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Assessment of PM_{10} and $PM_{2.5}$ concentrations and their health effects on rice mills workers in some selected areas of Mymensingh district in Bangladesh

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Abstract
When air pollution levels are unhealthy, fine particle pollution is a cause for concern. A study was conducted in some selected areas of Mymensingh district in Bangladesh. The research found that all operational units of auto and semi-auto rice mills reported levels of PM_{10} and $PM_{2.5}$ significantly higher than the 24-hour limits set by the AQI and the National Ambient Air Quality Standards of Bangladesh. The average highest concentration of both PM_{10} and $PM_{2.5}$ was found in Mymensingh Sadar, with the highest value of 525.75 µg/m^3 and 408 µg/m^3 respectively. Others Upazila concentration is not satisfactory. The average $PM_{2.5}$ value in the sampling areas ranged from 250 to 400 µg/m^3, significantly higher than the NAAQS of 65 µg/m^3. On the other hand, PM_{10} value in sampling area ranges from 330 to 530 µg/m^3, significantly higher than the NAAQS of 150 µg/m^3. PM_{10} and $PM_{2.5}$ concentration is higher in automated rice mils than semi auto rice mills. A questionnaire survey was done to determine health conditions of the workers. The result has shown that rice mill workers experienced respiratory symptoms and eye irritation (70%), asthma and allergies (73%), lung diseases (60%), arrythmia (18%), and shortness of Breath (42%). The findings highlight the need for improved ventilation systems to reduce dust in the rice mill areas and regulations to protect workers and the environment. Findings can also improve the environmentally responsible construction of rice mills and government monitoring of safe working conditions.

Keywords: Particle pollution, air quality monitoring, health effect, rice mills

Introduction

Air particle pollution has become a great concern in worldwide. In order to address the harmful effects of air pollution on health, the member nations of the World Health Organization issued a resolution in 2015 designating air pollution as a public health emergency (WHO, 2016). In 2019, air pollution became the fourth risk factor for premature death globally, with over 90% of the world population exposed to an annual average $PM_{2.5}$ concentration that surpassed the WHO air quality guideline value of 10 µg/m^3 (Povey *et al*., 2014) [14]. Particulate matter is one of the key pollutants in air pollution. $PM_{2.5}$ and PM_{10} contribute a major role in indoor and outdoor air pollution in Bangladesh (Mahmud *et al*., 2024) [9]. Bangladesh's ambient air pollution is mostly caused by both natural and man-made sources. Burning fossil fuels, such as coal and wood, agricultural leftovers outside, automobile emissions, emissions from agro-industries are examples of anthropogenic causes (Koul *et al*., 2022) [8]. The rice mill releases a significant amount of PM, which has an impact on both the environment and the rice mill workers (Choudhury *et al*., 2023) [2, 3]. There are two kinds of commercial mills in Bangladesh. These are either husking or traditional rice mills, or contemporary or mechanized rice mills. There were barely 200 automatic and semi-automatic rice milling machines in use in 2005. 18,700 rice mills (500 automated, 700 semi-automated, and 17,500 husking mills) exist in Bangladesh, according to the Auto Major and Husking Mill Owners Association (Mannan *et al*., 2022) [10]. In modern rice milling machines and automatic rice milling machines, all operations are performed through mechanical processes (Zaman and Farouk, 2006) [18]. Internal or external emissions from dust emissions from by-products and particulate matter that may be high in concentrations in the surrounding air continually affect our environment. Global studies reported that argo-based industries and factories are the largest stationary source of air pollution (Prasanna, 2022) [15]. The automatic rice mills emit large amounts of particulate matter every day, which has a devastating impact on rice mill workers and contributes to major sources of air pollution (Choudhury *et al*., 2023; Mohidem *et al*., 2022) [2, 3, 11]. The workers in the rice mills are exposed to both organic and inorganic pollutants. Several reports have suggested unprotected dust exposures in agricultural settings lead to pulmonary diseases (Ghosh *et al*., 2014) [6]. Particulate matter emitted from rice mills can also pose health risks to workers (Das *et al*., 2021) [4]. These particles, especially fine ones like $PM_{2.5}$, can enter the respiratory system when inhaled. Prolonged exposure may lead to respiratory issues, including chronic bronchitis and aggravated asthma (Fatima *et al*., 2016) [5]. When compared to the WHO's recommended level of 5 µg/m^3, fine particle air pollution ($PM_{2.5}$) shortens the average life expectancy of a Bangladeshi citizen by approximately 4 years (Roy *et al*., 2024) [16]. Bangladesh's fine particle air pollution performance is noticeably below average in some areas. In Bangladesh that rice is the main diet for the majority of people, and rice mills employ a large number of people. Workers at rice mills confront many issues, particularly respiratory illnesses, as a result of the absence of defined criteria for the establishment and operation of rice mills (Mulamalla *et al*., 2020) [12, 13]. The release of dust into the atmosphere from the handling or processing of the paddy or its byproduct can cause local air pollution. The fine air

