observed in Nashik C1. This variation in total N may be attributed to variation in nutrient content and chemical composition of river alluvium excavated for brick making. Significant increase up to extent of 12.43% in Total N was observed in green brick (S_2) which ranged from0.076 to 0.112 % with an average value 0.089%. The increase in total N content could be due to the addition of high load of organic matter in molding process as most of organic form of ammonical nitrogen in soil is a component of total nitrogen. Due to burning of organic matter as well as due to very high temperature the total N significantly decreased up to 32.34% in fired brick samples, which was ranged from 0.041 to 0.069 % with average value 0.054%. These results are in agreement with reports of Chen and Li (2003) and Yadav (2013).

Total N was significantly reduced in samples from below the brick kiln (S_4) as compared to normal agriculture soil samples(S_5) by 16.03% with average values0.051 to 0.078 % and 0.065 to 0.089 % having average values 0.065 % and 0.077 % respectively. This is due to impact of prolonged burning on the surface of soil beneath the brick kiln with loss of organic matter. Similar results were also reported by (Khan *et al.*, 2005) and (Salek, 2007).

Table 25. Effect of brick making on soil total nitrogen

Sr No.	Location	Soil total nitrogen (%)				
		Sample type				
		S_1	S_2	S_3	S_4	S_5
1	Nagar A1	0.077	0.089	0.049	0.057	0.069
2	Nagar A2	0.075	0.082	0.044	0.065	0.072
3	Dhule B1	0.084	0.09	0.063	0.061	0.087
4	Dhule B2	0.081	0.091	0.069	0.073	0.079
5	Nashik C1	0.066	0.076	0.049	0.059	0.073
6	Nashik C2	0.071	0.079	0.053	0.063	0.082
7	Pune D1	0.097	0.109	0.061	0.076	0.079
8	Pune D2	0.075	0.083	0.042	0.058	0.078
9	Sangli E1	0.087	0.094	0.055	0.063	0.089
10	Sangli E2	0.079	0.087	0.049	0.057	0.075
11	Satara F1	0.093	0.112	0.066	0.074	0.087
12	Satara F2	0.078	0.087	0.047	0.063	0.068
13	Solapur G1	0.068	0.079	0.041	0.051	0.077
14	Solapur G2	0.073	0.085	0.058	0.069	0.067
15	Kolhapur H1	0.096	0.107	0.069	0.078	0.065
16	Kolhapur H2	0.071	0.079	0.045	0.065	0.082
	Average	0.079	0.089	0.054	0.065	0.077
	Range	0.066-0.097	0.076-0.112	0.041-0.069	0.051-0.078	0.065-0.089
	Gain/Loss	*	G 0.010	L 0.026	L 0.012	#
	% G / % L	*	G 12.4	L 32.3	L 16.0	#
	Mean	0.07				
	SEm (±)	0.00				
	CD at 5%	0.01				

3.3.14Total phosphorus

The data in respect of total phosphorus is presented in table 26. The total P in excavated soil used for brick making (S_1) was ranged from 609.9 to 908.3 mg kg^{-1} with average value 800.6 mg kg^{-1}. Highest total P in soil used for brick making was observed in Nashik and Satara district whereas lowest in Sangli E1 this variation may be due different chemical composition of river alluvium which vary location to location. A small increase of 2.23% in total P was found in green brick samples ranging from 621.6 to 919.7 mg kg^{-1} with average value 818.5 mg kg^{-1}. Significant decrease of 10.10 % in fired brick samples as compared to excavated soil used for brick making (S_1) in which total P in fired brick samples ranged from 511.6 to 827.7 mg kg^{-1} with average of 719.8 mg kg^{-1}. The loss of total P might be attributed to loss of organic matter during firing of red bricks, change in clay mineral composition and P transformations and less sensitivity of soil P to temperature as compared to N and S.

Total P was significantly reduced in samples from below the brick kiln (S_4) as compared to normal agriculture soil samples(S_5) by 5.01 % which ranged in total P content of 654.8 to 855.0 mg kg^{-1} and 701.5 to 921.4 mg kg^{-1} having average values 765.6 mg kg^{-1} and 806.0 mg kg^{-1} respectively. This is due to impact of prolonged burning on the surface of soil beneath the brick kiln with loss of organic matter. The loss in total P as compared to total N is quite low as soil phosphorus is less affected by increase in temperature. Similar results were reported by (Salek, 2007) and (Ismail, 2012).

