Int. J. Sci. R. Tech., 2025 2(4)
A Multidisciplinary peer-reviewed Journal
www.ijsrtjournal.com [ISSN: 2394-7063]

Original Article

Assessing the Impact of Coal Characteristics on Thermal Power Plant Efficiency and Pollutant Emissions

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ABSTRACT

The quality of the coal utilized greatly impacts the efficiency and emissions of power plants. This study looks at how coal quality affects power plant performance, with an emphasis on emissions and efficiency. The analysis shows that power plant efficiency and emissions are influenced by coal quality characteristics, including calorific value, ash content, moisture content, sulfur content, and nitrogen content. The impact of coal quality on emissions of sulfur dioxide, carbon dioxide, nitrogen oxides, and particulate matter is also examined in the study. Strategies for improving coal quality to enhance power plant efficiency and reduce emissions can be informed by the study's findings.

Keywords: Coal quality, Power plant efficiency, Emissions, Environmental impact, Coal combustion

INTRODUCTION

The efficiency and emissions of power plants are significantly impacted by India's reliance on coal for energy generation. With thermal power plants being the main source of electricity generation, coal serves as the nation's main fuel source and contributes significantly to energy production (S., & Pal, A. 2020; Mittal, M., & Sharma, C. 2012; Guttikunda, S., & Jawahar, P. et al 2014). These plants' operational efficiency and the amount of emissions they create are greatly influenced by the quality of the coal they use. The combustion process and, as a result, the emissions of greenhouse gases like CO2 as well as other pollutants like SO2 and NOx are directly impacted by variations in coal quality, especially about net calorific values and ash content (Sarkar, P., Sahu, S., Patange, O., Garg, A., Mukherjee, A., Kumar, M., & Singh, P. 2021; Phadke, P., Rao, A., & Chandel, M. et al 2020). Indian coal, which has a high ash percentage but little sulfur, makes it difficult to burn efficiently and produces more pollutants than higher-grade coals (Shah, B., & Unnikrishnan, S. et al 2021). This has caused serious environmental issues because coal-fired power plants are one of the main causes of air pollution, causing high amounts of particulate matter and other dangerous emissions (Cropper, M., Cui, R., Guttikunda, S., Hultman, N., Jawahar, P., Park, Y., Yao, X., & Song, X. 2021; Oberschelp, C., Pfister, S., Raptis, C., & Hellweg, S. et al 2019). The implementation of carbon capture systems and cleaner coal technologies, which seek to increase plant efficiency and lower the carbon footprint, has been one strategy to minimize these emissions (S., & Pal, A. 2020). Economic and policy obstacles frequently prevent the use of such technology,thus a calculated strategy is required to enhance coal quality management and emission control methods (Shearer, C., Fofrich, R., & Davis, S. 2017; Shah, B., & Unnikrishnan, S. et al 2021).

MATERIALS AND METHODOLOGY:

Proximate analysis was used to identify important quality factors in coal samples. Standard laboratory techniques were used to determine the study's moisture content, pH, ash content, calorific value, and fixed carbon. To determine the overall quality and utility of the coal, each parameter was assessed using accepted techniques in accordance with ASTM and IS standards. **(**IS 1350 Part 1 (1984) Standard-grade laboratory equipment and instruments were used for analysis, included

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Oven (105–110°C) – for moisture analysis

