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Exposure to Particulate Matter and the Health Risks Associated with Burning of Biomass in Rural Areas: A Review

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Abstract: ***Air pollution has emerged as a significant environmental health risk factor in society. The seventh - largest risk factor for the global disease burden that causes early deaths is the exposure to fine particulate matter that results from residential air pollution. The main residential energy source for half of the world's population is biomass fuel. Most of the tribal society people relies on fuelwood as their primary source of cooking energy which leads to mass of particulate matters (PM). Due to increased inhalation of smoke when cooking, women are more prone to the adverse effects of wood burning. Burning of biomass releases gases including sulphur dioxide, nitrogen oxides, and carbon monoxide, along with other toxic particulates that can pollute the air, posing health problems which should be examined further for both long - term and short - term exposure. Research on the impacts of indoor air quality has been done on tribal monitoring, with a particular focus on using biomass fuel for cooking at intervals of eight hours, in rural areas based on the concentrations of particulate matters respectively. In addition, a real - time monitoring system on Indoor air quality was deployed to ascertain the house's temperature, humidity, and carbon monoxide concentration while performing household chores or other activities. Based on data from epidemiological studies, most rural regions worldwide, especially those in poor nations, often burn urban biomass which leads to higher risk in human health perspective. Over two fifths of biomass is used in the form of wood, crop leftovers, and animal manure. Household and ambient air pollution are mostly caused by incomplete burning of biomass. Particulate matter, which has been connected to a number of health hazards like respiratory and cardiovascular conditions, is emitted by this source. It is necessary to investigate several elements such as fuel type, combustion circumstances, and climatic factors that affect the amount of particulate matter produced while burning biomass. In addition, the review determines the possible health effects of particulate matter exposure, emphasizing respiratory and cardiovascular conditions. In order to effectively mitigate exposure, it emphasises the need for more study on the health dangers related to burning of wood in rural locations and allows to explore the advantages of improved health and the environment.***

Keywords: Air pollution, Health risks, Particulate matter, Biomass, Personal exposure, Rural women

1. Introduction

Cooking is an essential activity for human survival and well - being. However, for many rural people in developing countries, cooking also poses serious health and environmental risks. Biomass fuels, including firewood, charcoal, manure, and agricultural waste, are used by about 2.8 billion people for cooking (World Health Organisation, 2022). According to the Census of India 2011, numerous households still use firewood for cooking, and around 20% utilize various types of biomass fuels. Around 80 - 90% of rural households depend upon biomass fuels for heating and cooking purposes (Kumari et al., 2021). With 80% of the population living in rural regions and 40% of the country's energy consumption, India is renowned for its dependence on traditional fuels, especially fuelwood. According to data from NSSO (2002), fuelwood serves as the primary source of cooking fuel in 75% of rural populations (Pandey R et al., 2012).

Due to a number of factors, including poverty, limited access to alternate fuel sources, and a lack of power, rural residents mostly rely on biomass for cooking. Because of this, biomass continues to be the main energy source for cooking, especially in underdeveloped nations where access to modern energy sources is limited (Sasmita Patnaik et al., 2017). It is rare to use kerosene or gas for cooking in rural areas, let alone electricity. Based on epidemiological research, adults and children who are exposed to smoke from the burning of biomass fuels are more likely to get respiratory illnesses (Mondal D et al., 2020).

Biomass is an organic substance that is renewable and may be divided into two categories: woody and non - woody biomass. The biologically degradable portion of any resource, product, or waste derived from plants, forests, and vegetable materials is known as woody biomass. Animal and municipal wastes, industrial wastes, and farming and agro - industrial leftovers are the sources of non - woody biomass. When soils are sufficiently nutrient - and moisture - rich, biomass grows. The advantages of biomass energy have led to a resurgence of interest in this sustainable and widely available energy source, which is also carbon neutral (Harshika Kumari, 2021).

Indoor biomass smoke, a major contributor to domestic air pollution, is estimated to be responsible for over 39 million years of life with an impairment and over 500, 000 premature deaths annually from acute respiratory tract infections (Claire E. McCarthy et al., 2022). Biomass in the form of wood, crop residues, and animal dung is used in more than two fifths of the world's households as the principal fuel (Smith K R et al., 2000). Numerous studies have connected high levels of PM2.5 from wood burning and wildfires to heart and respiratory diseases, particularly in aged, young, and sensitive adults (Edwin S. G et al., 2018). Acute lower respiratory infections (ALRI) are a leading cause of morbidity and mortality in children in many parts of the world. Cooking with wood - burning stoves was associated with higher indoor air

concentrations of respirable particles and with an increased risk of Acute lower respiratory infections (Robin L. F et al., 1996).