Table 26. Effect of brick making process on soil total P

Sr No.	Location	Soil total phosphorus (mg kg^{-1})				
		Sample type				
		S_1	S_2	S_3	S_4	S_5
1	Nagar A1	745.8	762.3	674.9	698.3	789.6
2	Nagar A2	785.8	801.5	715.6	775.6	815.6
3	Dhule B1	805.7	824.6	731.4	728.3	788.0
4	Dhule B2	879.5	896.2	791.9	840.5	891.4
5	Nashik C1	907.5	919.7	827.7	848.6	921.4
6	Nashik C2	817.0	836.9	716.0	768.7	822.6
7	Pune D1	797.4	842.4	660.7	759.1	802.4
8	Pune D2	802.6	821.5	788.6	735.5	789.2
9	Sangli E1	609.9	621.6	511.6	659.8	701.5
10	Sangli E2	908.3	918.3	817.2	855.0	906.1
11	Satara F1	809.7	817.2	769.6	798.4	801.6
12	Satara F2	797.5	808.3	758.1	748.5	758.6
13	Solapur G1	804.3	800.7	745.6	800.3	788.7
14	Solapur G2	845.2	865.7	720.3	824.5	844.4
15	Kolhapur H1	706.0	767.0	612.3	654.8	701.7
16	Kolhapur H2	788.1	791.4	675.3	754.2	773.3
	Average	800.6	818.5	719.8	765.6	806.0
	Range	609.9-908.3	621.6-919.7	511.6-827.7	654.8-855.0	701.5-921.4
	Gain/Loss	*	17.82	80.83	40.38	*
	% G / % L	*	2.23 L	10.10 L	5.01 L	*
	Mean	782.10				
	SEm (±)	17.56				
	CD at 5%	49.47				

3.3.15 Total Potassium

The data in respect of total potassium is presented in table 27. The total K in excavated soil used for brick making (S_1) was ranged from 3985 to 6521 mg kg^{-1} with average value 4953 mg kg^{-1}. A significant increase of 4.54 % in total K was found in green brick samples having range values from 4189 to 6638 mg kg-^{1} with an average value of 5177 mg kg^{-1}. Significant decrease in total K to the tune of 26.7% in fired brick samples was observed as compared to excavated soil used for brick making (S_1) in which total K in fired brick samples ranged from 2838 to 4832 mg $kg^{-1}$with an average of 1324 mg kg^{-1}. The loss of total K might be attributed to change in clay mineral composition and K transformations under dihydroxylation process.

A significantly high increase in total K content was observed in samples from below the brick kiln (S_4) as compared to normal agriculture soil samples (S_5) by 41.1 % with average values 5841-8210 mg kg^{-1} and 3931 to 6106 mg kg^{-1} having average values 6746 mg kg^{-1} and 4782 mg kg^{-1} respectively. The increase in K concentration is due to prolonged accumulation and deposition of ash on surface of soil below the kiln as ash mainly contains high amount of potassium. This ash continually deposits from kiln on surface of soil selected for establishment of kiln at every single kiln rotation due to burning of biomass and coal.

Table 27. Effect of brick making on soil Total potassium

Sr No.	Location	Soil total potassium (mg kg^{-1})				
		Sample type				
		S_1	S_2	S_3	S_4	S_5
1	Nagar A1	5132	5356	3908	7400	5200
2	Nagar A2	5246	5421	2838	6152	5284
3	Dhule B1	5413	5692	4219	7211	5496
4	Dhule B2	6521	6638	4832	6832	5263
5	Nashik C1	4219	5121	3532	6544	4354
6	Nashik C2	4738	4832	4198	6372	5413
7	Pune D1	5670	5861	4321	6432	6106
8	Pune D2	5210	5483	3210	7628	3937
9	Sangli E1	4613	4812	4152	8210	4037
10	Sangli E2	5431	5492	3340	5934	5832
11	Satara F1	4937	5123	3161	5841	4224
12	Satara F2	5546	5162	3258	7152	4062
13	Solapur G1	4241	4366	3316	6980	4138
14	Solapur G2	4241	4924	3493	6512	4018
15	Kolhapur H1	3985	4189	3027	6890	3931
16	Kolhapur H2	4100	4365	3248	5852	5210
	Average	4953	5177	3628	6746	4782
	Range	3985-6521	4189-6638	2838-4832	5841-8210	3931-6106
	Gain/Loss	*	G224.6	L1324	G1964	#
	% G / % L	*	G 4.54	L 26.7	G 41.1	#
	Mean	5057.25				
	SEm (±)	167				
	CD at 5%	469				

