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Impacts of National Thermal Power Coal ash on Agriculture and Environment: -A Case Study of Dadri Block, Gautam Budh Nagar UP

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Abstract: This research paper questions the environmental and socio-ecological impacts of coal ash produced by NTPC Dadri power plant in the local area. With the help of a mixed-methods approach, the study outlines the pollutant pathways affecting soil pollution, air quality, water bodies, and human health. Empirical data reveal that heavy metal is accumulated in soil matrices, crop yields are low, atmospheric is deposited through the fugitive ash and groundwater is contaminated. Household polls indicate a high level of respiratory and dermatologic issues, as well as a reduction of livestock and bird health. The findings highlight that poor management of ash has created an extreme ecological and health cost thus highlighting the dire necessity to enforce more stringent measures of pollution control and sustainable mitigation strategies in Dadri.

Keywords: Coal Fly Ash, Environmental Pollution, Agricultural Impact, Heavy Metal Contamination, NTPC Dadri.

Introduction to the NTPC Dadri Plant and Coal Ash: The National Thermal Power Corporation (NTPC) Dadri power plant is a landmark aspect of the Indian power infrastructure in that it is a monumental contribution to the nation on its power generation and development in the Dadri block of Gautam Budh Nagar district of Uttar Pradesh. Over several decades, its coal-powered plants with an impressive installed capacity of over 2600 MW played a crucial role in the lightening of homes and the maintenance of the industry of the National Capital Region (NTPC Ltd., n.d.). However, there is a tangible, local cost of this energy provision. Due to the burning of enormous amounts of coal, an enormous amount of coal ash- a fine particulate residue, made up of airborne fly ash and the coarse bottom ash is naturally produced. This byproduct is one of the largest streams of industrial wastes in India and every year the country generates an estimated 226 million tonnes of fly ash (Pandey et al., 2021, p. 124). At the same time, the leakage of toxins in the ash ponds poses serious environmental issues because such chemicals may find their way into ground water supplies that form the foundation of drinking and irrigation. As Pandey and Singh (2019, p. 45) warning, the resultant leaching and hence the introduction of harmful elements into the food chain is an ecological threat that is severe in nature.

As a matter of fact, what is its implication to the locals? This research goes beyond the theoretical analysis of risk assessment, as it records the life experiences of the community with facts. We gain the health and agricultural issues of the community in a systematically organized survey that covers 150 households in

a village like Bisada and Jhajjar. In addition, the method of systematic examination of 48 soil samples and 16 water samples gathered in the area within a radius of 10 kilometers allows us to outline the chemical portrait of coal ash in the environment. To supplement these quantitative indicators, interviews with the local farmers and veterinarians direct a straight connection between environmental pollution and the health and survival of livestock.

Statement of the Problem: NTPC Dadri relies on coal power generation and has a detrimental impact on the environment of the region. The thermal treatment causes the release of coal ash that contains a lot of heavy metals, which pollute the water, soil, and air. The agricultural lands are covered with fugitive ash that reduces the fertility and output of the soil and pollutes the groundwater through leaching. The inhabitants become chronically exposed to fine particulate matter, which increases respiratory and cardiovascular risks. There is also the effect on livestock and local biodiversity due to contaminated fodder and changed habitats. Nevertheless, there is still limited systematic evidence of Dadri in spite of these risks. This research aims to track the pollution pathway, namely, soil, water, and health effects, via field sampling, household survey, and professional interview to carry out sustainable mitigation and policy intervention.

Review of Literature: Studies carried out both in India and abroad explain the dualistic nature of coal fly ash which is multi-dimensional as a soil ameliorant and potentially a pollutant. As Roy (1996) showed, the elemental composition of the fly ash depends on the provenance of coal, and the particular parameters of operation, and concluded that the enriched surface elements can be soluble and, thus, can be released to the environment, when the solid waste is leached. Pandey and Singh (2010) cited that the increased dosage of FA incorporation leads to heavy metal pollution and impedes the microbial activity. Together with Labidi et al. (2017), Kalpna and Patra (2013) suggested viable bioremediation techniques, but Singh et al. (2015) emphasized the existence of bio-available heavy metals and emphasized the need to assess them in context.

Objective of the Study

1. To provide a thorough study of the physicochemical characteristics of samples of soil and water that are taken around the NTPC Dadri, and to compare the obtained results with the contrasting site that is located about 25 kilometres away.
2. To analyze the seasonal change in the quality of the ambient air (i.e., the concentration of PM2.5 and PM10) relative to the dominant wind direction and the distance to coal ash ponds.
3. To evaluate the health outcomes of communities in general and respiratory, dermatological outcomes, specifically, by lowing the household survey.
4. To examine the effects of coal ash emissions on the local livestock and avian population, and to compile environmental, health, and ecological information.