Using fuelwood contributes to the atmospheric issues of deforestation, particulate matter emissions, and greenhouse gas emissions, most notably CO2. According to Smith et al., 2006 burning biomass inside emits pollutants that are harmful to human health, with women and children being particularly vulnerable. Poor ventilation in rural homes, according to Huboyo et al., 2009, is the primary source of indoor air pollution (IAP), which can result in cardiovascular disease, respiratory illnesses, and unfavourable pregnancy outcomes (Bruce et al., 2000, Smith et al., 2000, Laxmi et al., 2003 and Smith, 2005).

Wood smoke contains a variety of toxic pollutants, such as PM, carbon monoxide, nitrogen oxides, and volatile organic carbons (Naeher L. P et al.,). Furthermore, different fuels are occasionally burned in wood - burning stoves to provide heat, which could increase the harmful impacts of indoor air pollution on human health (Ashley A. Lowe et al.,). It is difficult to burn biomass fuels in simple domestic cookstoves due to the highly complex premixing of fuel and air required for effective combustion. These cookstoves emit harmful pollutants such as carbon monoxide (CO), sulphur dioxide (SO2), nitrous oxides, respirable particulate matter (PM2.5 and PM10), polycyclic aromatic hydrocarbon (PAH), formaldehyde, and metals (Rumi Rabha et al., 2018).

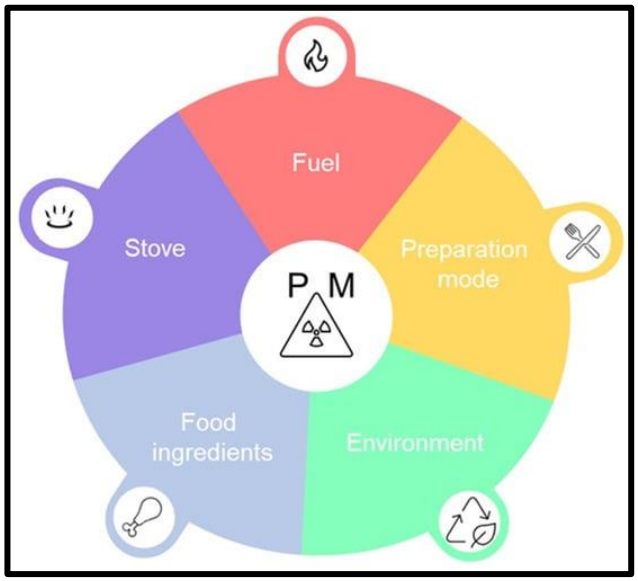


Figure 1: The main sources of indoor particulate matter (PM) generated during cooking, and factors influencing PM physico - chemical properties. ***SOURCE: Lachowicz JI et al., 2023***

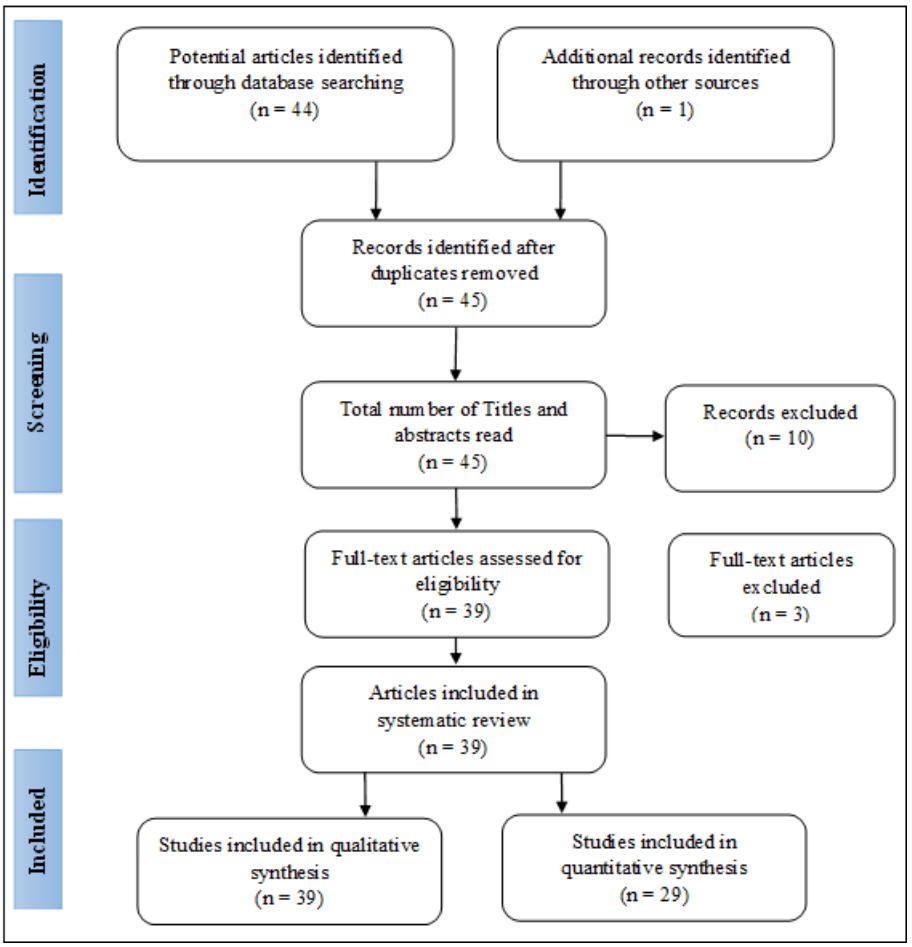
High concentrations of smoke from solid fuel indoor cooking can reach up to 1000 mg/m3 PM, and even higher concentrations have been seen (Smith K R et al., 2014). The World Health Organisation (WHO) standards and the national ambient air quality standard for PM set by the US Environmental Protection Agency are orders of magnitude lower than these amounts. Depending on the kind of fuel burnt, biomass smoke can also contain PM, carbon monoxide, nitrogen oxides, formaldehyde, and a variety of hazardous organic chemicals (such as benzene, 1, 3 butadiene, benzo [a]pyrene, and other polycyclic aromatic hydrocarbons). In terms of PM and gas emissions, burning biomass such as wood and other biomass is qualitatively comparable to burning tobacco, but without the nicotine (Warwick H et al., 2004).