4.4 Change in biological property during brick making process.

4.4.1 Dehydrogenase enzyme activity

The data pertaining to dehydrogenase activity is presented in table 20. The DHA activity of soil used for brick making observed in range of 52.4 to 109.9 µg TPF g^{-1} soil 24 hr^{-1} with an average of 67.2 µg TPF g^{-1} soil 24 hr^{-1} which is normal in nature. The decrease in DHA activity to the tune of 32% was observed in green brick samples, with ranging values from 19.7 to 68.0 µg TPF g^{-1} soil 24 hr^{-1} having average value 45.7 µg TPF g^{-1} soil 24 $hr^{-1,}$ this decrease in DHA could be contributed to the compaction followed by exclusion of soil air and water on drying of green brick samples. A significant loss in DHA up to the extent of 99% was observed in fired brick samples which ranged from 0.0 to 4.7 µg TPF g^{-1} soil 24 hr^{-1} with average value 0.7 µg TPF g^{-1} soil 24 hr^{-1}. This tremendous decline in DHA due to the loss of biomass and O.M. during burning and inability of any microorganism to sustain in such extreme temperature of brick burning which up to 700-1100^{0}C. (Karaman *et al.*, 2006)

The sharp decline of 62.3% in DHA activity was recorded in samples below the brick kiln (S_4) as compared to normal agriculture soils (S_5). The DHA activity of these two samples ranged from 9.9 to 36.9 µg TPF g^{-1} and 25.4 to 83.0 µg TPF g^{-1} soil 24 hr^{-1} with average value of 22.3 µg TPF g^{-1} soil 24 hr^{-1} and 61.9 µg TPF g^{-1} soil 24 hr^{-1} respectively. The decrement in DHA may be due to higher pH and EC of soil below the brick kiln and impact of temperature as discussed earlier.

Table 28. Effect of brick making on soil dehydrogenase activity

Sr No.	Location	DHA activity (µg TPF g^{-1} soil 24 hr^{-1})				
		Sample type				
		S_1	S_2	S_3	S_4	S_5
1	Nagar A1	109.9	51.9	0.0	29.1	70.6
2	Nagar A2	57.1	53.5	0.0	22.3	73.7
3	Dhule B1	66.5	40.5	0.0	17.1	59.2
4	Dhule B2	84.1	48.8	0.0	16.1	66.0
5	Nashik C1	70.1	49.3	0.0	36.9	57.6
6	Nashik C2	52.4	47.3	0.0	26.5	78.9
7	Pune D1	56.4	62.8	3.3	10.9	25.4
8	Pune D2	71.0	36.3	0.0	19.7	61.3
9	Sangli E1	59.2	68.0	0.0	9.9	47.3
10	Sangli E2	71.7	61.9	0.0	32.7	74.8
11	Satara F1	42.0	19.7	4.7	30.1	68.0
12	Satara F2	47.8	46.7	0.0	27.5	45.2
13	Solapur G1	73.7	46.7	0.0	31.7	83.6
14	Solapur G2	82.1	46.7	1.5	27.0	66.0
15	Kolhapur H1	54.0	28.6	0.0	12.5	40.0
16	Kolhapur H2	76.8	22.8	1.0	22.8	72.2
	Average	67.2	45.7	0.7	23.3	61.9
	Range	52.4-109.9	19.7-68.0	0.0-4.7	9.9-36.9	25.4-83.0
	Gain/Loss	*	L 21.4	L 66.5	L 38.6	#
	% G / % L	*	L 31.9	L 99.0	L 62.3	#
	Mean	39.7				
	SEm (±)	3.1				
	CD at 5%	8.8				

4.5 Pot culture experiment

There was ample growth of wheat seedlings in pots containing normal agriculture soil (S_1) whereas vigorous growth observed in pots containing molded brick sample (S_2) due to presence of high amount of organic matter in molded bricks. Germination and vigor of seedling was normal in (S_1) and (S_2).

