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Influence of brick processing on changes in soil physico-chemical properties of Bhaktapur District, Nepal

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Abstract
In the name of Urbanization and Industrialization, numbers of brick kilns are increasing day by day with the abundant manufacture of brick utilizing top fertile soil from the nearby agricultural land. So, this study was conducted to investigate the effect of brick industries on agricultural productive land in Bhaktapur district. The research was conducted in ten different brick factories of Bhaktapur district starting during 2018. The purpose of the study is to know the amount of nutrient dumped by brick factory and nutrient stored in the brick. With the objective of soil fertility assessment of nearby degraded land of brick factory this study was carried out. For this, purposive sampling method was followed by selecting four treatment from ten different locations of Bhaktapur district i.e. raw brick, furnished brick, soil within the premises of industry and soil from nearby agricultural land. Soil samples were collected and analyzed for total nitrogen, available phosphorus, available potassium, pH and organic matter content following standard procedure. The data obtained were subjected to statistical analysis using GenStat software.

The result showed that there is significant decrease in total nitrogen, available phosphorus, available potassium and organic matter content of the soil from agricultural land to excavated land and from raw brick to brunt brick. Highest amount of soil nutrients (total N, available phosphorus and available potassium) and organic matter content were found on agricultural land but in lower range whereas, lowest is present in burnt bricks. Soil from agricultural land was found to be more acidic (<5 pH) in comparison to excavated land. Similarly, slight decrease in pH was noticed after burning of the brick. It was observed that about 45% of Nitrogen is stocked in finally prepared brick while 83% of nitrogen is lost from excavated land to furnace brick. Similarly, 52.8 % and 67.8% of phosphorus and potassium is stocked in furnace brick with the loss of 69.13% and 81.66% of them respectively from excavated land to burnt brick whereas, 46.60% of organic matter is dumped in brick with loss of 59.70% from excavated land.

Keywords: Brick kilns, agricultural land, excavated land, raw brick, burnt brick, soil chemical properties, etc.

Introduction

Nepal is one of the ten least urbanized countries in the world. However, it is also one of the top ten fastest urbanizing countries. In 2014, the level of urbanization was 18.2 percent, with an urban population of 5,130,000, and a rate of urbanization of 3 per cent (UN DESA, 2014) [15]. For the period 2014- 2050, Nepal is claimed to remain amongst the top ten fastest urbanizing countries in the world with a projected annual urbanization rate of 1.9 per cent (Bakrani, 2015) [3]. The urban population distribution is uneven across the country. 33.5 per cent of the urban population is concentrated in 16 urban centers each with a population of over 100,000 people (MoUD, 2015) [11]. The Central Development Region has the highest proportion of the urban population. Among geographical regions Kathmandu Valley has witnessed a relentless growth in the level of urbanization and remains the most urbanized region in Nepal.

The 7.8 magnitude earthquake in April, 2015 destroyed nearly half million buildings, therefore, demand for construction material increased (Ulak, 2015) [14].

This tremendous increase in number of houses means extra-large demand of bricks. Brick is considered as one of the most important raw material for construction purpose. There are about 1000 brick kilns in Nepal where annually six billion bricks are produced (Baum, 2012) [4].

In Nepal, major brick industries are located in Kathmandu valley and terai region. It is estimated that 110 brick kilnsare in operation in Kathmandu valley. Among 110 kilns operated in Kathmandu valley, 15 are present in Kathmandu district, 32 and 63 in Lalitpur and Bhaktapur respectively. Majority of brick kilns are situated on leased lands and utilize clay from nearby agricultural land/fields. In Nepal, 96% of kilns are outdated and use energy intensive and highly polluting technologies causing harmful impacts on health and agricultural yields(from nitrogen oxide) locally and contribute to global warming (Amatya, *et. al.,* 2017) [2].

The net ultimate result of brick kiln is land degradation. Land is one of the major natural resource of a developing country like Nepal. More than 90% of the population is dependent upon the land for their fulfillment of basic needs (food, fodder, fuel, fiber and timber) (LRMP, 1986) [9]. Land degradation may occur through different physical, chemical and biological processes which are directly or indirectly induced by human activities. Brick kilns near agricultural land leads to declination in soil fertility (MoEST, 2008) [10]. Peripheral agricultural land near brick industries suffers from heavy metal deposition, nutrient declination, disturbance in soil texture and organic matter content that declines crop productivity (Bisht and Neupane, 2015) [5]. Brick kiln are the major source of lower production in the land where the soil are excavated for brick processing (Islam *et al.,* 2015) [6]. The topsoil nutrient elements and soil biota are destroyed through brick burning.Availability of various primary nutrients (Nitrogen, phosphorus and potassium) and secondary nutrients (sulphur, calcium, magnesium etc.) in the nearby land depends upon organic matter content, CEC, pH and soil texture which are changed due to brick making operations (Pendias and Pendias, 2001) [7].