particulate matter emitted from the mills is very harmful for both inside and outside people (Kim *et al*., 2015) [7]. The PM_{10} and $PM_{2.5}$ concentrations are very high in the working zone of rice mills, causing pollution of the air and severe diseases for the workers. Long-term exposure to $PM_{2.5}$ can increase the morbidity of people (Chen & Hoek, 2020 [1]. We analyzed the concentration of $PM_{2.5}$ and PM_{10} in Trishal, Bhaluka, Muktagacha, Mymensingh Sadar, and Fulbaria upazila rice mills and assessed the health effects of PM_{10} and $PM_{2.5}$ on rice mill workers in some selected areas of Mymensingh district. Though rice mills are one of the most important contributors to the development of the country, the respiratory problems of the workers are still neglected. Keeping all the factors in mind, we conducted a study about the effect of $PM_{2.5}$ and PM_{10} on the workers health, and we also measured the concentrations of the dust particles.

Materials and methods

1. Study Area

The Mymensingh District of Bangladesh is 4080.18 square kilometers and is situated between latitudes 24°15' and 25°12' north and longitudes 90°04' and 90°49' east. There are thirteen upazilas in the district of Mymensingh. The Mymensingh District's five upazilas were chosen as study areas (Fig-1). The study encompassed Trishal, Fulbaria, Bhaluka, Muktagacha, and Mymensingh Sadar in Mymensingh District. Mostly, auto- motorized rice mills, which were important features of our study area, led to the selection of the study location. Because automated rice mills emit PM_{10} and $PM_{2.5}$ at a higher rate than manual or traditional rice mills, the locations with the greatest number of rice mills were chosen.

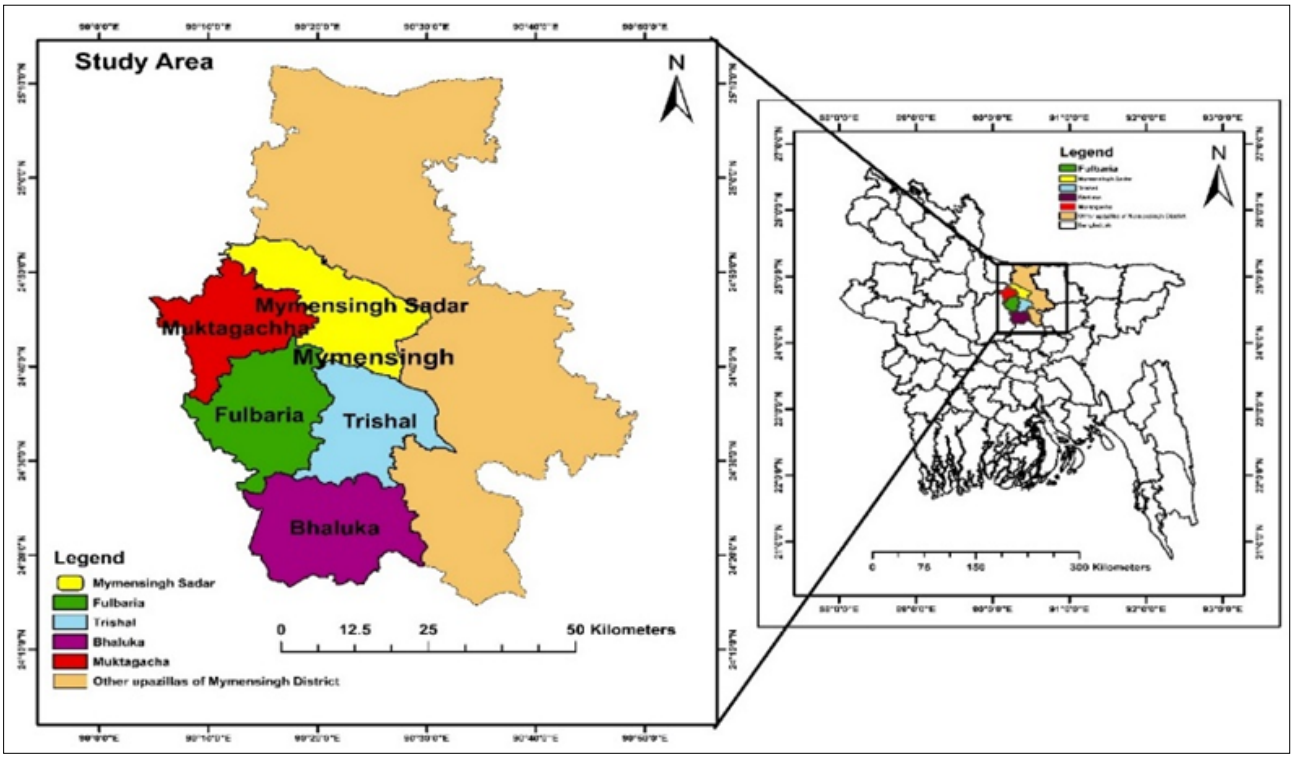

Fig 1: Selected study areas of Mymensingh district in Bangladesh.

