Journal of AgriSearch, 13 (1) : 26-29
An Open Access International Peer Reviewed Quaterly

ISSN : 2348-8808 (Print), 2348-8867 (Online)
https://doi.org/10.21921/jas.v13i01.15278

Impact of Desurfacing on Quality of Top Soil for Brick Manufacturing in Bhopal, Madhya Pradesh

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ABSTRACT

Brick kiln activities are one of the well-known causes of air as well as soil pollution. The present study was executed to investigate the impact of brick earth mining operation on the degradation of quality of topsoil of agricultural lands in the study area. To assess the impact of desurfacing on topsoil quality the samples of soil were collected from different sites and analysed for various soil fertility parameters including macro and micro-nutrients. Results revealed that rampant mining of cultivable land for brick kiln activity has immensely affected the quality of topsoil. The macronutrients- Organic carbon, N, P, K and micronutrients- Fe, Mn, Zn and Cu were found significantly decreasing in the desurfaced soil as compared to unexposed topsoil of nearby undug lands. This study also suggested amelioration processes and remedial measures for the reclamation of productivity of desurfaced soil due to brick earth mining operation.

Keywords: Brick kilns, Topsoil, Soil desurfacing, Macro & micronutrients, Environment

ARTICLE INFO

Received on	:	11/03/2026
Accepted on	:	25/03/2026
Published online	:	31/03/2026

INTRODUCTION

In Indian economy construction sector marks a significant contribution in the GDP with considerable annual growth. Bricks have been considered the most common construction material due to their strength, easy availability and affordable price. (Islam et al., 2015). Clay-fired bricks are widely used in India, and their production mainly involves mining, minor minerals such as clay and sand. Brick earth mining leads to depletion of fertile upper stratum of earth crust along with spectrum of micro flora and fauna. (Rajonee and Uddin, 2018). Soil earth mining on large scale may change the land use pattern and adversely affect the agricultural activities. (Saha et al., 2021; Koirala et al., 2025).

The brick sector in Indian is having low mechanization rate and involves earth mining, hand moulding, sun drying and Bull's Trench Kiln clamp firing process for clay brick making. The brick sector in India is unorganised and makes significant contribution to environmental degradation right from digging of brick earth to emissions of quantum of gaseous and particulate pollutants (Suwal, 2018; Kumar et al., 2020). To conserve the environment and to synchronize the small-scale mining, Ministry of Environment Forest & Climate Change came up with legislation for regulating mining of minor minerals for the purpose of brick production. Minor mineral refers to stones, gravel, ordinary clay and ordinary sand other than sand used for prescribed purposes. Worldwide estimate the production of 1000 bilion clay bricks year losing 3500 million tons soil year translated to 1300 Km2 soil year which is equivalent to 131578.95 ha of land every year is lost forever. It takes several hundred thousand years in nature for the retrieval process and regeneration of fertility of soil (Jeet et at., 2020; Das, 2015; Ismail et al., 2012,; Skinder et al., 2014; Sarkar et al., 2016).

Various studies are available regarding the impact of brick kilns and brick earth mining on quality of top soil (Biswas et al., 2018; Saha et al., 2021; Islam et al., 2015; Maji and Alam, 2025). A study carried out on soil contamination in Khejuri area due to brick kiln operation leading to problem of land degradation. A study on soil, dust and plants of Peshawar region of Pakistan revealed the presence of heavy metal concentration in soil and dust. Similar studies on brick kilns of Budgam District of Kashmir, India discussed the major impacts on the environment in respect of air quality, soil and human health. (Bhat et al., 2014) Another study carried out in Bangladesh region in 2015 reveals that every year a large agricultural land area has lost its fertility for excavation of topsoil done for brick manufacturing. (Islam, 2021; Saha et al., 2021). The present study aimed to evaluate the impact of brick earth excavation on topsoil fertility in selected districts around Bhopal, Madhya Pradesh, India, by comparing desurfaced soils with undisturbed agricultural soils.