When compared to the 67 risk factors that contribute to the Global Burden of Disease estimates, Household Air Pollution ranks fourth (second among women). PM2.5 (< 2.5 m) levels in households utilising solid fuels were found to be 10 to 50 times higher than the WHO annual average Air Quality Guideline level. (Pope, D et al., 2015). Exposure to biomass smoke has been linked to chronic bronchitis and chronic obstructive pulmonary disease in women, as well as lower birth weight, premature babies, infant mortality, and an increased risk of pneumonia and cataracts (Rumi Rabha et al., 2018).

It highlights how important it is for rural areas to embrace renewable energy sources and put in place practical plans to reduce the amount of biomass burned. This include encouraging the use of cleaner fuels, enhancing the effectiveness of cooking stoves, and increasing public knowledge of the risks to one's health posed by particulate matter exposure.

2. Materials and Methods

PRISMA 2009 FLOW DIAGRAM



The present investigation employed a methodical literature analysis to ascertain and investigate the potential exposure to particulate matter and the health risks associated with burning of biomass in rural areas. The process involved identifying potential articles, screening them, assessing their eligibility, and ultimately selecting which ones would be featured. More precisely, a detailed search of the literature and research on the subjects of exposure and health consequences connected to tribal people was part of this review. Since this research did not include human participants, an IRB application was not necessary.

The literature search will cover the years 2000–present in order to include the most current developments and trends. Both Google Scholar and the databases from National University Library Services (NULS), which included ScienceDirect, PubMed, Elsevier, research gate and other sources, were used for the searches. The World Health Organisation (WHO) and the Centres for Disease Control and Prevention (CDC) were two more reliable sources that were consulted. The most common illness has been evaluated from this review article. Peer - reviewed publications and official reports will be given precedence to preserve the calibre of the sources. Once the literature has been gathered, do a thematic analysis to find reoccurring themes, trends, and research gaps. This will provide a thorough picture of the state of knowledge in tribal societies today.

Furthermore, by employing a systematic approach and thematic analysis, we hope to provide a thorough understanding of the efficacy of PM methodologies in addressing the particular challenges faced by indigenous populations. We will also analyse the factors that influence the success or failure of PM initiatives in tribal contexts, including the role of local leadership, community participation, and external support in the implementation and sustainability of PM projects. This assessment of the literature will add to the continuing conversations about capacity building and sustainable development in these contexts while offering insightful information on how project management techniques are applied in tribal communities. Our goal is to provide a thorough knowledge of the efficacy of PM approaches in addressing the particular difficulties encountered by indigenous communities via the use of a theme analysis and a systematic methodology.

2.1 Particulate Matter

A combination of microscopic particles and liquid droplets present in the air is referred to as particulate matter or PM. Many sources, including industrial operations, building sites, automobile emissions, and even natural events like dust storms and wildfires, can produce these particles. The two primary categories of particulate matter are PM2.5, which are even smaller particles with a diameter of 2.5 micrometres or less, and PM10, which are particles with a diameter of 10 micrometres or less. Because of their tiny size, these particles may readily enter the circulation and infiltrate the respiratory system, raising the risk of a variety of illnesses, including cancer, heart disease, respiratory disorders, and early death.