Very less or zero growth of wheat seedling was observed in pots containing crushed fired brick sample (S_3). So this conclude, the irreversible change in normal soil during the firing process as this medium no longer be a true soil and unable to sustain normal plant growth. This is due to conversion of active clay present in soil into dent clay and exclusion of organic matter and essential nutrients during firing process of bricks.

Table 29. Dry matter of wheat seedlings after 15 days after sowing as influenced by different treatments

	Dry matter of wheat seedlings after 15 DAS				
Replication / Treatment	**R_1**	**R_2**	**R_3**	**R_4**	**Mean**
T_1 (S_1)	1.7	2.1	1.9	1.2	1.72
T_2 (S_2)	2.6	2.3	2.1	2.5	2.37
T_3 (S_3)	0.1	0.0	0.05	0.1	0.08
T_4 (S_4)	0.9	0.1	0.5	0.7	0.55
T_5 (S_5)	2.4	2.8	2.7	2.9	2.7
Mean	1.54	1.82	1.45	1.48	1.48

There was succulent growth of wheat observed in pots containing normal agriculture soil (S_5) whereas less germination and mortality of seedling was observed in pots containing soil below the brick kiln (S_4). This is due to excess amount of salt, less organic matter and nutrient in (S_4) samples.

So this small pot culture experiment concludes that brick making process converts normal soil into non soil component and it will not support biological growth of any plant. Hence use of soil as raw material for brick making process eventually converting fertile precious natural nutrient stock into nonproductive inert mass which is of no use in terms agriculture point of view.

5. SUMMARY AND CONCLUSIONS

The study entitled, “Assessment of soil and nutrient loss during brick making process in western Maharashtra” was under taken during year 2016-17.

The survey of total 16 brick factories from 8 districts of western Maharashtra was carried out with semi structured questionnaires. The information and data generated has utilized to calculate soil loss in terms of weight (tones year^{-1}) and area (hectares year^{-1}). Total 80 samples were collected from study area and analyzed by using standard analytical methods for physical, chemical and biological properties and nutrient status.

5.1 Summary

5.1.1.a) Soil loss during brick making process (tonnes year^{-1})

The soil loss from single brick factory in terms tonnes of soil i.e. on an average single brick factory responsible for 2023.3 tonnes year^{-1} whereas all sixteen brick factories under study area have utilized 32484.8 tonnes of soil per year.

5.1.1.b) Soil loss during brick making process (ha year^{-1})

The soil loss from single brick factory in terms hectare of land (top 15 cm layer) i.e. average soil loss from single brick factory was 0.90 hectare year^{-1} whereas overall sixteen brick factories under study area responsible for 14.5-hectare year^{-1}.

5.2.1 Change in physiochemical properties during brick making process

The texture, bulk density, water content at 1/3rd and 15 bars, soil colour, pH, EC of soil excavated for brick making (S_1) and agriculture soil (S_2) were found in normal range.

The Sand content in samples from below the brick kiln was increased whereas clay content drastically reduced which ranged from 8.2 to 14.1% and 9 to 30% respectively.

The bulk density of (S_2) and (S_3) ranged from 1.88 to 2.40 and 2.24 to 2.60 Mg m^{-3} respectively whereas bulk density of soil below brick kiln ranged from 1.63 to 2.00 Mg m^{-3}.

Water content at 1/3rd and 15 bars was found highest in (S_2) samples and lowest in (S_3) samples which ranged from 23.0 to 31.6 and 8.2 to 14.1% respectively.

The pH of soil below the brick kiln (S_4) significantly increased during brick making process and ranged from 7.12 to 9.50 with average value 8.15.

The EC of soil below the brick kiln (S_4) significantly increased with drastic average increment of 485%, ranging from 7.12 to 9.50 dS m^{-1} with mean value of 3.17 dS m^{-1}.