MATERIALS AND METHODS

Study Area

The study was conducted in the vicinity of Bhopal, Madhya

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Pradesh, India, including Raisen, Vidisha, Hoshangabad, and Sehore districts. The region contains approximately 40–50 clay-based brick manufacturing units. The dominant soil type is clayey Vertisol and the land is primarily used for agriculture. The Google map revealing the study area along with the sampling locations is depicted in Figure 1.

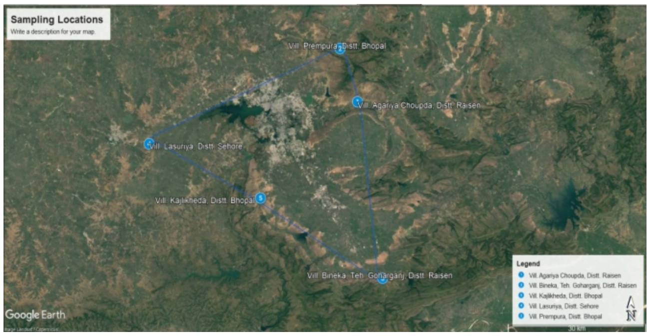

Fig. 1: Google map showing the sampling locations for the study

Soil Sampling

Soil samples were collected from five excavation sites (A1–E1) where topsoil had been removed for brick manufacturing and from five adjacent undisturbed agricultural sites (A2–E2). Samples were collected from the upper 15 cm soil layer using an auger. Composite samples were prepared from multiple points at each site. A total of ten samples were collected, sealed in polythene bags, labelled and transported to the laboratory.

Sample Preparation and Analysis

The collected composite samples were air dried and sieved through a 2 mm sieve and then 500 gm of each sample were stored for chemical analyses. The soil pH was determined using glass electrode pH meter at a soil: water ratio of 1:2.5 as described by Jackson (1985). The Electrical conductivity was measured using a digital EC meter in 1: 5 soil water suspensions (Biswas and Mukherjee, 1987). Total N is determined using Kjeldahl method. Soil samples were extracted by Aqua regia with a ratio of 1: 10 for total P, K, Zn, Cu, Fe and Mn. Micro- nutrients were analysed by atomic absorption spectrometer and Potassium was analyzed using flame photometer with standard procedure. The following parameters were analysed & presented in table 1.

Table 1: Methods used for estimation of-physico chemical property of sample

Particular	Method	Reference
pH (1:2.5)	Glass electrode (1:2.5 soil water suspension)	Richards (1954)
EC	Conductivity meter	Richards (1954)
Organic carbon	Wet-oxidation method	Walkley and Black (1934)
Available Nitrogen	Alkaline Potassium Permanganate Method	Subbiah and Asija Method (1956)
Available phosphorus	Sodium Bicarbonate Extraction (for neutral to alkaline soils)	Olsen's Method (1954)
	Ammonium Fluoride Extraction (for acid soils)	Bray and Kurtz No. 1 Method (1945)
Available Potassium	Neutral Normal Ammonium Acetate Extraction Method	Schollenberger and Simon (1945)
Micronutrients (Fe, Mn, Zn, Cu)	0.005M DTPA+ 0.01M CaCl2+0.1M TEA	Lindsay and Norvell (1978)

All analyses were conducted with following standard laboratory procedures. Results were expressed in SI units. The details of the samples collected with location are mentioned in Table-2

Table 2: Details of sampling locations

Location	Sample Code	Co-ordinates	Type of sampling	Type of Soil
Site A: Vill. Agariya Choupda, Distt. Raisen	A1	23.266384, 77.594891	Location composite	Brick earth soil
	A2	23.2635346, 77.5989703	Location composite	Agricultural land top soil
Site B: Vill. Prempura, Distt. Bhopal	B1	23.3628711, 77.5582258	Location composite	Brick earth soil
	B2	23.3630939, 77.5575430	Location composite	Agricultural land top soil
Site C: Vill. Bineka, Teh. Goharganj, Distt. Raisen	C1	22.9471229, 77.6468160	Location composite	Brick earth soil
	C2	22.9471229, 77.6468160	Location composite	Agricultural land top soil
Site D: Vill. Lasuriya, Distt. Sehore	D1	23.1909265, 77.1546187	Location composite	Brick earth soil
	D2	23.1907168, 77.1548686	Location composite	Agricultural land top soil
Site E: Vill. Kajlikheda, Distt. Bhopal	E1	23.0927084, 77.3898761	Location composite	Brick earth soil
	E2	23.092509, 77.3894235	Location composite	Agricultural land top soil

