International Journal of Science and Research Archive

eISSN: 2582-8185

Cross Ref DOI: 10.30574/ijsra

Journal homepage: https://ijsra.net/

(Research Article)

Check for updates

Physico-chemical analysis of soil: A comparative study of Borjan and Upper Tiru Coalmine under Naginimora Sub-division, Mon, Nagaland

Manjong N *, Imtiwabangla, Sangyu Yaden, Yoh Veswu, Viketouzo Zao and Wangshimenla Jamir

Nagaland University, Lumami, Department of Geography.

International Journal of Science and Research Archive, 2025, 16(03), 1153-1158

Publication history: Received on 16 August 2025; revised on 23 September 2025; accepted on 26 September 2025

Article DOI: https://doi.org/10.30574/ijsra.2025.16.3.2671

Abstract

This study compares the Physico-chemical properties of soil from Borjan and Upper Tiru coal mines in Mon District, Nagaland. The two regions, exposed to different mining practices-rat-hole (underground) in Borjan and open-cast in Upper Tiru reveal differences in soil quality. Results indicate that Borjan has a healthier soil compared to Upper Tiru although both areas pose potential risk if not monitored regularly. The soil samples were analyzed for soil pH, Texture, moisture content, nitrogen, organic carbon, phosphorous, exchangeable potassium, electrical conductivity, bulk density and particle density. The upper Tiru coal mine area (open cast mining) employs heavy machinery for large scale mining results in mass excavation of surface land and thereby causing stronger soil acidity and higher electrical conductivity. This also shows the salinization risk and nutrient depletion. These findings suggest the need for regular monitoring, intervention of government for strategic planning such as soil reclamation through vegetating and backfilling the excavated pits to ensure ecological sustainability and soil recovery in mining impacted regions.

Keywords: Soil Quality; Coal Mining; Borjan; Upper Tiru; Nagaland; Environmental Degradation

1. Introduction

Soil is an important aspect of lithospheric component in the earth's crust for it sustain all kinds of life. It acts as a home to many animal and plant communities. In the earth's crust, different types of soil and mineral co-exist together and one such common mineral is coal. Coal is the fossil formed from the remains of death plants buried millions of years ago. It is one of the most common and abundant fossil fuel found on the earth and so to India too. It plays a humungous role in industrial development of the country as many basic and heavy industries use coal as the raw material. It also plays a vital role in uplifting the economy. Despite coal being an important resource, exploitation and utilization in an unscientific way has caused a threat to environment all over. In a country like India, mining is extracted through two process – open cast also called the surface mining and the underground mining. Out of which the open cast or the surface mining is the most common. Opencast mining is a type of surface mining, which entails removing the vegetation, topsoil and rock (called overburden materials) above the mineral deposits. The choice of mining method depends on various factors such as geological condition (depth, size, type, and quality of deposit), technological development and level of mechanization (Mukherjee and Pahari, 2019). Open cast mining, especially in the areas where there are vast areas of forests, leads to loss in biodiversity, soil nutrients etc. (Rai et al., 2011). The extraction and processing of coal disturb the natural soil profile, leading to physical and chemical degradation (Ghose, 2004). Soil in mining areas often becomes compacted, acidic, and contaminated with heavy metals, reducing its fertility and affecting plant growth (Pandey and Singh, 2010). Residues are released either into the water or to the soil after the mining extraction is done and this has created a serious threat to the surrounding areas. Coal mining contaminated the nearby soil through atmospheric deposition and is one of the most common sources of pollution in soil (Mondal et al., 2010. The area that falls under the mining site becomes uninhabitable for all living organisms rendering it unfit for cultivation as the soil fertility is drained by the chemical compositions in the coal waste (R Tzudir, Y Srikanth, 2022).

* Corresponding author: Manjong N

Copyright © 2025 Author(s) retain the copyright of this article. This article is published under the terms of the Creative Commons Attribution Liscense 4.0.

In the Upper Tiru Fertile land for generations used for farming became a vast excavated surface where randomly heaped hillocks are followed by mining holes, some of them already filled with polluted water. Due to deteriorating conditions of the soil in many areas the land had to be already abandoned (Maria, 2018). Underground mining, specifically the "rat-hole" mining method used in Borjan has had significant impacts on soil quality. It causes substantial long-term damage to soil health, particularly in areas like Borjan where unregulated practices are common. These alterations not only disrupt local ecosystems but also pose long-term challenges for land reclamation and sustainable land use. Understanding the extent and nature of soil degradation in coal mining regions is important for developing effective remediation strategies and minimizing environmental damage. Both opencast and underground mining methods have contributed to severe environmental degradation in the region. The uncontrolled expansion of mining activities has led to acid mine drainage, contaminating water sources and devastating ecosystems.

