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Impact of biomass cookstove on environmental pollution: A review

Mahendra Shrivastava[1], Savita Vyas[2]
[1,2]*School of Energy and Environment Management, UTD-RPGV, Bhopal*

Abstract- As human beings, food is an essential aspect of our lives, without it, we cannot survive. To cook our meals, we require energy, which can be obtained from various sources such as fossil fuels, electricity, and renewable energy. Speaking of renewable energy, in rural areas, biomass is a significant energy source for cooking food, which is abundantly available there. Biomass such as crop residue, animal waste, wood, etc., are the key source of energy to fulfill the energy requirement for rural areas. Biomass is widely available and can be used directly in cookstoves. The government has implemented programs for the efficient use of biomass in cookstoves. This review discusses biomass cookstoves' impact on the environment and well-being, including recent design improvements.

Keywords- **Biomass, Cookstove, Pollution, Environment**

I. INTRODUCTION

Wood has been used in different heating processes as the primary energy source in developing countries for centuries. In most emerging nations, households rely on traditional fuels like forest biomass, waste from agriculture and animals, and charcoal. Worldwide, three crore societies tranquil use these fuels. In Traditional cooking, biomass is burned in an open fire, Sometimes, cooking vessels are protected from wind and supported by mud or brick enclosures. However, this method is inefficient and highly polluting [1]. Smoke produced by burning biomass adds to environmental pollution to 3 percent of the global disease burden, causing 1.6 crore premature deaths annually, including 0.9 crore deaths of children under five years old, according to a report by the World Health Organization (WHO) [2]. Extra focus is needed especially in the tribal areas where the population is growing rapidly, which has led to the reforestation of forest areas in many areas around the villages to meet the demand for cooking beyond the natural regeneration capacity of the nearby jungles. The daily lives of villagers are directly impacted by local deforestation, as they must spend time and energy collecting fuel.

This review article was written to discuss different cooking stove designs, test protocols, the role of stoves in reducing greenhouse gases, energy examination, global adaptation through various implementation programs, economic evaluation, and recent developments in biomass cooking.

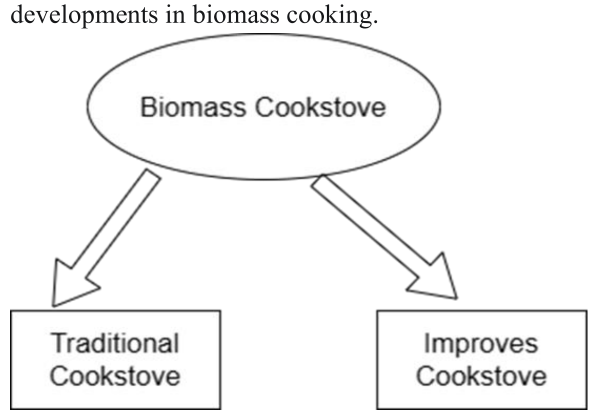

Figure 1.1 biomass cookstove

II. METHOD

Studies from 2001 to 2021 in Web of Science and Google Scholar identify and select pollutant emissions from biomass stoves. Publications were screened by entering biomass or stove in the subject field. Titles and abstracts were excluded if they didn't provide information on pollutant emissions from biomass. The remaining studies were fully reviewed to extract data, findings, and conclusions related to pollutant emissions and relevant influencing factors.

III. EVALUATION METHODS FOR POLLUTANTS IN HOUSEHOLD BIOMASS COOKSTOVES

Main contents:

We analyze the environmental and health impact of pollutants like CO, NOx, particulate matter (PM10, PM2.5 and PM1.0), organic carbon (OC), black carbon (BC) and PAHs. CO, a lethal gas, is formed from complete combustion of carbon in solid fuel. PM formation mechanism is complex and involves incomplete combustion, intense combustion, fly ash, condensation, coagulation and more.

Factors affecting various pollutant emissions:

Main factors affectoing the different types of pollutant emission are

1. *Test and combustion phase:*

There was a significant difference (p = 0.041) in CO emission performance among the three laboratory test protocols: international WBT, CWBT, and BIS. CWBT has the lowest CO emission factor (average: 1.033 g/MJ), followed by international WBT (average: 3.643 g/MJ), and BIS (average: 4.023 g/MJ). The main reason for this could be the longer boiling period of CWBT, which would reduce the contribution of the light period to CO emissions. For the international WBT, the average CO emission factor in the high-intensity phase at the beginning of cold (12.10 ± 7.37 g/MJ (mean ± SD)) is lower than the high-intensity phase at the beginning of heat (21.27 ± 14, 63 grams). / MJ) [18], but the difference is not significant (p = 0.277)[5], [6].

CCT gives the highest PM emission factor based on the useful energy transmitted, followed by WBT and CWBT, while BIS has the lowest PM emission . CWBT produces a lower emission factor of OC, EC and PAHs than WBT due to the higher combustion temperature of CWBT . The average emission factor of OC and EC from CCT is higher than WBT due to lower temperature combustion during CCT . In addition, the hot start of the high power phase produces a higher PM emission factor based on the useful energy delivered from the cold start of the high power phase. However, there is no significant difference between this test protocol or between the two initial regimens (p = 0.943 and 0.177, respectively) [5], [6].

2. *Cookstove design:*

CO emissions from different types of biomass stoves vary in different ranges (22.10–325.8567 g/kg and 0.512–36.589 g/MJ). Three-stone stove, chulha, built-in stove, rocket stove, Berkeley stove, Jinqilin gas stove, Philips gas stove, THU gas stove, TLUD gas stove, and charcoal stove are common types of biomass cooking in available studies.Based on fuel consumption, coal stoves have the highest CO emission factor among stove types, followed by built-in stoves (Figure 2).