This study was carried out to explore the present status of agricultural land nearby the brick factories of Bhaktapur district. Main focus of study was to be familiar with the soil fertility status of productive and excavated land due to brick kilns and to know about the nutrient fluctuation throughout the brick manufacturing process.

Materials and Methods

Very little work has been done on changes in nutrient content in brick during processing of brick. Efforts have been made to study fluctuation of nutrient at varying stages of processing of bricks. The study has been carried out in Bhaktapur district of Kathmandu Valley, where there are large number of brick kilns with highly productive area. Selection of brick industry for the study was done based on the presence of excavated land nearby whose top soil layer has been removed for brick manufacturing process. Site selection or brick kiln selection was done randomly. Ten brick kilns were selected for the study. Sampling method that we followed in this case study is Purposive sampling method. From each brick industry 4 samples were taken where soil samples weighing around 0.5 kg from the depth of 15cm was taken from agricultural field and excavated land nearby. Similarly, single piece of raw brick and furnished brick from each brick kiln were selected for further analysis. Soil samples (0.5 kg) from both lands were taken using simple random soil sampling techniques. Raw brick and furnished brick were crushed in mortar and pistel and passed through 0.2mm sieve while soil samples collected were air dried for few days and passed through the sieve. Sample prepared were then used for analysis in soil laboratory using standard procedure.

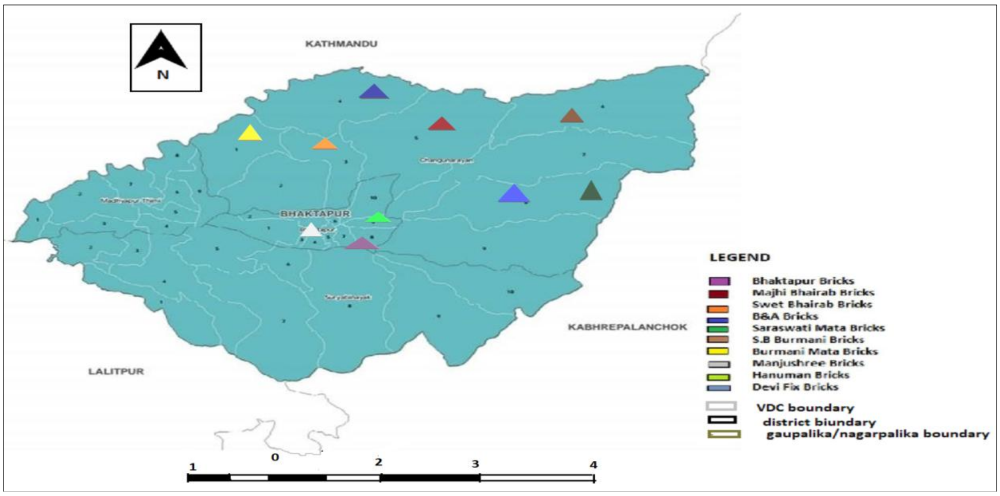

Fig 1: Map of Bhaktapur district showing study areas.

In this study Randomized block design approach of research was adopted. Location wise blocking was carried with four treatments where each block represents the brick kiln of different location within Bhaktapur district. Each kiln factory was considered as replication. Therefore, four treatments with 10 replications were adopted for the study. Treatments detail of the study is presented in table-1.

Table 1: Treatments Detail

Treatment	Samples From
1	Raw Brick
2	Furnace Brick
3	Soil samples from excavated land
4	Soil samples from the agricultural land nearby

The percentage of nutrients and Organic matter (OM) content stocked in finally prepared brick and percentage of nutrients and OM lost from excavated land to burnt brick is calculated using the equation mentioned below.

- % of nutrient (N, P &K) stocked in finally prepared brick:

$$= \frac{\text{Mean value of nutrients in raw brick - Mean value of nutrient in furnace brick}}{\text{Mean value of nutrients in raw brick}} \times 100$$

- % of OM stocked in finally prepared brick:

$$= \frac{\text{Mean value of OM in raw brick - Mean value of OM in furnace brick}}{\text{Mean value of OM in raw brick}} \times 100$$

- % of nutrients (N, P & K) lost from excavated land to burnt brick:

$$= \frac{\text{Mean value of nutrients in excavated land- Mean value of nutrinets in burnt brick}}{\text{Mean value of nutrients in excavated land}} \times 100$$

- % of OM lost from excavated land to burnt brick:

$$= \frac{\text{Mean value of OM in excavated land- Mean value of OM in burnt brick}}{\text{Mean value of OM in excavated land}} \times 100$$

Data collected from the routine analysis of each sample were then recorded in MS-Excel and were used to analyze general ANOVA using GenStat Discovery edition 4 software.