To assess the impact of desurfacing of topsoil of agricultural land for brick manufacturing operation on the quality of soil, the collected soil samples were are analyzed for various important soil fertility parameters including some macro and micro-elements. The parameters studied in the samples are pH, Electrical conductivity, Total Organic Carbon, Available macronutrients- Nitrogen, Phosphorus and Potassium and Available micro-nutrients- Iron, Manganese, Zinc & Copper.

RESULTS AND DISCUSSION

The availability of various nutrient in soils for plant uptake is limited by several soil factors. The factors include: soil pH levels, clay mineralogy, organic matter, free iron and aluminium, calcium carbonate, soil temperatures and availability of other nutrients among other factors. The observed values of soil fertility parameters are presented in Table 3.

Table 3: Soil Fertility Parameter Values

Sample Code	pH	EC	Organic C	N	P	K	Fe	Mn	Zn	Cu
		(ds/m)	(%)	(kg/ ha)			(mg/ kg)			
A1	8.29	0.356	0.70	150.53	16.55	375.20	29.56	16.08	0.61	3.02
A2	8.40	0.30	0.64	163.07	70.57	320.32	49.60	15.38	1.30	4.14
B1	8.35	0.15	0.15	137.98	5.84	224.00	10.26	6.96	0.40	1.45
B2	8.00	0.33	0.91	163.07	67.16	489.44	26.18	25.80	1.25	1.97
C1	8.17	0.08	0.18	188.16	8.27	209.44	15.79	26.46	0.44	1.20
C2	7.29	0.10	0.45	150.53	8.76	262.08	20.82	25.18	0.62	1.69
D1	7.26	0.13	0.21	137.98	16.06	157.92	31.38	33.08	0.58	4.02
D2	7.60	0.14	0.30	163.07	11.19	175.84	30.94	36.74	0.74	5.85
E1	7.80	0.19	0.61	125.44	6.81	265.44	24.90	29.50	0.68	4.64
E2	7.89	0.36	0.76	225.79	20.44	417.76	14.04	21.38	0.55	2.75

pH and Electrical Conductivity

The pH ranged from 7.26 to 8.29 in desurfaced soils and 7.29 to 8.40 in undug soils. Both soil types were slightly alkaline. However, all kinds of crops are grown well in the range of 5.6-7.3 as all required nutrients are available in this range of pH. The values of EC for both the set of soil samples show the non-saline nature of soil in the studied areas. However, for desurfaced soil samples the EC calculated lower as compared to undug topsoil samples.

Organic Carbon Percent

Organic Carbon Percent is an important property of soil that affects other physical and chemical properties of soil. A level of Organic Carbon Percent greater than 0.75% indicates good soil fertility. 11 12 There is a direct relation between Organic Carbon Percent and Nitrogen. Organic Carbon Percent sequestration cannot occur in the absence of N. A reasonable loss in Organic Carbon Percent values were significantly lower in excavated soils. The highest reduction (76%) was observed at site B1 (0.15%) compared with B2 (0.91%). Organic Carbon Percent values in desurfaced soils were mostly below 0.75%, indicating poor fertility.

Macronutrients

Nitrogen (N), Phosphorus (P) and Potassium (K) are the primary macro nutrients of soil that play crucial role in soil fertility. The available N content ranged from 150.53 to 225.79 kg/ha and 125.44 to 188.16 kg/ha in the undug topsoil and desurfaced soil respectively. The reasonable value of available N in soil should be greater than 225kg/ ha. But for both the groups of samples the study observed lower level of available nitrogen in the soil. However, the desurfaced soil contains even much lesser N as compared to that calculated in undug topsoil samples collected from the nearby agricultural land. Lower value of nitrogen in the studied soil may be due less content of organic matter which contains nitrogen fixing micro-organisms.