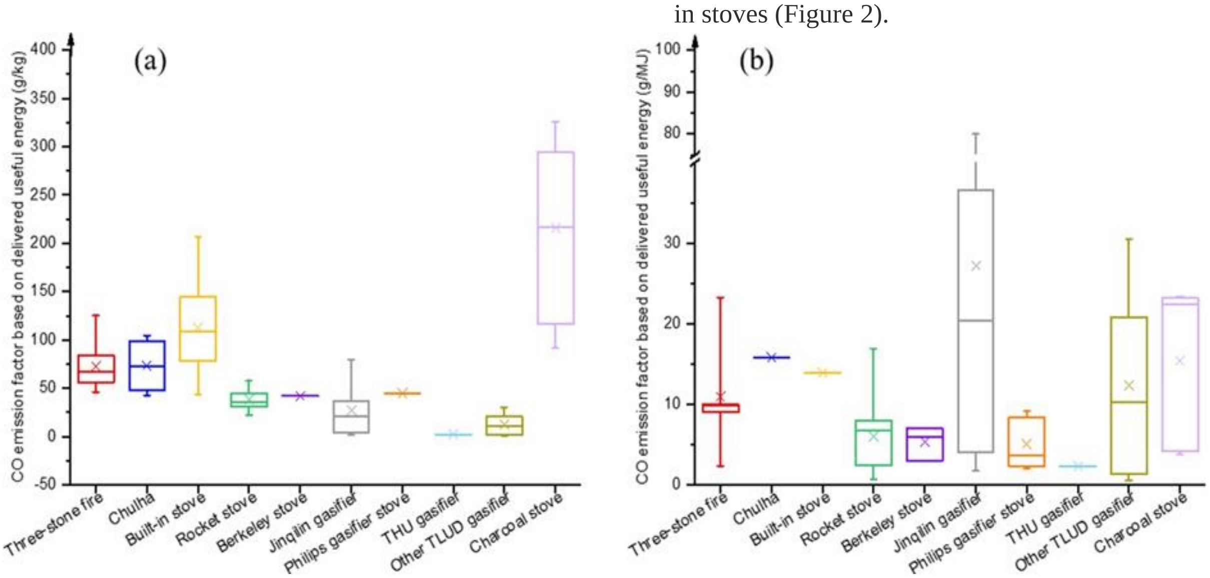

Figure 2: Factor affecting the emission of CO

Gas stoves produce the highest CO emission factors based on the useful energy delivered, followed by stoves and coal stoves. CO emissions from traditional biomass stoves (such as three-stone stoves, stoves, and internal stoves) are low compared to the advanced types of gasification stoves available in the Tier (i.e., THU and Philips gasification stoves). 4 (best performance according to IWA class ISO furnace rating). Therefore, the development of gasification technology is essential to produce truly clean biomass stoves.[7], [8], [9].

Different cooking appliances produce different NOx emissions. The TLUD gasification furnace produces a higher NOx emission factor than the new prototype hybrid furnace when burning wood particles. A closed chimney contributes to the reduction of up to 71% of NOx . Air supply parameters (such as air flow rate and distribution) affect NOx emissions. The forced air supply mode leads to a higher NOx emission factor than the natural air supply mode due to the higher oxygen supply than the previous mode and the NOx formation mechanism associated with biomass combustion. NOx emissions have a positive relationship with the air flow rate when the forced air supply air flow rate is between 93 and 277 L/min. The primary and secondary airflow ratio of the airflow decreased between 183 and 297 L/min, and the airflow rate decreased due to 93 L/min. Proper air distribution is crucial in minimizing NOx emissions during the combustion of biomass. [8],[9].

The emission performance of different biomass cooking species varies. Some TLUD gas stoves have a maximum PM and PM2.5 emission factor based on fuel consumption and three-stone combustion. Certain types of new biomass stoves (e.g., rocket stoves, Philips gas stoves, and Berkeley stoves) emit fewer particulates while fuel efficient. There is an important difference between the particulate matter of this type of stove based on fuel consumption ($p = 0.0377$). However, due to the improved thermal efficiency of the biomass stove, the TLUD gas stove produces PM and PM2.5 emissions lower than the three stone fireplaces for the same amount of energy input. The former reached a higher ISO level than the second, which means that the TLUD gas furnace can reduce particulate emissions after replacing the three-stone burner. Coal furnaces also have lower particulate emissions, which can be attributed to better furnace design and decreased fuel volatility, resulting in lower combustion. Most biomass stoves need to be upgraded in terms of PM2.5 emissions to reach higher standards. Less advanced gas furnaces can achieve the best performance in the rating of ISO IWA class furnaces, so the particle performance of other types of furnaces should be improved to provide more "true clean". choice for the user.

IV.LIMITATIONS

This study has several limitations. The number of articles focused on influencing factors is unevenly distributed; therefore, the result in some influencing factors of some types of pollutants may be missed. In addition, many parameters can interact with each other, but due to different data limitations in different studies, it is difficult to do a comprehensive analysis of all results to determine the contribution of each influencing factor. Therefore, this study mainly uses the univariate analysis method to investigate the effect of several parameters on the effect of pollutant emissions. In the future, the modeling study can be further developed to identify the combined effect of several indicators on the chef's performance and determine the optimal combination of factors. The same analysis method is not used in the analysis of fuel types and cooking types because there are several common fuel-fuel combinations in the real world and each fuel type or cooking type can calculate pollutant factors based on popular combinations. It shows emissions performance and can be compared to other types of fuel or cooking.

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