2. Sampling

The investigation was carried out over the course of a month utilizing the stratified random sampling technique. It was focused on the five different upazilas from the reputed auto and semi-auto rice mills in Mymensingh district. This research employs an informal questionnaire survey, inventory, site selection, and field-level data collection by observation. A sample was collected from random local rice mills for $PM_{2.5}$ and PM_{10} assessment. The major instrument used in this investigation to assess particulate matter concentrations in the study area was the Airveda $PM_{2.5}$-PM_{10} Air Quality Monitor. Accurately assessing air quality and providing real-time data on $PM_{2.5}$ and PM_{10} pollutants, the Airveda PM monitor is a dependable and portable gadget. The data was collected while the paddy was being processed in order to improve the results. The study was conducted among 20 workers of 20 rice mills in Mymensingh District from different locations such as Fulbaria, Trishal, Bhaluka, Muktagacha, and Mymensingh Sadar. For determining the health and safety condition, workers employed for at least 4 years in the rice mills have given a predesigned questionnaire.

Table 1: Sampling locations of PM_{10} and $PM_{2.5}$ in the rice mills of Mymensingh District

Sample No.	Rice mills Location	Latitude	Longitude	Mill types
1	Fulbaria	24.578637	90.335253	Semi-auto
2	Fulbaria	24.616621	90.258792	Auto
3	Fulbaria	24.616818	90.258851	Semi-auto
4	Fulbaria	24.603862	90.251234	Auto
5	Mymensingh Sadar	24.7748251	90.463929	Semi - auto

6	Mymensingh Sadar	24.786160	90.485260	Auto
7	Mymensingh Sadar	24.7736165	90.458908	Auto
8	Mymensingh Sadar	24.7729599	90.457636	Auto
9	Muktagacha	24.779542	90.162180	Semi -auto
10	Muktagacha	24.779246	90.163856	Auto
11	Muktagacha	24.77476	90.165301	Auto
12	Muktagacha	24.777813	90.168834	Semi -auto
13	Bhaluka	24.398235	90.391114	Auto
14	Bhaluka	24.403765	90.516499	Semi-auto
15	Bhaluka	24.523364	90.513421	Auto
16	Bhaluka	24.383392	90.472010	Auto
17	Trishal	24.582599	90.398979	Auto
18	Trishal	24.672652	90.404647	Semi-auto
19	Trishal	24.673708	90.399192	Auto
20	Trishal	24.673414	90.403899	Semi-auto

3. Data Analysis

3.1. Air sampling and analysis to estimate $PM_{2.5}$ and PM_{10} levels

In study areas, 20 samples of 20 rice mills from different locations were taken by the Airveda $PM_{2.5}$-PM_{10} Air Quality Monitor through short-term sampling from randomly chosen stations. The sampler was placed in the area where different mechanical processes (rocks and unfilled grains, grain marinating, boiling, and drying) were done in rice mills, and the concentrations of $PM_{2.5}$ and PM_{10} were collected in a data sheet for comprehensive analysis. The monitors were calibrated, and the readings were taken instantly to ensure the consistency of the collected data.

3.2. Questionnaire surveys for the assessment of health conditions

A questionnaire was designed based on prior research and observed respiratory and visual disorders caused by exposure to PM_{10} and $PM_{2.5}$. Symptoms of lung disorders, lung cancer, arrhythmia, bronchitis, renal ailments, and eye irritation or inflammation were the main topics of discussion. Particulate matter emissions were a source of exposure for those particular workers. They were chosen from among the various age groups. The owner of those rice mills gave permission for the study to be done. With their prior consent, each participant was interviewed.

Results and Discussions

1. Data analysis of $PM_{2.5}$ and PM_{10}

Based on the information gathered from the various rice mills, the data were examined. Each piece of information and finding is analyzed in light of the study's goals. Exceedance analysis was carried out, and the number of threshold exceedances was computed in accordance with the NAAQS and AQI standards.

1.1 PM_{10} concentration exceedance in the rice mills

Every operational unit of the rice mills had reported levels of PM_{10} that were much higher than the 24-hour PM_{10} and concentration limit (150 $\mu g/m^3$) set by the AQI for indoor air pollution and the National Ambient Air Quality of Bangladesh. The highest concentration of PM_{10} 703 $\mu g/m^3$ which was found in the rice mills of Mymensingh Sadar. These results suggest that there is a strong correlation between the frequency of respiratory symptoms and dust concentration in various operating parts of rice mills, as well as between those areas and their employees. The milling area of the rice mills had the greatest concentrations of $PM_{2.5}$ and PM_{10}.