Results and Discussion

Practically less research has been carried out with regard to nutrient stocking by brick industries. Most often, research thrust was put in environmental perspective. Soil samples were collected as per the treatments and analyzed in the laboratory. Results obtained during the study period were systematically arranged and explicitly described under different headings as follows:

Changes in soil physico-chemical properties as influenced by brick processing

Soil reaction

The p-value of pH measurement is 0.008 (p-value<0.05) which signifies that treatment are significantly different with least significance difference of 0.4904 between them. Meanwhile, the identifier shows us that the pH of agricultural land and raw brick are different from each other while pH of furnace brick and excavated land are found to statistically similar. pH is found to be adversely affected by brick processing and brick burning. pH of agricultural land near to the kiln is found to be acidic with value of 4.98 which is found to be significantly different than pH of raw brick, burnt brick and excavated land whose top layer has been removed for brick manufacturing. However, pH value of raw brick and excavated land is somehow similar with the mean value of 5.81 and 5.6. pH value is found significantly increased in burnt or furnace brick by 0.25 pH unit than in the soil of agricultural land which is in contrast with result of Khan H.R *et al*. (2007) [8] and with the result obtained by Rajonee and Uddin (2018) [13]. pH is increasing from agricultural land to nearby kiln area to unburnt brick and slightly decreased in burnt one. But the result of study is in favor of study conducted by Bisht Gunjan and Neupane Sanjila (2015) [5]. pH was observed increasing towards kiln area (Table-2).

Organic matter content

Perusal of the data in table-2 revealed that the highest percentage of organic matter content was observed in agricultural land. Treatments significantly differed from each other. Likewise, OM content on furnace bricks seems to be gradually decreased after burning of raw bricks. Organic matter content is directly related to variation in organic matter incorporation and surface soil removal process. Organic matter concentration is found to be highest in agricultural land which decreases along with the excavated land near kilns and through the brick making process i.e. amount of OM is seen lowest in burnt bricks than raw bricks. This result has noticed to be similar with the results obtained by Bisht and Neupane in their research, which suggests that organic matter increases with the distance and claims that Organic carbon level greater than 0.8% indicates good quality soil. However, overall mean value of Organic matter content in soil near kilns and in soil used for brick making is found in lower range compared to land unaffected by brick kilns. 46% of the organic matter was stocked and 59.70% of the organic matter was found to be lost.

Total Nitrogen Content

Total Nitrogen content in all the brick samples and soil samples showed that it significantly decreased with every step of brick processing (Table 2). Perusal of the results in table 2 revealed that total nitrogen content is much higher in agricultural land and decreased with excavation and processing of brick. The furnished brick showed least N content comparatively to all the treatments adopted. The P-value of N analysis is <0.001 (p<0.05) which signifies that there is significant difference in the nitrogen content of four samples. The table shows that the mean value of nitrogen is increasing from Furnace brick to agricultural land where least amount of nitrogen is present in burnt brick. Higher amount of Nitrogen content was found in agricultural land in comparison to other treatments while lowest concentration of nitrogen is found to be in burnt bricks. This result is similar with the findings of Abdalla *et al.,* 2012 [1], which stated that the areas from which soil was removed for brick-making were found to have lost substantial amount of nitrogen (N). Similarly, significant amount of nitrogen has been lost while burning of raw brick, in the process of making furnished brick as nitrogen starts to volatilize after 200°C (Nearya *et al.,* 1999) [12].

Total nitrogen loss from excavated land to burnt brick throughout the brick forming process was found to be 82.75% which is in tally with the study carried by Khan H.R *et al*., 2007 [8]. This result provided the estimation of N stocked in furnace brick and percentage of N lost during brick processing. Where, about 44.89% of Nitrogen is found to be stocked in finally prepared brick while 83.125% of nitrogen is lost from excavated land to furnace brick.