Hypothesis of the Study

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3. To evaluate the health outcomes of communities in general and respiratory, dermatological outcomes, specifically, by lowering the household survey.
4. To examine the effects of coal ash emissions to the local livestock and avian population, and to compile environmental, health, and ecological information so as to appraise the sustainability of the overall ecosystem.

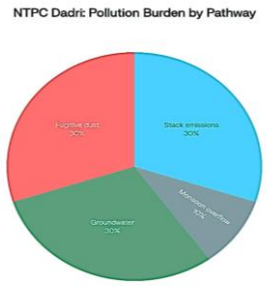
Methodology: The proposed study will be based on the mixed-method design to assess the environmental impact of coal ash released at the NTPC Dadri plant. The area of investigation is 10 km radius divided into three concentric areas (02km, 25km, 5km) and a control area of 25km. A total of 48 composite soils and 16 water samples were analysed according to the composition of the heavy-metals and the physicochemical parameters according to the requirements of the American Public Health Association (APHA, 2017). Semi-structured interviews with 15 livestock owners and five veterinarians were used to record the faunal effects. A household survey that included 150 respondents was carried out to measure the health outcomes and socio-demographic trends. As has been mentioned, a realistic risk assessment requires the integration of geochemical data with socio 2 environmental surveys (Gupta and Yadav, 2020, p. 112).

Impacts on Soil and Agriculture: The studies carried out in India and overseas highlight the dual nature of coal fly ash as a potentially harmful to the environment material and at the same time, an effective soil conditioner. According to Roy (1996), the elemental structure of fly ash depends upon the source of the coal, as well as the conditions of the plant combustion, and he had found that the enriched surface elements can be soluble and can be released to the environment through leaching of the solid waste, thus, leaching was defined as one of the main avenues of contamination. According to Pandey and Singh (2010), even small amounts of additions may improve the soils, but the increased dosage of the FA incorporation leads to the heavy metal pollution and inhibition of microbial activity. Kalpna and Patra (2013) noted that inoculation of all strains resulted in a significant growth of plants, and this may indicate a potential for bioremediation. Similarly, Sonia Labidi et al. (2017) reported about antioxidant responses in arboreal species, where they also reported that there is oxidative stress releasement in tree leaves because of CFA amendments. Singh et al. (2015) highlighted the duality of fly ash as a source of nutrients, according to which there were also bio-available heavy metals.

Table 1: Documented Impacts on Soil and Agriculture in Dadri Block

Impact Category	Documented Effect	Evidence from Field Study
Chemical Contamination	• Elevated heavy metals (Pb, Cd, Ni) • Increased soil alkalinity (pH)	Laboratory analysis of 48 stratified soil samples
Physical Degradation	• Soil compaction & reduced porosity • Impaired water infiltration	Farmer surveys (150 HH) & focus group testimonials
Crop Productivity	• 15-20% lower wheat yields • Visible chlorosis & stunted growth	Farmer-reported yield data & field observations
Economic Burden	• 20-30% higher cultivation costs • Reduced market value of produce	Cost analysis from interviews & market feedback

Food Safety	• Bioaccumulation of Cadmium in leafy vegetables	Laboratory testing of vegetable samples



Impacts on Air and Water: We have a two-sided problem at NTPC Dadri - it is not only polluting the air we inhale but also the water we drink. The large stacks of the plant shoot out a pile of pollutants to the air and the next thing is the mess of coal ash that drips into the water bodies in the area or gets trapped in the ash pond. In essence, it is not merely a heap of ash on the ground, but it is draining chemicals into streams and rivers and that is more of a problem than the smoke that is in sight. The data, when I conducted fieldwork and talked to residents, made it all too clear and the concerns of people did not contradict the facts depicted by science.