2. Study Area

The studies were conducted in two coal mining regions of the Nagini mora sub-division of Mon district, Nagaland. According to Census 2011, the total area of Nagini mora Circle is 184 km^2, which includes 179.57 km^2 of rural area and 4.00 km^2 of urban area. It is in the northwestern part of Mon district between 26°48′33″N latitude and 94°48′36″E longitude. The regions are the Borjan coal mine where underground mining is practiced and the Upper Tiru coal mine where open cast mining is practiced. These coal fields fall under the Schuppen belt and are known for their sub-bituminous coal. Both Borjan and Upper Tiru are situated a few kilometers from the trade hub of Naginimora and adjoins the Dikhu River. The two regions are under the same agro-climatic zone but have very different mining processes and landforms. The difference provides a good background for comparative studies, especially in soil characteristics. Sub-surface excavation processes with comparatively less surface disturbance are experienced at Borjan while extensive surface changes due to open cast processes are experienced at Upper Tiru. These differences affect variables like soil structure, nutrient content, erosion patterns and vegetation recovery. The two areas are ecologically sensitive and have a critical role to play in the regional landscape, which is dominated by hilly terrain with tropical to subtropical climate regimes. The selection of the study area was based on the necessity to understand how various mining methods affect soil quality and ecosystem sustainability in geographically and climatically similar environments. The different mining activities under a common ecological environment are crucial to understanding the wider implications of coal mining on land degradation and environmental quality.

3. Methodology

Soil samples were collected from two coal mining sites of Borjan and Upper Tiru. Soil samples were collected (from 0 to 30 cm depth) from active coal mining sites. Unwanted particles were removed manually, and the sample were collected in plastic sample bags. Soil parameters such as pH, moisture content, nitrogen, organic carbon, available phosphorous, potassium, electrical conductivity, bulk density and particle density were analyzed to determine various physical and chemical properties using standard laboratory methods. Soil pH was measured using a glass electrode pH meter. Moisture content was determined through the gravimetric method by oven-drying soil at 105°C, with Borjan showing higher moisture retention. Nitrogen content was estimated through the alkaline permanganate method. Organic carbon was measured by the Walkley-Black method, Exchangeable potassium was extracted with ammonium acetate and measured using a flame photometer, Electrical conductivity (EC), an indicator of soluble salts, was measured using a conductivity meter, Bulk and particle densities were determined using core sampling and pycnometer methods respectively, with both locations showing similar physical properties.

4. Results and Discussion

The comparative analysis of soil samples from Borjan and Upper Tiru reveals distinct variations in their physical and chemical properties, which have significant implications for soil fertility and agricultural productivity.

4.1. Soil pH of Borjan and Upper Tiru

The pH levels of both Borjan and Upper Tiru indicate that soils from both mining sites are acidic. The pH levels of Upper Tiru with 5.33 are more acidic than the soil of Borjan (6.18). The main cause of acidic soil in mining zones is due to the process called acid mine drainage (AMD). Coal contains pyrite ($FeS2$) and when this mineral gets exposed to oxygen and water (during and after mining), it undergoes a chemical reaction that releases sulfuric acid which results in lowering the pH making the soil acidic.

Table 1 Comparative table based on the soil pH levels between Borjan and Upper Tiru

Parameter	Site-1 Borjan	Site-II Upper Tiru	Interpretation
pH Level	6.18	5.33	Both soils are acidic, but Upper Tiru is more strongly acidic
Acidity classifications	Moderately acidic	Strongly acidic	pH 5.33 in Upper Tiru may severely limit nutrient availability
Effects on Nutrients	Nutrient availability is relatively better	Reduced availability of P, Ca, Mg and other cations	Strong acidity binds nutrients making them less available to plants

4.2. Moisture Content

Moisture content in coal mining sites is often lower due to disturbances caused by mining activities. A comparative analysis of moisture content between the Borjan and Upper Tiru reveals that moisture content is considerably higher in Borjan (16.76 %) than in Upper Tiru (11.01%), which shows that there is better water holding capacity in Borjan (Fig.1). The difference in mining practices such as open cast mining and underground mining reflect the variation in soil health as more modern machinery are deployed in open cast mining which result in mass removal of vegetation and topsoil as well as the compaction soil. Whereas in Borjan, the method of mining is traditional (Rat-hole mining) which requires more manual labor. This method results in less removal of topsoil and vegetation allowing the soil to retain more moisture as compared to Upper Tiru.