Table 2: PM_{10} concentration in the Mymensingh District

Location	PM_{10} ($\mu g/m^{3)}$	Average value ($\mu g/m^3$)	PM_{10} standards according to AQI ($\mu g/m^3$)	PM_{10} Standards according to NAAQS ($\mu g/m^3$) in Bangladesh
Fulbaria	288	410.25	Very Unhealthy	150
	570			
	482			
	301			
Mymensingh Sadar	348	525.75	Hazardous	150
	606			
	703			
	446			
Muktagacha	290	335.75	Unhealthy	150
	427			
	324			
	302			
Bhaluka	345	424.5	Very Unhealthy	150
	239			
	449			
	665			
Trishal	532	436.75	Hazardous	150
	226			
	650			
	339			

According to the graph below, one of the rice mills in Mymensingh Sadar, Bhaluka, and Trishal has the largest range of PM_{10} emissions, at 703 µg/m^3, 665 µg/m^3, and 650 µg/m^3, respectively. The average concentration of PM_{10} in rice mills in Mymensingh district is given below in Fig-a.

1.2 $PM_{2.5}$ concentration exceedance in the rice mills

It was discovered that there was more dust in the milling (492.1 and 678.19 µg/m^3) in terms of $PM_{2.5}$ **(**Table-3**)**. The graph (Fig-b**)** indicates that all of the rice mills at the sampling site had extremely high $PM_{2.5}$ concentrations. In all those sampling regions, the average $PM_{2.5}$ concentration is similarly very high. The results we obtained ranged from 250 to 400 µg/m^3, which is significantly higher than the NAAQS of 65 µg/m^3. This table also shows that these numbers don't match the NAAQS and AQI standards. According to standards, the air quality is very unhealthy and hazardous. According to the study, Trishal rice mills had an average $PM_{2.5}$ value of 292.25 µg/m^3, with a maximum value of 421 µg/m^3, which is among the highest levels ever recorded.

Table 3: $PM_{2.5}$ concentration in the Mymensingh District

Location	$PM_{2.5}$ (µg/m^3)	Average value (µg/m^3)	$PM_{2.5}$ standards according to AQI (µg/m^3)	$PM_{2.5}$ Standards according to NAAQS (µg/m^3) in Bangladesh
Fulbaria	181	278.75	Hazardous	65
	350			
	289			
	295			
Mymensingh Sadar	238	408	Hazardous	65
	456			
	600			
	338			
Muktagacha	195	211.25	Very unhealthy	65
	257			
	203			
	190			
Bhaluka	205	250.5	Hazardous	65
	102			
	306			
	389			
Trishal	305	292.25	Hazardous	65
	116			
	421			
	327			

The graph indicates that all of the rice mills at the sampling site had extremely high $PM_{2.5}$ concentrations. In all those sampling regions, the average $PM_{2.5}$ concentration is similarly very high. The results we obtained ranged from 250 to 400 µg/m^3, which is significantly higher than the NAAQ standard of 65 µg/m^3.

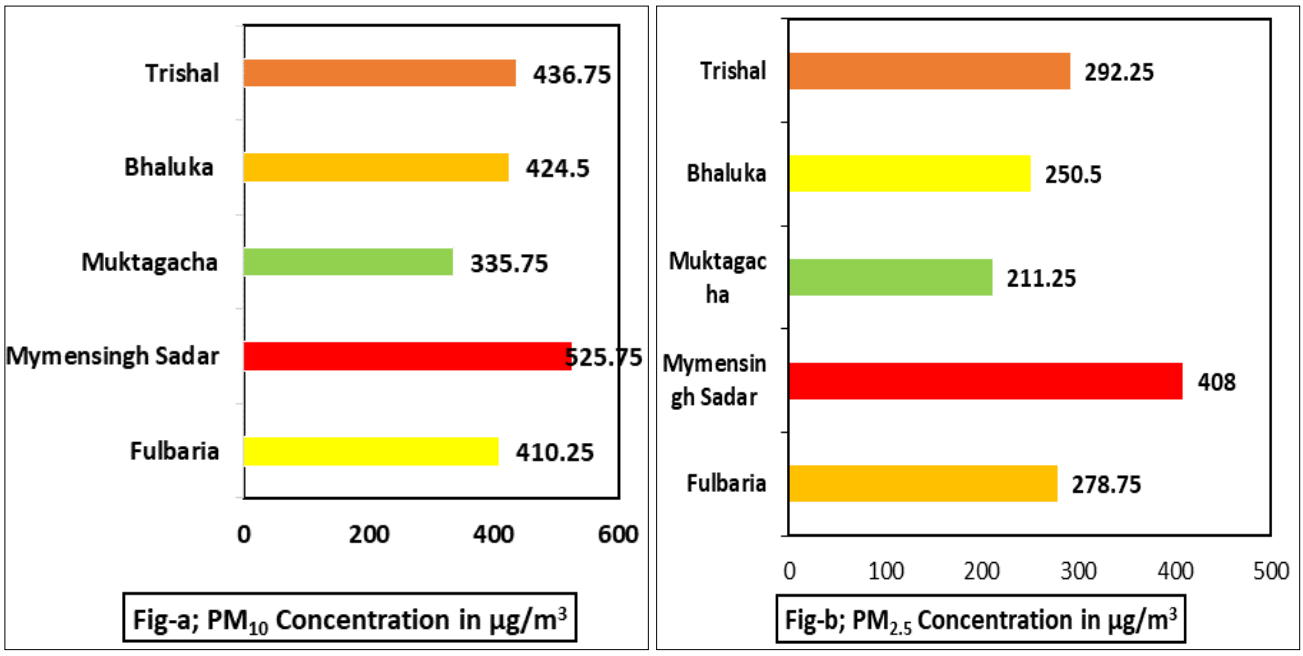

Fig 2: a) Average PM_{10} concentrations in sampling areas; b) Average $PM_{2.5}$ concentrations in sampling areas