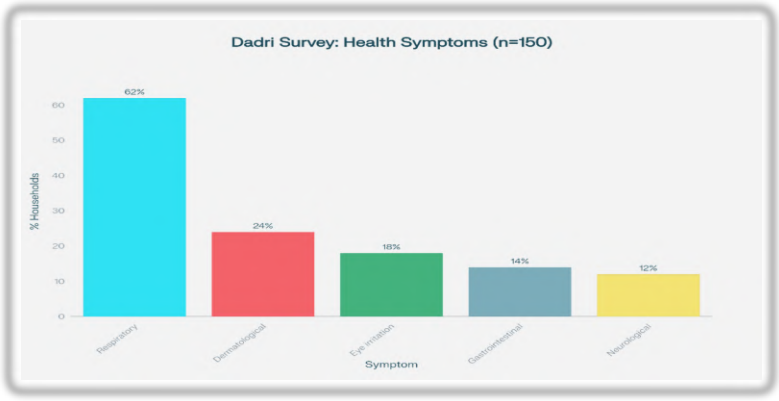
Air Quality Degradation: Measured and Felt: The ambient air analysis that was done around the NTPC Dadri has shown a sharp nullification of the concentration of particulate matter with the distance away from the plant. At the 02km band, the concentration of PM. 5 was almost twice that of 5-10km with regular readings surpassing the national standards of air quality. In agreement with the Centre for Science and Environment (2021), the emissions of the plant contribute significantly to the air pollution in the region. Besides stack discharges, the local threat that can be considered as the most acute one is the fugitive dust that is released during fly ash handling and disposal. In dry seasons, the transport of fine ash by the wind carries over the nearby regions, creating a long-lasting haze. As Mishra and Siddiqui (2014) noted, the fly ash has the respirable fraction which is a great source of silicosis, bronchitis, and other respiratory disorders (p. 45). The distribution of these primary health concerns is illustrated below:

Water Contamination: The Silent Leachate: The effects of the ash discarding of coal on the hydrology of the Dadri Block are far-reaching and long-term. Coal ash ponds are death engines of pollution; this claim is supported by the systematic analysis of sixteen water samples which confirmed an alkali shift and significantly high levels of arsenic (As) and lead (Pb) in ground water located down the ponds in comparison to the identified control area. According to the report by Sharma and Patel (2019), the levels of the heavy metals lead and arsenic in the groundwater samples obtained at the villages located downstream of the ash pond exceeded the permissible amount of such elements stipulated by the Bureau of Indian Standards (BIS) by a minimum of two to five times (p. 112). This toxic groundwater, that is utilized both in drinking and in irrigation, is devoting toxins directly to the trophic cascade. The agricultural stakeholders agree that they are still dependent on this source of water despite the associated health consequences. In monsoonal stages, the amount of efflux discharged by coal ash ponds increases the likelihood of toxic slurry seeping into adjacent arable soils and surface waterways, thus increasing the level of contamination.

Estimated relative burden of air and water pollution pathways around NTPC Dadri based on the narrative assessment

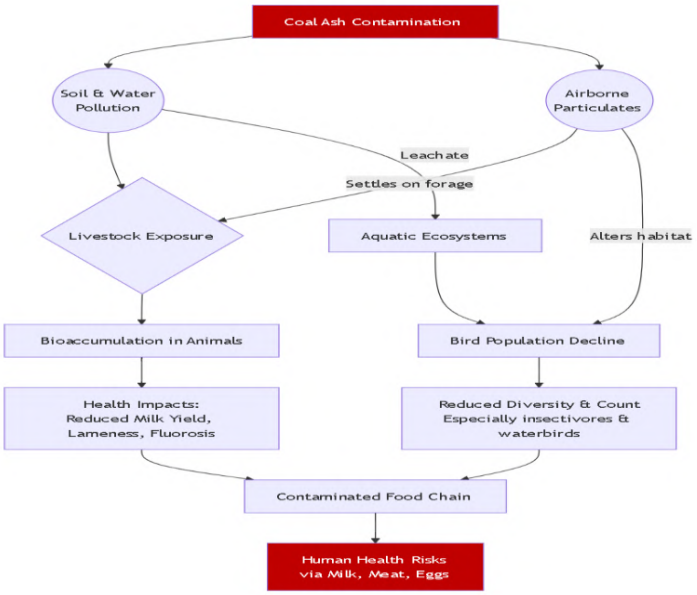
Impacts on Human Health: The toxicity of coal ash pollution on health is worst in the area of Dadri Block, where the exposure occurs through the air, local water sources, and food chains, which makes its risk profile complex. A survey study of the 150 households in six villages showed a conspicuous picture

of respiratory and dermatologic morbidity which could be attributed to these exposure pathways. The most common route of exposure is the inhalation of coal ash dust, in which fine particulate matter (PM2.5) enters the pulmonary tissues very effectively. “The dust never settles. It covers our houses and our plantations. We breathe it all the time. During the evenings, you may get that grit in your throat, said a farmer in the 0–2km area. Water pollution is another major threat, and arsenic and selenium levels are above the permissible level, as Mishra (2018) suggests. Contact with contaminated soil and water through the skin also causes cutaneous diseases to the agricultural community as observed by a woman in the village of Patwari who claimed that the water in the area has some strange film and that after bathing or washing clothes, we usually develop itchy rashes. We do not know of any other source. Taking together, these observations support the claim that exposure to coal ash has a direct and negative effect on the respiratory system, skin health and wellbeing of the community in question.