Table 2: Nitrogen Analysis of different brick and soil sample

Treatments	pH	Organic matter content (%)	Total Nitrogen content (%)	Av. Phosphorus (kg/ha)	Av. Potassium (kg/ha)
Raw brick	5.810^{a}	0.4935^{c}	0.0245^{c}	13.84^{c}	40.04^{c}
Furnace brick	5.230^{bc}	0.2635^{d}	0.0135^{d}	6.59^{d}	12.87^{d}
Excavated land	5.600^{ab}	0.6540^{b}	0.0800^{b}	21.35^{b}	70.20^{b}
Agricultural land nearby	4.980^{d}	1.0820^{a}	0.1404^{a}	34.38^{a}	107.60^{a}
CV%	9.9	7.7	13	8.7	10.8
SEM (±)	0.2392	0.021	0.00389	0.739	5.7342
L.S. D	0.490	0.044	0.00799	1.516	2.7947
P-value	0.008	0.02	<0.001	<0.01	<0.01

Available Phosphorus content

Available Phosphorus content was found highest in the nearby agricultural land than that of excavated land whereas there is decrease in the phosphorus content of brick after burning as compared with raw brick. P-value of phosphorus content is <0.01 that means there is significant difference between the treatments that can also be illustrated by the identifiers present. Likewise, table shows that the highest mean value of phosphorus is present in agricultural land nearby and the least is present in burnt bricks. The availability of P is strongly depends on the soil condition such as pH, clay content, moisture, temperature and P minerals already present in the soil. At pH 6.5, there is maximum availability of P for plants (Hopkin, 2005). However, low pH concentration around brick factory affects the phosphorus concentration of soil. It was observed that, amount of phosphorus has been significantly changed during brick making process where reduction in P concentration from raw brick to furnished brick has been found to be around 52.38% which is similar to the result obtained by Khan H.R et.al., 2007 [8] and 69.13% of nitrogen is found to be lost from excavated land to furnace brick.

Available Potassium content

There is decrease in the content of potassium on burnt bricks compared to raw unburnt bricks. On the other hand, K content in land suffering from excavation is found in lower range than that of nearby cultivated land. Potassium content significantly ($p<0.05$) decreased in burnt brick and was found to be 67.85% lower from raw to furnace brick where Khan H.R *et al*. (2007) [8] suggested it at range of 23-88%.Concentration of K is found highest at agricultural land but in lowest range (<110kg/ha) than excavated land. Similarly, 81.66% of potassium is found to be lost from excavated land to burnt bricks.

Annex 1: Calculation of nutrient stock of different brick and soil sample

Trts	OM%	OM Stock (%)	OM Lost (%)	TN (%)	N stock (%)	N lost (%)	Av. P (kg/ha)	P stock (%)	P lost (%)	Av. K(kg/ha)	K stock (%)	K lost (%)
RB	0.4935	46.6	59.7	0.0245	44.89	83.12	13.84	52.38	61.13	40.04	67.85	81.66
FB	0.2635			0.0135			6.59			12.87		
EL	0.654			0.08			21.35			70.2		
AL	1.082			0.1404			34.38			107.6		

Note: RB=Raw Brick, FB=Furnished brick, EL=Excavated land, AL=Agricultural land, OM= Organic matter, TN=Total nitrogen, N= Nitrogen, Av=Available, P=Phosphorus, K=Potassium

Summary and Conclusion

The quality of land is degrading due to the brick kilns. It was found out that total nitrogen, available potassium and available phosphorus content of soil significantly decreases with brick burning along with the value of Organic matter content. The value of nutrient decreases from agricultural land to excavated land to raw brick and furnace brick. We can analyze that every soil parameters we were dealing with are in decreasing order to burnt brick as well as the parameters were decreasing in the soil of kiln area as well. Brick kiln are massively resulting is soil nutrient loss. Soil of kiln area have severe loss of soil nutrients than nearby agricultural land.

Soil fertility status of nearby agricultural land is found to be in depleting condition with low range of nutrient and organic matter content. Soil mining through brick making near brick kilns is changing productive land into barren field leaving land unsuitable for crop production. Also, nutrient is lost while making raw bricks from soil of such excavated land that again undergoes wide range of depletion while burning the brick.

Value of all the soil nutrients, organic matter content and pH all differed significantly in all treatment which makes us clear that the brick factories have adverse effect on the soil nutrient loss. Soil fertility status of nearby agricultural land is found to be in depleting condition with low range of nutrient and organic matter content.

From this study it is observed that, about 45% of Nitrogen is stocked in finally prepared brick while 83.125% of nitrogen is lost from excavated land to furnace brick. Similarly, 52.80 % and 67.85% of phosphorus and potassium is stocked in furnace brick with the loss of 69.13% and 81.66% of them respectively from excavated land to burnt brick whereas, 46.60% of organic matter is dumped in brick with loss of 59.70% from excavated land. In case of pH, pH of furnace brick is lesser than raw brick with difference of 1 pH unit.

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