Particulate matter exposure poses a serious threat to public health since it impacts millions of individuals globally. Prolonged exposure to particle matter has also been associated with an increased chance of developing long - term health issues like heart disease, asthma, and chronic obstructive pulmonary disease (COPD). It is critical to monitor air quality, put into place efficient pollution control measures, and urge people to take preventative measures such as avoiding outdoor activities during high pollution periods and using air purifiers in their homes in order to reduce the health risks associated with particulate matter exposure.

2.2 Health Issues

Tribal people often cook with biomass, which has been linked to a number of health problems. The principal causes of concern are indoor air pollution and wood, agricultural waste, and animal dung combustion. As a result, breathing in the smoke can cause lung cancer, asthma, and chronic obstructive pulmonary disease (COPD), among other respiratory issues. Furthermore, low birth weight, premature birth, and an increased risk of infection have all been connected to the negative health impacts of biomass cooking on mothers and children. Moreover, the laborious process of gathering biomass fuel and using it for cooking can have an adverse effect on the general welfare of indigenous groups by reducing their access to social interaction, education, and earning prospects. Promoting healthier cooking methods and installing renewable energy sources in tribal areas are necessary to address these health issues.

2.3 Wood Burning Stoves

Tribal communities rely heavily on wood - burning stoves for warmth and culinary purposes. However, conventional wood - burning stoves frequently add to indoor air pollution, which can cause several health concerns including eye and respiratory disorders. Interventions like upgraded cookstoves, ventilation systems, and substitute cooking fuels have been suggested as solutions to these problems. Wood smoke contains toxic pollutants such as PM, carbon monoxide, nitrogen oxides, and volatile organic carbons. For example, improved cookstoves are made to burn fuel more effectively, which lowers smoke emissions and interior air pollution. The quality of indoor air is further improved by ventilation systems, which aid in removing smoke and other contaminants from inside areas. Promoting the use of alternative cooking fuels, such as biogas or solar energy, can also help cut emissions and lessen dependency on wood. Moreover, other fuels are also burned in wood - burning stoves to provide heat, including can intensify indoor air pollution's detrimental impact on health.

2.4 Indoor Cooking in Tribal Area

Traditionally, biomass fuels including wood, manure, and agricultural waste are used for indoor cooking in tribal regions. For the most part, indoor air pollution is caused by burning these easily accessible and reasonably priced fuels in open flames or simple stoves. Particulate matter (PM), carbon monoxide (CO), and volatile organic compounds (VOCs) are just a few of the dangerous pollutants present in the smoke that can have a major negative impact on respiratory health. Children and women are more likely to be exposed to lead and suffer the related health effects since they cook more frequently and spend more time indoors.

3. Discussions

Combustion produces complicated combinations of gases and particulates that pollute both indoor and outdoor environments. An intricate and varied problem with substantial consequences for health, the environment, and socioeconomic development is the use of biomass fuel for cooking in tribal regions. While the usage of biomass fuels is linked to several issues such as gender inequality, deforestation, and indoor air pollution, for many tribal people it is a necessary source of energy. A multifaceted approach including behavioural, policy, and technology interventions should be used to address these issues. Reducing the negative effects of cooking with biomass fuel may be achieved in large part through community - led efforts, improved cookstove designs, and renewable energy options. Sustainable solutions over the long run also require tackling the underlying issues that lead to the usage of biomass fuels, such as poverty and limited access to contemporary energy services. To assist the shift in tribal regions towards cleaner and more sustainable cooking methods, cooperative measures including the government, non - governmental organisations, and local populations are required.

Previous studies have shown that children living in rural areas without access to clean fuels have death rates greater than those living in rural areas with cleaner fuels, and that children's exposure to indoor combustion sources increases their chance of developing asthma and the severity of their asthma. To improve indoor air quality and lower health hazards, it is imperative that particulate matter (PM) emissions from tribal biomass cooking be reduced. The study demonstrates the effectiveness of many strategies in lowering PM levels, including better cookstoves, ventilation systems, and behavioural adjustments. In addition to significantly lowering PM emissions, these measures also improve the general well - being of the indigenous populations. To address the particular difficulties encountered by tribal groups, such as their lack of access to resources and technology, further study and implementation work are nonetheless required. All things considered, the results indicate that long - term PM reduction and better health outcomes require sustainable solutions customised to the unique requirements of tribal populations.

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