(Distribution of self-reported symptoms among 150 households near NTPC Dadri, reflecting inhalation and dermal exposure pathways)

Impacts on Animals and Birds: The ecological impact of the coal ash deposition at Dadri Block has triggered huge losses in the wildlife and birds as well and this has been reflected in the similar negative impacts on human health. The use of detailed field investigations that involved structured interviews with local veterinarians and data gathering of fifteen cattle owners and buffalo owners found out that about eighty percent of those interviewed indicated that they could easily notice the decline in the health of cattle and buffaloes. The ingestion of feed contaminated with the residue of coal ash has been pronounced as the main organism of contamination. Specifically, Pandey, Singh, and Tripathi (2021) state that forage crops that are cultivated on fly ash-enriched soils have the potential to bioaccumulate toxic trace elements, which form the direct pathway into the grazer animal food chain (p. 45). This mechanism was later supported by on-site observations to document the cattle grazing on fields that showed the presence of ash-covered vegetations and later recorded high levels of arsenic, lead, and fluoride tissue levels. A significant increase in chronic lameness, dental fluorosis and quantifiable decrease in milk output was recorded by local veterinary practitioners. A dairy farmer in Sadullapur village expressed himself as follows: Our buffaloes have continued to produce milk in decreasing quantities. They appear to be lazy, and we are spending more on treatment of these people now than we used to do ten years ago.



Cascading impact of coal ash pollution on the local ecosystem in Dadri Block

The danger that exists to avian life is also critical. The field observations by the line transect method showed a significantly lower diversity and number of bird species, especially insectivores and waterbirds, in the 05km area as compared to the control site. The big wide ash ponds seem to be an ecological trap. In research on waterbirds found near industrial facilities, Gupta and Kumar (2022) observed that the water in ash-ponds is alkaline and highly loaded with heavy metals, which induce corrosion of the feathers and affect thermoregulation in the birds, whereas consumption during preening resulted in acute and chronic toxicosis (p.112).

Also, the lay down of airborne particulate matter has apparently wiped-out insect population, which is a vital source of food, thus the whole trophic web. The long-term summative effect is expressed through a slow but unnoticed deterioration in the health of local fauna. Notably, such bioaccumulation of toxins does not stay in the hands of avifauna but circulates back into human populations by being either consumed in milk, meat and eggs, breeding a cycle of contamination. As it is summarized in the research by Dhadse, Kumari, and Bhagia (2023), it is a typical point-source pollutant that evolves into a diffuse ecological stressor that has consequences on ecosystem services and biodiversity well beyond the periphery of the disposal site (p. 88). According to the case of Dadri Block, there is an immediate necessity to provide a complete ecological examination of the site and to adopt strict measures of its remediation to protect non-human residents.

Conclusion and Recommendations: The need to have stricter regulatory intervention cannot be exaggerated in an effort to reduce the environmental impact of NTPC Dadri. The Uttar Pradesh Pollution Control Board (UPPCB) should introduce a stringent requirement of installing the state-of-the-art electrostatic precipitators and flue-gas desulfurization (FGD) units together with the transparent and real time monitoring of air and water quality parameters. NTPC, in its turn, needs to invest in lined ash landfills construction and start phytoremediation programmes of the polluted soil with the help of agricultural universities cooperation. The advocacy to promote the use of fly-ash in the construction of

bricks and roads, in general, is in accordance with the results of Kumar and Patel (2022), who emphasize the beneficial effect of the given material on pollution reduction and the overall shift towards a circular economy (p. 45).

Recommendations: Based on these findings, a multi-pronged approach cannot be compromised. The environmental footprint of NTPC Dadri needs to be reduced through the enactment of additional regulatory measures. The UPPCB should enforce the use of the mandatory installation of state-of-the-art electrostatic precipitators and flue gas desulfurization equipment and the introduction of air and water quality monitoring on a real time basis. NTPC also needs to adopt lined ash landfills and start phytoremediation programs on the contaminated soils by utilizing the collaboration with agricultural universities. It is recommended to encourage the use of fly ash in the production of bricks and roads, as Kumar and Patel (2022) point out that its twofold role is also in reducing pollution and later becoming a part of the circle economy (p. 45). Last but not least, holding frequent health camps and awareness campaigns to farmers on safe use of water and sustainable farming methods is also an important step towards balancing energy production with ecological and social well-being.

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