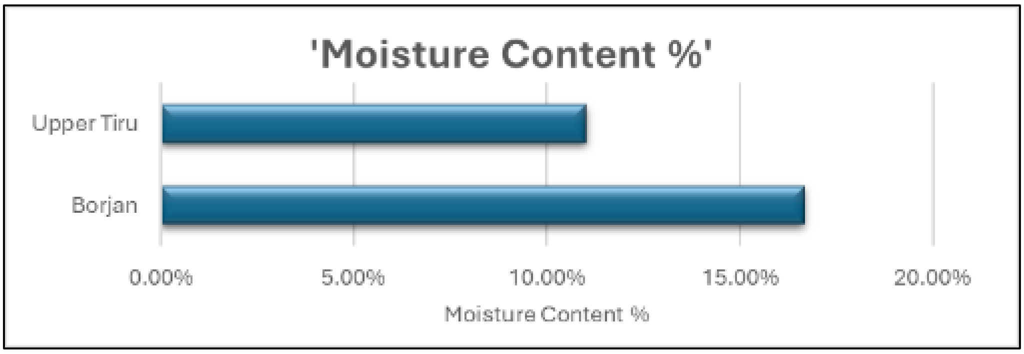

Figure 1 Comparative analysis of moisture content between the Borjan and Upper Tiru

4.3. Available Nitrogen and Organic carbon

The available nitrogen in Borjan records 380 kg/ha, compared to 293 kg/ha in Upper Tiru (Table.3). This shows that the mining methods play a major role where underground mining does not cause many disturbances to the land surface. As a result, the natural nitrogen cycle remains relatively intact, allowing for better retention of nitrogen in the soil. Whereas Upper Tiru practices opencast mining which requires complete clearance of surface land. This extensively disrupts the soil structure and reduces nitrogen availability.

Mining activities such as removal of vegetation hindered the formation of organic matter in the soil. Continuous mining in this region has led to the disruption of the natural carbon cycle. The result indicates that the organic carbon which determines the soil structure and microbial activity is higher in Borjan (0.69%) as compared to Upper Tiru (0.56%), reflecting better organic content in Borjan (Table.2).

Table 2 Comparative table based on the available nitrogen and organic carbon between Borjan and Upper Tiru

Parameter	Site-1 Borjan	Site-II Upper Tiru	Interpretation
Available Nitrogen	380 kg/ha	293 kg/ha	Borjan has higher nitrogen, supporting vegetative growth
Organic Carbon	0.69%	0.56%	Indicates better soil health and organic matter content in Borjan
Soil fertility potential	Higher	Lower	Borjan higher N and OC support better overall fertility

4.4. Available Phosphorus and Exchangeable Potassium

The available phosphorous content in the soil of Borjan records 24kg/ha and 20 kg/ha in Upper Tiru, both within the moderately sufficient range. Having slightly phosphorous content, Borjan has a better nutrient status compared to Upper Tiru. Exchangeable potassium is also marginally higher in Borjan (180 kg/ha) as compared to Upper Tiru (160 kg/ha). This reveals that there is better cation availability for the growth of vegetation in Borjan soil.

Table 3 Comparative table based on the available phosphorous and exchangeable potassium between Borjan and Upper Tiru

Parameter	Site-1 Borjan	Site-II Upper Tiru	Interpretation
Available Phosphorus	24 kg/ha	20kg/ha	Both are moderately sufficient, but Borjan has slightly better nutrient status
Exchangeable Potassium	180 kg/ha	160 kg/ha	Higher in Borjan, indicating better cation availability for plant uptake
Nutrient status	Moderate	Low	Borjan shows higher macro-nutrient levels.

4.5. Electrical Conductivity (EC)

Electrical Conductivity, which is a key contrasting characteristic of soil, is significantly higher in Upper Tiru (0.85 mS/cm) relative to Borjan (0.21 mS/cm). Although both values are below the vital limit for salinity problems. The slight difference shows that Upper Tiru has a greater soluble salt content, which could start to impact the growth of vegetation if it increases further.

Table 4 Comparative table based on the electrical conductivity between Borjan and Upper Tiru

Parameter	Site-1 Borjan	Site-II Upper Tiru	Interpretation
Electrical conductivity	0.21 mS/cm	0.21 mS/cm	Both within safe limits, but Upper Tiru has significantly higher EC
Salinity Risk	Low	Moderate	Higher EC in Upper Tiru indicates more soluble salts, posing a further risk

4.6. Bulk Density and Particle Density

Similar values between the two sites are seen in terms of physical characteristics, bulk density and particle density. Although both values are within the normal range, Borjan exhibits a slightly greater bulk density (1.58 g/cm3) than Upper Tiru (1.53 g/cm3). The slightly elevated bulk density at Borjan suggests nominally more compacted soil. Particle density is marginally higher in Upper Tiru (2.75 g/cm3) than Borjan (2.65 g/cm3). This indicates that the presence of heavier mineral soil or lower organic matter is slightly greater in Upper Tiru.