Phosphorus (P) is the second most important macronutrient in the soil vital for plant growth and sustained agricultural productivity. Healthy soil contains phosphorus in the range of 20- 35 kg/ ha. In the studied soil sample, the available Phosphorus content was observed in the range of 5.84 to 16.55 kg/ha in the excavated soil samples while found in the range of 8.76 to 70.57 kg/ha in nearby agricultural soil. Both from land excavated for brick mining and undug top soil from agricultural land, the soil samples B1, C1, C2 & E2 collected showed low available phosphorus content below 11.0 kg/ ha. The soil sample A1, D1, D2 & E2 showed available phosphorus in the medium range, 11- 22 kg/ ha; while two of the sample from undug agricultural land viz. A2 & B2 showed much higher range of available phosphorus. The increased phosphorus buildup in the agricultural lad soil samples may be caused by excessive use of inorganic fertilizers or use of composts and manures high in phosphorus. Potassium is an essential macronutrient that regulates water balance, enzyme activation, and stress tolerance. Low potassium can limit crop yield. Values ranged from 157.92 (D1) to 489.44 (B2). Potassium was generally higher in samples B2 (489.44) and A1 (375.20), while D1 showed the lowest availability.

Micronutrients

The analysis of soil samples (A1–E2) reveals considerable variation in the levels of essential micronutrients—iron (Fe), manganese (Mn), zinc (Zn), and copper (Cu)—which collectively play a vital role in plant growth and soil fertility. Iron and manganese are present in relatively higher amounts across most samples, ensuring basic support for chlorophyll formation, photosynthesis, and enzymatic functions, while copper occurs at moderate to high levels, contributing to enzyme activity, lignin formation, and reproductive development. In contrast, zinc is consistently found at the lowest concentrations, making it the most limiting nutrient in these soils and a potential factor for stunted growth and yield reduction if not managed properly. Overall, soils such as A2 and D2 appear nutrient-rich with balanced levels of these micronutrients, while B1 is the most deficient site, showing low values for nearly all elements. The combined micronutrient profile suggests that while Fe, Mn, and Cu are generally adequate, zinc deficiency remains a common constraint that could significantly impact crop productivity, emphasizing the need for integrated nutrient management strategies. The results demonstrate that excavation of fertile topsoil for brick manufacturing significantly reduces soil fertility. The marked decline in SOC directly affects nitrogen availability due to their interrelationship. Reduced phosphorus and potassium further limit plant growth and productivity. Although iron, manganese, and copper were present in adequate amounts, zinc deficiency was common and may adversely affect crop yield. Similar findings of nutrient depletion and land degradation near brick kiln sites have been reported by Das (2015), Ismail *et al*. (2012) and Skinder *et al*. (2014). The persistence of slightly alkaline pH conditions indicates that nutrient depletion is primarily associated with removal of fertile topsoil rat her than changes in soil reaction. Given the slow natural regeneration of soil, continuous excavation threatens long-term agricultural sustainability.

CONCLUSION

The present study establishes that large-scale excavation of fertile topsoil for brick kiln activities has significant impact on the soil quality. Comparative analysis between desurfaced and undisturbed soils revealed a marked decline in organic carbon, nitrogen, phosphorus, potassium, and essential micronutrients, particularly zinc, in the mined sites. While iron, manganese, and copper remain at relatively adequate levels, the combined loss of macronutrients and the consistently low zinc content pose serious threats to soil fertility, agricultural productivity, and long-term sustainability of the land. Sustainable brick production policies, strict monitoring of unregulated units, and awareness among stakeholders are critical to mitigating the adverse impacts of brick kiln operations on soil resources and ensuring environmental conservation.

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Citation:
Verma R C, Wankhede S, Saha J K and Chaturvedi A.2026. Impact of desurfacing on quality of top soil for brick manufacturing in Bhopal, Madhya Pradesh. *Journal of AgriSearch* 13(1): 26-29.