5.2.2 Nutrient loss during the brick making process.

Total 90.5 % of organic carbon is lost during process the firing of bricks if we compare organic carbon content in soil excavated for brick making process (S_1) with fired brick samples whereas 51.8 % loss incurred when agriculture soil (S_5) compared with soil below the brick kiln (S_4).

The concentration of available N, P, K and S were increased in molded brick (S_2) considerably to the tune of 20.7%, 10.3%, 31.9% and 19.2% respectively whereas in fired brick samples (S_3) significant decrease in tune of 80.9%, 27.1%, 10.2% and 53.9 % observed when compared to soil excavated for brick making process.

The concentration of available N, P and S were significantly decreased in samples from below the brick kiln (S_4) as compared to normal agriculture soil (S_5) to the tune of 60.9 %, 22.1 % and 30.1 % respectively where as significant increase of 138.9 % in available K content in (S_4) samples.

Total N, P and K content in fired brick samples (S_3) significantly increased in tune of 32.34%, 10.10% and 26.7% respectively as compared to soil excavated for brick making (S1). In soil samples from below the brick kiln (S_4) total N and P content decreased by 16.03 % and 5.01 % whereas total K content increased by 41.1 % in (S_4) samples.

The dehydrogenase enzyme activity (DHA) was found highest in soil used for brick making (S_1) and normal agriculture soil (S_5) samples, whereas it was least in fired brick samples (S_3).

5.2 Conclusions

The single brick factory on an average responsible for loss of 2023.3 tonnes of soil per year or 0.90 hectare of top 15 cm layer of agriculture soil per year brick during brick making process in western Maharashtra.

Use of soil for brick making responsible for tremendous loss of organic matter and essential nutrients viz. available N, P, K and S, DTPA micronutrients and total N, P and K during the firing process of brick making and establishment of brick kiln on agriculture land leads to degradation of agriculture soil in various ways such as alteration of physical properties, removal of nutrients and increased salt content in soil below the brick kiln.

Hence it can be concluded that production of burnt clay bricks from fertile agricultural soil as it is presently practiced in the study area is highly unsustainable. Brick industry is responsible for enormous loss of soil, nutrients along with degradation of agriculture land. Brick industry should be considered as urgent environmental threat specifically to the fertile loamy alluvium which is well known for highly productive land.

5.3 Future line of research work

There is need to study the greenhouse gases emission studies during brick making process.

The development of integrated land reclamation technologies where land utilized for brick production kiln.

In order to reduce the pressure on fertile soil stock for brick making, other alternatives for soil may be identified such as fly ash, basalt grit and dust etc.

7. LITERATURE CITED

http://www.ecobrick.in

http://www.etbricks.co.uk

http://www.resourceefficientbricks.org

http://www.vsbkindia.com

http://www.brick-india.com

http://www.damleclaystructurals.com

http://www.indiamart.com/vpindustrials

http://www.gkspl.in

Abdalla, I., Abdalla. B.C., Kamal E.S., Moller. D. and Buerket.A. (2012) Effects of red brick production on land use, household income and greenhouse gas emission in Khartoum, Sudan. *Journal of Agriculture and Rural development in the Tropics and Subtropics,* **113(1),** 51-66.

Anonymous.2011 a. Agriculture Statistics at a Glance.

Anonymous.2011 b. Economic Survey of Maharashtra.

Agarwal,A., (1982) The State of Indian Environment– A Citizens Report, Centre for Science and Environment, Delhi. 4-7.

All India Soil Land Survey organization (1970), *Soil Survey Manual*, Indian Agricultural Research Institute, New Delhi. pp 50-52 and 58-64.

Allison.L.E. and Moodier,C.D.(1965) Methods of soil analysis. Part II, Black C.A. (Ed.) *American Society of Agronomy*, Madison, W.I. pp1387-88

Araya S.N. (2014) Effect of combustion temperature on soil organic matter properties: A study of soils from the western elevation transect in central sierra Nevada, California. MS thesis submitted to Unversity of California, Merced. pp: 18-23, 24-37.

Bhushan,C., Basu,D.D., Yadav,N.K. and Kumar,R. (2016) National Brick Mission- A scoping paper, Centre for Science and Environment, New Delhi.