2. Variations of PM_{10} and $PM_{2.5}$ concentration based on various rice mills

In Bangladesh, there are two types of rice mills and these are auto and semi-auto rice mills. Every operation in a contemporary or automatic rice mill is carried out by a mechanical process and the surroundings are constantly being polluted by things like dust released from byproducts. Numerous illnesses and disorders may consequently arise. Furthermore, the syndrome may even arise from operating huller machines, igniting boilers, carrying heavy items over the head, back, and shoulders, and manually and mechanically separating rice husks from head. Every step of the rice milling process in an automated rice mill is operated by automated machinery. That's why the auto rice mills have a great chance of particulate matter pollution than the semi auto rice mills. Also, there is the chance of high concentration of PM_{10} and $PM_{2.5}$ in the auto rice mills rather than semi-auto rice mills (Fig-3). The PM_{10} concentration of both auto and semi-auto rice mills is 534.84 µg/m^3 and 326.75 µg/m^3, respectively. So, there is a huge difference in the value of PM_{10} concentration. The auto rice mills are the source of air pollution and the respiratory disturbance of the workers and people around the area. The average $PM_{2.5}$ concentration in semi-auto and auto rice mills in Mymensingh District is shown in the graph. It is clear from the graph that the type of rice mill affects $PM_{2.5}$ concentration, as both auto and semi-auto rice mills have $PM_{2.5}$ concentrations of 343.75 µg/m^3 and 204.75 µg/m^3, respectively. This indicates a significant difference in $PM_{2.5}$ concentration values.

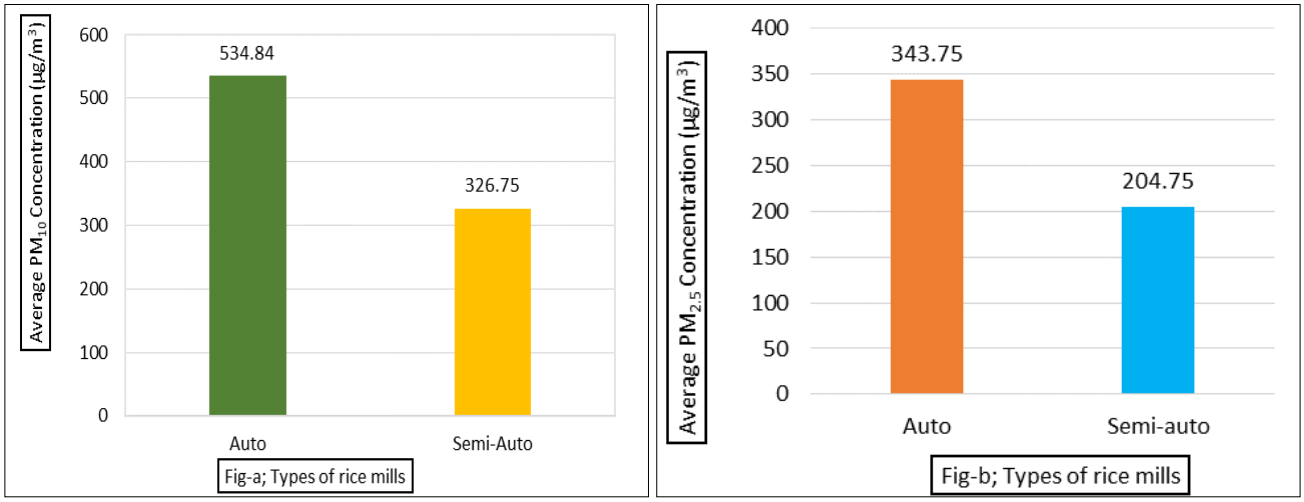

Fig 3: a) PM_{10} concentration difference between auto and semi-auto rice mills; b) PM_{10} concentration difference between auto and semi-auto rice mills