Table 5 Comparative table based on the bulk density and particle density between Borjan and Upper Tiru

Parameter	Site-1 Borjan	Site-II Upper Tiru	Interpretation
Bulk Density (g/cm^3)	1.58	1.53	Slightly higher in Borjan, indicating slightly more compact soil
Particle Density (g/cm^3)	2.65	2.75	Slightly higher in Upper Tiru, both within the normal range
Soil Compaction Tendency	Slightly higher	Slightly lower	Borjan soil may have marginally higher resistance to root penetration

5. Conclusion

Different mining methods between Borjan and Upper Tiru reveal significant differences of soil samples. Borjan, characterized by underground "rat-hole" mining, mostly shows healthier soil parameters, less acidic, higher moisture content, better organic carbon and nitrogen levels indicating higher nutrient availability and relatively lesser surface disruption. Whereas Upper Tiru, which employs open cast mining, shows stronger acidity with less moisture and nutrient retention. It also has higher electrical conductivity and greater salt concentration, indicating soil deterioration and greater surface disruption.

Mining practices from both sites pose environmental concern, however, sever degradation of soil quality is caused by open cast mining. These findings suggest the need for control measures to prevent further soil degradation in these two mining sites. Reclamation of soil through backfilling of excavated pits, revegetation (native species), monitoring and management are vital for these regions. Area-specific strategic planning, remediation-organic amendments and afforestation need to be necessitated especially in Upper Tiru.

Compliance with ethical standards

Acknowledgments

The authors would like to express their sincere gratitude to all individuals and institutions that contributed to the successful completion of this work. We thank Nagaland University, Nagini mora Town Council for their valuable support, guidance, and feedback throughout the research and writing process. We would like to assert that all authors listed in the manuscript have contributed significantly to the research and writing of the article. We confirm that all authors listed on the manuscript have made substantial contributions to the research process, including the design, analysis, and interpretation of the data, as well as writing and revising the manuscript.

Disclosure of conflict of interest

All authors declare that they do not have conflict of interest.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

References

[1] Ghose, M. K. (2004). Effect of opencast mining on soil fertility. Journal of Scientific and Industrial Research, 63(12), 1006–1009.

[2] Kekane, S. S., Chavan, R. P., Shinde, D. N., Patil, C. L., and Sagar, S. S. (2015). A review on physico-chemical properties of soil. International Journal of Chemical Studies, 3(4), 29-32.

[3] Pandey, S. K., and Singh, R. (2010). Impact of coal mining on vegetation: A case study in Jaintia Hills district of Meghalaya, India. International Journal of Environmental Sciences, 1(3), 445–450.

[4] Poonam Poonia1 *, Ram Prasad Choudhary2 and Sangeeta Parihar3

[5] Mukherjee, S., and Deb Prakash Pahari. "Underground and opencast coal mining methods in India: a comparative assessment." Space and Culture, India 7.1 (2019): 39-55.

[6] Maria, (2018). Rampant Coal Mining in Tiru, Nagaland: Adverse Prospects for the Future of Local People and Environment

[7] Rai, A. K., Paul, B., and Singh, G. (2011). A study on physico chemical properties of overburden dump materials from selected coal mining areas of Jharia coalfields, Jharkhand, India. International Journal of Environmental Sciences, 1(6), 1350-1360.

[8] Tzudir, Repakaba, and Yamsani Srikanth. "Socio-ecological impact of coal mining: a study in molungkimong village, Nagaland." Man Environ. Soc 3 (2022): 23-36.

[9] Albert, R. P., Pinto, L. F. S., Miguel, P., Stumpf, L., and Leidemer, J. D. (2022). Acidification potential of geological materials in a coal mining area in southern Brazil. Journal of South American Earth Sciences, 120, 104103.

[10] Yaseen, S., Pal, A., Singh, S., and Skinder, B. M. (2015). Soil quality of agricultural fields in the vicinity of selected mining areas of Raniganj Coalfield India. Journal of Environmental and Analytical Toxicology, 5(3), 269.

[11] Sucheta, K., Sheela, G., and Dhaval, P. (2020). Analysis of Soil Samples for Its Physical and Chemical Parameters from Mehsana and Patan District.”.