Biswas, T.D. and Mukherjee S.K. (1994) *Textbook of Soil Science,* Second edition, Tata McGrew-Hill Pub. Ltd. New Delhi. pp 1-2, 90-92, 222, 361-36.

Blake,G.R. and Hartage,K.H.(1986) Bulk density. In methods of soil analysis,part I, Klute,A.(Ed) II edition , American Society of Agronomy Inc. and Soil Science Society of America Inc.,Madison,USA.pp.371-373.

Casida, L.E., Jr. Klein, D.A. and Santora, T. (1964) Soil dehydrogenase activity. *Soil Science* **98**, 371-378.

Chapman, H.D. and Pratt, P.F. (1961) *Methods of analysis of soils, plant and water*, Division of Agricultural California University., USA. pp. 309

Chen, X. and Li B. (2003), Change in soil carbon and nutrient storage after human disturbance of a primary Korean pine forest in Northeast China, *Forest Ecology and Management* **186**,197-206.

Eswaran,H. (1999) Recommendation in the proceedings of the 2nd International conference on land degradation, khon kaen, 25-29.

Gollany, H.T., Schumacher,T.E., Lindstrom, M.J., Evenson, P.D., and Lemme,G.D. (1992) Top soil depth and desurfacing effects on properties and productivity of a Typic Argiustoll. *Soil Science Society of America Journal*. **56**, 220-225.

Grewal, M.S. and Kuhad, M.S. (2002) Soil Desurfacing–Impact on Productivity and Its Management. 12th ISCO Conference.

Hedge, R., Natrajan , A., Naidu , G.K., and Sarkar, D. (2011) Soil Degradation, Soil Erosion Issues in Agriculture, Dr. Danilo Godone (Ed.)

Ismail, M.A. (2012) Soil fertility of brick fields and nearby agricultural fields at Madhupur UpaZila in Tangail, MS Thesis, Bangladesh Agricultural University, Mymensingh.

Jackson, M.L. (1973) Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi, pp. 69-182.

Kamyotra, J. S. (2007) Brick kilns in India, Director, Central Pollution Control Board Delhi, India.

Karaman,S., Ersahin,s. and Gunal,H. (2006) Firing temperature and firing time influence on mechanical and physical properties of clay bricks, *Journal of Scientific and Industrial Research*. **65**,153-159

Kathuria (2007) Environmental cost of using top-soil for brick making –A case study from India, (Plate 2 in Appendix 1), EAERE

Keeny, D.R. and Nelson, D.W.(1982) Nitrogen-inorganic forms *In Methods of Soil Analysis* Part 2, Chemical and Minerological properties, Page,A.L.(Ed), II Edn. American Society of Agronomy Inc. and Soil Science Society of America Inc. Madison, Wisconsin, USA.pp.643-693.

Khan,H.R., Rahman,K., Rauf,A.J., Sattar,G.S., Oki Y., and Adachi, T., (2005) Assessment of degradation of agricultural soils arising from brick burning in selected soil profiles, *International Journal Environmental Science and Technology* **4**(**4**),471-480.

Kudesen, D., Peterson, G.A. and Pratt, P.F. (1982) Lithium, sodium, potassium in methods of soil analysis. part II page, A.L. (Ed) Madison, Wisconsin, USA, pp.225-246

Kumar,S.K., Jakoji, S.C.,Chinagodaba,S.B., Karne,K. and Kumar ,V.G.(2015) Role of Brick Industry in the Degradation of Land and Enverionment-A Case Study of Mallaram in Nizamabad, Telangana State. *International Journal of Civil and Structural Enginnering Research*, **3(1)**, 222-227.

Lalchandani D. and Maithel S. (2013) Towards Cleaner Brick Kilns in India, Greentech Knowledge Solutions Pvt. Ltd, New Delhi. A Shakti Sustainable Energy Foundation Supported Initiative, pp 6-8.

Lindsay, W.L. and Norvell, W.A. (1978) Development of DTPA soil test of Zn,Fe, Mn, and Cu. *Soil Science Society of American Journal* **42**, 421-428.

Maithel,S., Lalchandani, D., Malhotra, G., and Bhanware, P. (2015) Monitoring of brick kilns & strategies for cleaner brick production in India, Greentech Knowledge Solutions Pvt .Ltd., New Delhi ,India.