3. Correlation of PM_{10} and $PM_{2.5}$ with temperature

The concentrations of PM_{10} and $PM_{2.5}$ vary with temperature. From the data, it is clearly evident that PM concentration is varying with temperature. The concentration indicates a negative correlation between the temperature and PM_{10} concentration. The correlation coefficient is -0. 19104. They have an inverse relationship. In Mymensingh Sadar, the PM_{10} concentration peaked at 703 µg/m^3 at 23.1 ºC in an automatic rice mill. At 33 ºC, the lowest PM_{10} concentration was found in semi-auto rice mills in Trishal Upazila, with 226 µg/m^3. According to the correlation coefficient is -0.3278 which is indicating the negative correlation between the $PM_{2.5}$ and temperature. As the temperature rises, $PM_{2.5}$ concentration decreases. An automatic rice mill in Mymensingh Sadar recorded a peak PM_{10} concentration of 600 µg/m^3 at 23.1 ºC. The lowest PM_{10} concentration, 102 µg/m^3, was recorded at 32 ºC in Trishal Upazila semi-auto rice mills. Correlation of PM_{10} and $PM_{2.5}$ with temperature was shown in Fig-4**.**

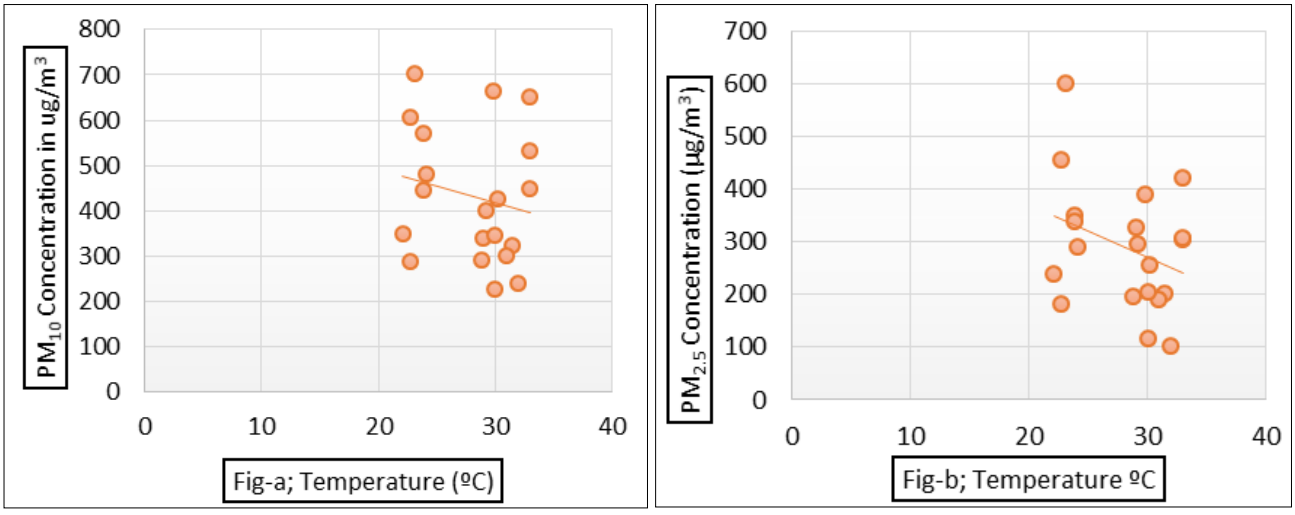

Fig 4: a) Correlation of PM_{10} with temperature; b) Correlation of $PM_{2.5}$ with temperature

4. Correlation of PM_{10} and $PM_{2.5}$ with humidity

The rise in PM concentration is largely unaffected by humidity levels, but they are crucial for limited visibility in a steady atmospheric environment. While higher temperatures often encourage the creation of airborne dust, increasing humidity can lower the concentration of airborne particles. However, high humidity can lead to higher levels of endotoxins and bacteria. The concentration of $PM_{2.5}$ in the air rises with a rise in relative humidity. Many studies have shown that humidity is directly proportional to the relative humidity, rate of $PM_{2.5}$ deposition increases with increasing relative humidity. Correlation of PM_{10} and $PM_{2.5}$ with humidity was shown in Fig-5.

