We used a negative binomial generalized linear mixed model (glmmTMB package in R) with a log link function to analyze the relationship between smoke characteristics and airborne fungal spore concentrations. The model included PM2.5 concentration (log-transformed), modified combustion efficiency (MCE), moisture ratio, and site (Project) as fixed effects, with relevant interactions. Random effects for Sample were included to account for repeated measures. The model controlled for sampling volume and laboratory batch effects through offset terms. We modeled dispersion as a function of PM2.5 and MCE to account for heterogeneity in variance.

Fungal spore concentrations in smoke were significantly associated with multiple combustion characteristics. Spore counts increased with PM2.5 concentration (β = 14.13, p = 0.002) but decreased with moisture ratio (β = -4.06, p = 0.020). The Konza site showed significantly higher baseline spore counts compared to the reference site (β = 69.13, p < 0.001). We observed significant interactions between combustion variables. The positive effect of PM2.5 concentration was moderated at higher combustion efficiencies (PM2.5:MCE interaction: β = -18.36, p = 0.001), suggesting that more complete combustion may reduce certain types of spore emissions despite higher particulate matter. The site-specific response to combustion efficiency (Project:MCE interaction: β = -74.63, p < 0.001) highlights the importance of fuel type in determining fungal spore emissions. Notably, our model revealed significant heterogeneity in spore count variance, with the dispersion affected by both PM2.5 and combustion efficiency (p < 0.05 for all dispersion terms). This indicates that not only do these factors affect mean spore concentrations, but they also influence the variability in spore emissions.

The main effect for ProjectKonza4 is significantly positive (β = 69.13, p < 0.001), indicating that at the reference levels of other variables, Konza4 had higher spore counts. However, there's also a significant negative interaction between Konza4 and MedianMCE (β = -74.63, p < 0.001).

This means that the higher spore concentrations at Konza4 were moderated as combustion efficiency increased. When reporting this finding, you should specify:

"The Konza4 site showed significantly higher fungal spore concentrations compared to the reference site (β = 69.13, p < 0.001). However, this site difference was strongly moderated by combustion efficiency, with the site effect diminishing at higher MCE values (Project interaction: β = -74.63, p < 0.001). This suggests that while Konza4 generally produced more fungal spores in smoke, this difference was less pronounced during more complete combustion conditions."

This nuanced interpretation accurately reflects the complex relationship captured by your model, acknowledging both the main effect and the important interaction.

Our analysis revealed contrasting site effects depending on whether we examined all conditions or focused specifically on smoke samples. In the comprehensive model including both ambient and smoke conditions (Model 1), the Konza4 site showed significantly lower overall fungal spore concentrations compared to the reference site (β = -1.31, p = 0.003). However, when analyzing smoke samples exclusively (Model 2), we observed a more complex pattern: Konza4 exhibited significantly higher spore concentrations under smoke conditions (β = 69.13, p < 0.001), but this effect was strongly moderated by combustion efficiency (Project interaction: β = -74.63, p < 0.001).

This apparent contradiction suggests fundamentally different fungal spore dynamics between sites under ambient versus smoke conditions. While Konza4 typically maintained lower baseline spore levels in ambient air, it produced relatively more fungal spores during combustion events, particularly under incomplete combustion conditions (lower MCE values). This site-specific response likely reflects differences in the underlying fungal communities and fuel characteristics between locations.

A computer screen shot of numbers and letters

AI-generated content may be incorrect.

Our analysis revealed complex site-specific patterns in fungal spore dynamics. In the comprehensive model including ambient conditions (Model 1), Konza4 showed significantly lower overall spore concentrations compared to the reference site (β = -1.31, p = 0.003). However, our smoke-specific models (Models 2 and 3) revealed dramatically different site responses during combustion events.

The most comprehensive smoke model (Model 3, AIC = 739.0) identified a significant three-way interaction between PM2.5 concentration, combustion efficiency, and site (β = 186.76, p < 0.0001). At the reference site, spore concentrations increased with both PM2.5 and combustion efficiency individually, but with a diminishing combined effect. In contrast, at Konza4, the baseline spore concentration during smoke events was substantially higher (β = 1095.58, p < 0.0001), but the site showed significantly different responses to both PM2.5 (β = -180.14, p < 0.0001) and combustion efficiency (β = -1138.00, p < 0.0001).

These findings suggest fundamentally different mechanisms driving fungal spore emissions between sites during combustion events, likely reflecting differences in fuel characteristics and fungal communities. While Konza4 maintained lower ambient spore levels, it produced distinct spore emission patterns during combustion that varied with smoke conditions in ways not observed at the reference site.

At the reference site, higher PM2.5 and higher combustion efficiency individually increase spore counts, but their combined effect shows diminishing returns.

At Konza4, the pattern is fundamentally different. The baseline spore concentration during smoke events is higher, but the responses to PM2.5 and MCE are dramatically different, with the positive three-way interaction suggesting that at Konza4, the combination of high PM2.5 and high MCE can lead to increased spore counts in ways not seen at the reference site.

This could indicate different fungal communities responding differently to combustion conditions at each site, or that the different fuel types at each site produce smoke with different characteristics that affect spore release and viability in distinct ways.

Visually, this would manifest as different slopes in the relationship between PM2.5 and spore counts at different MCE values, with these slope differences themselves differing between sites.