Maithel,S. (2013) Evaluating Energy conservation potential of brick production in India, A Final report prepared for SAARC Energy centre, Islamabad.

Miller, C.E. and Turk, L.M. (2002) Fundamentals of Soil Science, Daya Books.

Munsell Color Company (1975) Munsell soil color charts 1975 ed. Munsell color Co., Baltimore, MD.

Nelson, D.W. and Sommer, L.E (1982) Total carbon and organic matter. *In Method of Soil Analysis*. Part 2, Page, A.L.(Ed), American Society of Agronomy Inc. Soil Science Society of America Inc. Madison, Wisconsin, USA. pp. 539-579.

Ngwu, O. E., Mbagwu, J. S. C., and Obi, M. E., (2005) Effect of Desurfacing on Soil Properties and Maize Yield—Research Note, *Nigerian Journal of Soil Science*, **15 (2)**, 148–150.

Noll D. (2015) Socio-ecological impacts of brick kilns in the Western Ghats: A socio –metabolic analysis of small scale industries in the Mumbai metropolitan region, Maharashtra, India. *Social ecology Vienna*, social ecological paper 164.

Page A.L., Miller, R.H. and Keeny, D.R. (1982) *Methods of Soil Analysis. Part 2, Chemical and Microbiological Properties*

(2nd ed.), Soil Science Society of America, Madison, Wisconsin, USA.

Panse, V. G. and Sukhatme, P.V. (1985) Statistical method for Agriculture Workers, Revised Edn. ICAR. New Delhi.

Pariyar, S. K., Das T. and Ferdous T. (2013) Environment and health impact for brick kilns in Kathmandu valley.*International Journal of Scientific & Technology Research,* **2(5)**,16-19

Peterson,G.W. and Corey,R.B.(1966) A modified Chang and Jackson procedure routine fractions of inorganic soil P. *Soil Science Society of America journal* **30**,363-565

Peterson,J.B.(1964) The relation of soil fertility to soil erosion. *Journal of Soil Water Conservation* **19**,15-18

Piper,C.S.(1966) Soil and Plant Analysis, Hans Publication Bombay.pp.368.

Richarrds,L.A.(1941) A pressure membrane apparatus for soil solution extraction .*Soil science* **51**,377-385

Salek, M.A. (2007) Effect of brick field on some chemical properties of soil at Birganj of Dinajpur. MS thesis, Bangladesh Agricultutre University, Mymensingh.

Saviour, M.N. and Stalin, P (2012) Soil and Sand Mining: Causes, Consequences and Management. *IORS Journal of Pharmacy*, **2(4)**, 1-6.

Singh, P., Devi, R., Hooda, R.S. and Grewal, M.S. (2014) Map and identify desurfsced soils in Rohatak and Jhajjar disticts in last five years using RS. *International Journal of Emerging Science and Engineering*, **2(4)**, 27-32.

Singh, P., Devi, R., and Hooda, R.S. (2015) Dynamics of soil desurfacing due to brick kilns and suggestive management techniques. *International Journal of Multidisciplinary Research and Development*, **2(4)**,292-298

Subbiah, B.V. and Asija, G.L. (1956) A rapid procedure for estimation of available nitrogen in soils. *Current Science,* **25**,259-260.

Suraj R. and Neelakantan R. (2014) Clay mining areas and its impact over the hydrological cycle ecosystem in mining district, south India, International Journal of Advancement in Remote Sensing, GIS and Geography, **2(2),**18-26.

Watanabe, F.S. and Olsen S.R. (1965) Test of ascorbic acid methods for phosphorus in water and sodium bicarbonate extract of soil procedures. *Soil Science Society of America Journal,* 21, 677-678.

Williams, C.H. and Steinberg, A. (1959) Soil sulphur fractions as chemical indices of available sulphur in some Australian soils. *Australian Journal of Agriculture Research* **10**, 340-352.

Yadav, S.K. (2013) Remote Sensing Based Management of Degraded Soil Due to Brick Industry for Sustainable Development – A Case Study. *Journal of Human Ecology*, **14(6)**, 451-455.

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* Original not seen

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