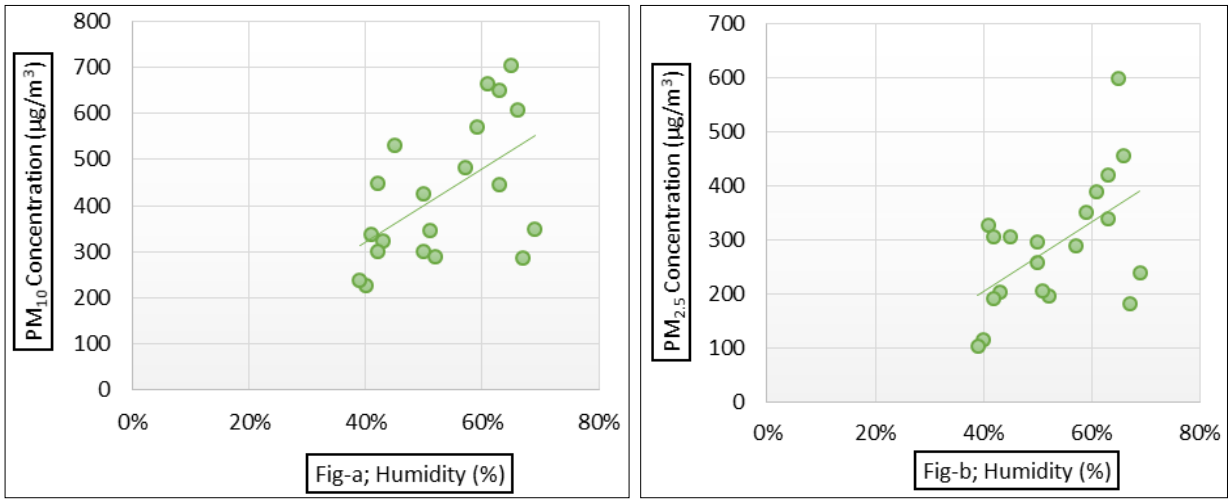

Fig 5: a) Correlation of PM_{10} with humidity; b) Correlation of $PM_{2.5}$ with humidity

The both graph (Fig-5) demonstrates the positive correlation between humidity and $PM_{10,}$ concentrations. In graph-a, the correlation coefficient is 0.549996. The concentration of PM_{10} increases with increased humidity. They have a positive correlation between PM_{10} concentrations and humidity. At 703 µg/m^3 and 65% humidity, the PM_{10} concentration peaked at an automatic rice mill in Mymensingh Sadar. With 50% humidity, the highest PM_{10} reading in Fulbaria was 570 µg/m^3. With 50% humidity, the highest PM_{10} concentration in Muktagacha was 427 µg/m^3. Lastly, Bhaluka greatest PM_{10} score was found at 61% humidity.

On the other hand, graph-b demonstrates the correlation coefficient is 0.550904. The $PM_{2.5}$ concentration at an automatic rice mill in Mymensingh Sadar peaked at 600 µg/m^3 and 65% humidity. Fulbaria maximum $PM_{2.5}$ value at 59% humidity was 350 µg/m^3. In Muktagacha, the highest $PM_{2.5}$ concentration was 257 µg/m^3 with 50% humidity. Finally, Bhaluka had the highest PM_{10} score which was 389 µg/m^3 at 61% humidity. The both graph's trend line depicts the proportionate link between humidity and PM. As the humidity in the sampling area rises, the PM_{10}, $PM_{2.5}$ concentration is rising from left to right.

5. Health status of the rice mills workers

Workplace exposure to endotoxins and organic dust can cause a variety of respiratory disorders, including asthma, allergy, chronic bronchitis, hypersensitivity pneumonitis, and acute or chronic impairment of lung function. We noticed apparent dust in the milling part of the rice mills, which appeared dense and hazy, during our examination. This is most likely caused by an increase in airborne particulate matter from dust-contaminated rice husk and emissions from milling machinery, especially old and badly maintained equipment. Based on those results, one may deduce that there is a strong correlation between the frequency of respiratory symptoms and dust concentration in various working areas of rice mills, as well as between those parts and the workers themselves.

5.1. Complications of the eyes and respiratory conditions of workers

A questionnaire was utilized to evaluate occupational history, including place of employment, years of employment, number of hours worked each day, type of work, and whether or not using gloves, a mask, or ventilation during work lessened the severity of work-related symptoms. Respiratory symptoms, such as sputum, dyspnea, and tightness in the chest, were also evaluated. The final results showed that the workers of rice mills are experiencing irritation or inflammation in their eyes (70%), asthma (55%), allergies (73%), lung diseases (60%), arrythmia (18%) and shortness in breathing (42%).

6. Usage of Personal Protective Equipment

In these study areas, 52% of the sample population as a whole was merely utilizing a piece of cloth as a mask or gloves, according to the results of the walk-through survey. Interviews revealed that 86% of them did not know that the dusty environment they worked in had any negative health effects, and 12% said the personal protective equipment (PPE) they were wearing was ineffective and inadequate. Most of them, 5% thought that the hot and muggy weather made masks and gloves uncomfortable to wear.

7. Observed Sources of PM_{10} and $PM_{2.5}$ in the Sampling Areas

A reconnaissance assessment found that the offloading of raw agricultural products within the mill premises was the initial source of coarse particle formation. After being boiled, dried, and threshed, they are brought to mill houses to be processed, packaged, and husked. It was necessary to shell some of the raw materials out of the coir and fry them

in the burners. Generators or electricity powered the mill buildings threshing, pressing, and husking gear. These devices lacked a cabin or covering to prevent husks from flying out due to their poor construction. The main source of biomass for the burners used for baking, frying, and boiling was agricultural waste such as twigs, coconut shells, corn husks, and straws. A few charcoal burners were present. When the workers tossed charcoal and biomass into the burners, they were surrounded by a cloud of dust and soot. The DoE recommends that the height of the stacks at each of the mills be at least 50 feet, yet they are only about 25 feet high. Because the stacks are closer to the ground, there may be a higher chance of concentrated particles in the surrounding air. Due to inadequate ventilation, the entire mill house remained dusty during working hours.