Muffle furnace (815°C) – for ash content

Bomb calorimeter – for calorific value

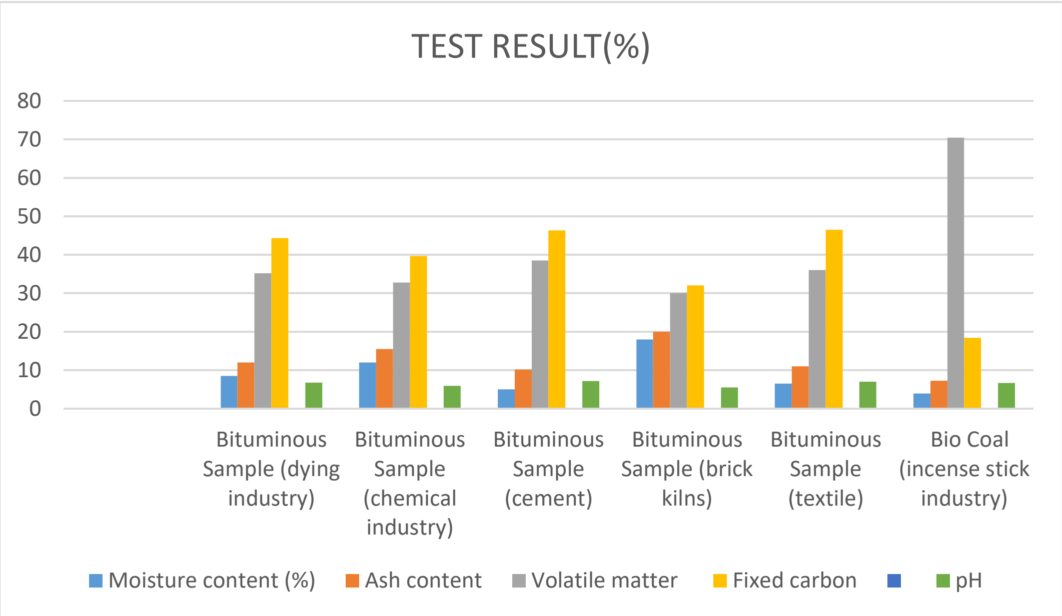
pH meter – for determining coal slurry pH

Analytical balance– for precise weight measurements

Proximate analysis and calorific value determination were used to assess the coal quality: The coal sample is heated in an oven at 105 to 110°C for an hour, and the weight loss is calculated to determine the moisture content. Ash Content: Determined by burning the coal sample in a muffle furnace at 815°C until the inorganic residue reached a consistent weight. A coal slurry made with 5g of coal and 50mL of distilled water is prepared, stirred, allowed to settle, and then measured using a calibrated pH meter to determine the pH value. Calorific Value: Using a bomb calorimeter, the temperature increase of water during full combustion was recorded in order to calculate the gross calorific value (GCV)and after calculate Fixed Carbon (%) = 100 − (Volatile Matter + Ash + Moisture)

RESULT AND DISCUSSION

Sample	Moisture content (%)	Ash content (%)	Volatile matter (%)	Fixed carbon (%)	Calorific value (kcal/kg)	pH
Bituminous Sample (dying industry)	8.5	12	35.2	44.3	7200	6.8
Bituminous Sample (chemical industry)	12	15.5	32.8	39.7	6500	5.9
Bituminous Sample (cement)	5	10.2	38.5	46.3	7800	7.2
Bituminous Sample (brick kilns)	18	20	30	32	5500	5.5
Bituminous Sample (textile)	6.5	11	36	46.5	7500	7.0
Bio Coal (incense stick industry)	3.9	7.3	70.40	18.40	4360	6.7



It is evident from coal sample analysis that the quality of coal has a major impact on emissions into the environment and combustion efficiency. Because of its high fixed carbon content, low ash content, and high calorific values (over 7500 kcal/kg), coal utilized in the cement and textile industries has excellent qualities that make it perfect for producing energy efficiently. The brick kiln sample, on the other hand, had a high ash content (20%) and moisture content (18%), which led to greater emissions and a lower calorific value (5500 kcal/kg) as well as decreased thermal performance. Despite being renewable and having little ash, bio coal was only appropriate for low-energy uses like creating incense sticks because of its high volatile matter content (70.4%) and low fixed carbon. Higher fixed carbon and calorific value were shown to improve energy efficiency, but moisture and ash content decreased it. The pH values, which varied from 5.5 to 7.2, showed a generally neutral to slightly acidic character, which may have an impact on the corrosion of equipment. All things considered, selecting the right coal quality is essential to maximizing power plant performance and lowering emissions.

CONCLUSION

The study emphasizes how coal quality has a substantial impact on power plant efficiency and emissions. The calorific value, ash content, moisture content, sulfur content, and nitrogen content of coal are important factors that affect plant performance. Higher-quality coal often has a higher combustion efficiency and releases less harmful pollutants, including particulate matter, SO_2, NO_x, and CO_2. These results highlight that in order to achieve sustainable power generation, stricter coal quality monitoring and greener energy policies are required

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HOW TO CITE: Kewat Anjali*, Aayushi Panchal, Bharat Maitreya, Solanki Hitesh, Assessing the Impact of Coal Characteristics on Thermal Power Plant Efficiency and Pollutant Emissions, Int. J. Sci. R. Tech., 2025, 2 (4), 523-525. https://doi.org/10.5281/zenodo.15257811