7.1. Mill Wastes from ashes and burned husks

Ash and husks burned Ash and burned husk from the mill damaged the soil, waterbeds, and the surrounding area. These wastes were haphazardly dumped on the mill grounds, wasting a lot of space that could have been utilized for useful purposes. According to MPCB, 2005 stated that some rice mills were forced to close because they were storing rice husk in an open area, which polluted the environment and annoyed the locals. Additionally, these mills lacked a covered shed to store rice husks.

7.2. Dust from Mill House and Drying Floors

Dust from the rice bran, drying floor, and mill house contaminated the air. Because the mill houses were typically poorly aired, the air inside of them contains fine dust and bran particles. The health of the workers is greatly endangered by these dusts. Workers lungs may be affected by the dust they breathe in, and long-term exposure may result in the development of lung cancer.

7.3. Ashes, black smoke and fire

The nearby residences' trees, residents, and livestock were all negatively impacted by the air pollution caused by ashes, black smoke, and gasses. The air was filled with mingled ashes, which covered the houses and trees in dirt. It was discovered that some rice mills with short chimneys released black smoke and flames, which warmed the surrounding trees and the atmosphere.

8. Possible Effects of rice mill pollution in the Surrounding Environment

They said that because the mill releases large amounts of ash and carbon dioxide into the atmosphere, Particulate matter and residents are more susceptible to respiratory conditions like asthma. In addition, the rice mill produces poisonous water that has soaked the nearby soil and contaminated the subsurface water. On the other hand, the mill's greatest and lowest pollution impacts were recorded at 0 to 1000 meters, respectively. At ground areas, the pollution impact was largest, while at 1000 meters, it was lowest. The pollutant contamination of the environment decreased agricultural output, and health problems. Dust particles, black smoke, and foul smells are the main causes of environmental pollution; on the other hand, rising CO_2, SO_2, dust particles, and hot water are the main causes of decreased agricultural productivity. The sound pollution caused by rice mills raises concerns about health**.** PM can have a detrimental effect on ecosystems, including plants, soil, and water, by deposition and subsequent uptake by plants or deposition into water where it can affect water quality and clarity. The metal and chemical components in PM have the greatest ability to alter plant growth and yield. Currently, the steam boiler highest ground level concentration emissions were between 1.4 and 177.3 µg/m3 on an hourly average and between 0.3 and 43.5 µg/m3 on a 24-hour basis. When the steam boiler and electric power generators run simultaneously, the concentrations average out to be between 29.7 and 257.8 µg/m^3, and the levels are between 8.8 and 95.8 µg/m^3 for the 24-hour period. Concurrent operation of the electric power generators and the steam boiler improves the ambient air quality of the host environment by around 0.41 to 84.78% of the relevant investigated air pollution limits. The majority of workers in rice mills encountered common environmental pollution, such as excessive dust in the mill house (91.12%), unpleasant soaking water odor (81.12%), noise pollution from belt movement (68.88%), inadequate facilities for disposing of waste, including soaking water (61.12%), drainage system pollution (54.45%), chimney-produced black smoke (84.45%), unhygienic conditions (80%), air pollution from ash (75.55%), air pollution from rice husk (87.78%), and a reduction in agricultural crop productivity (56.67%). The impacts of burning rice straw outside, which is known to produce large volumes of air pollutants, significantly decrease ambient air quality, affect climatic patterns, and harm public health, have been the subject of numerous studies. When rice straw is burned outdoors, it releases fine dust, CO, NOx, and other air pollutants into the environment in addition to greenhouse gases. 11 tons of CO_2 equivalent, NOx, and $PM_{2.5}$ fine dust particles were released per hectare of land as a result of burning rice straw.

Conclusions

The purpose of the study was to assess PM_{10} and $PM_{2.5}$ concentrations as well as the effects of long-term exposure on the workers. The quantities of PM_{10} and $PM_{2.5}$ observed in rice mills were higher than the standard's threshold limit. The highest average concentration of $PM_{2.5}$ and PM_{10} was in the rice mill of Mymensingh sadar which is 408 µg/m^3 and 525.75 µg/m^3 respectively. The lowest $PM_{2.5}$ and PM_{10} concentration was in the rice mills of Muktagacha upazila which was 211 µg/m^3 and 335.75 µg/m^3 respectively. The mill house workers there had the highest percentages of allergy, eye irritation, lung disease, and shortness of breath complaints. It was discovered that the DoE's monitoring system was ineffectual in the region. For personal protection, the authorities should provide the workers with dust masks. They should also provide technical advancements such water sprinkling systems and covered or closed ports in machinery. Dust exposure at work in rice mills ought to be a major topic of study. However, this also causes a lot of health and environmental issues in the region. More precisely, it has had certain detrimental effects on the rice mill employees. The health of workers is affected by pollution. In order to reduce the negative effects of air pollution and worker health, the mill should be built using contemporary technologies and all safety precautions should be followed.

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Disclosure statement

Conflict of Interest: The authors declare that there are no conflicts of interest.

Compliance with Ethical Standards: This article does not contain any studies involving human or animal subjects.

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