

Environmental and Health Impacts of Rice Milling: A Case Study of Dinajpur Sadar Upazila, Bangladesh

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Abstract

Rice milling plays a crucial role in Bangladesh's agricultural economy but contributes significantly to environmental pollution, affecting air, water, and soil quality, which in turn impacts public health and agricultural productivity. While prior studies have focused on immediate health effects like respiratory problems and reduced crop yields, they often overlook long-term consequences such as chronic diseases, soil degradation, and socio-economic impacts. Additionally, there is limited comparison between traditional and automated rice milling methods. Additionally, a lot of research uses self-reported data, which may be biased. This research fills these gaps by comprehensively assessing the environmental, agricultural, and health impacts of rice mill pollution in Dinajpur Sadar Upazila. It examines the effects of pollution on local communities, including their income, knowledge, and attitudes, and evaluates how proximity to rice mills influences crop productivity and health. Data was collected through surveys and interviews with residents, farmers, and health experts, and analyzed using statistical methods like linear regression. The findings reveal significant negative impacts on crop productivity and public health, particularly for those living within 500 meters of mills. The study calls for stronger environmental regulations, better waste management, and public awareness initiatives to mitigate pollution's effects, offering valuable insights for policymakers and planners in Bangladesh and similar areas.

Keywords: Dinajpur Sadar Upazila, distance effect, rice mill pollution, human health, environmental impact.

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INTRODUCTION

Rice milling is a crucial agro-processing activity in Bangladesh, particularly in Dinajpur Sadar Upazila, where it plays a significant role in the local economy. However, this process is associated with considerable environmental pollution that adversely affects agricultural productivity and public health [1]. Pollution is a widespread concern in Bangladesh, with severe consequences for ecosystems, human health, and the economy, including contamination of air, water, and soil [2]. Factors such as poverty, overpopulation, and a lack of environmental awareness exacerbate the issue, leading to problems like deforestation, wetland loss, and increased vulnerability to natural disasters [3]. Rice is the dominant crop in Bangladesh, occupying 80% of the country's cultivated land. Annually, the country produces 26.2 million metric tons of raw rice, with 17.3 million metric tons processed into milled rice, contributing significantly to the agricultural GDP [4].

The industrialization of rice milling has led to a transition from traditional methods to automatic and semi-automatic mills, creating new environmental challenges. These challenges include the release of dust, noise, odors, untreated wastewater, and organic runoff, all of which pose significant health risks, particularly to those living near rice mills. Common health issues in these areas include respiratory problems such as chronic cough and chest tightness. Additionally, rice mill pollution has been shown to affect crop photosynthesis, reducing agricultural productivity in surrounding areas [5]. Despite these evident health and environmental risks, there is a lack of comprehensive research on the impact of rice mill pollution in Bangladesh. This study, focused on Dinajpur Sadar Upazila, aims to assess the local residents' perceptions of the health and agricultural consequences of rice mill pollution, providing valuable information for policymakers and land-use planners to develop mitigation strategies. Several studies have highlighted the adverse effects of rice mill pollution. Choudhury et al. (2023) identified respiratory problems, including chronic cough and lung conditions, among rice mill workers in Rangpur, indicating significant occupational health risks [6]. Mannan et al. (2022) also examined the health and environmental consequences of rice mill pollution, recommending the relocation of mills at least 500 meters from settlements and farmland to reduce these impacts [7]. They also called for stronger regulations to control emissions. Padhan and Sahu (2011) focused on the detrimental effects of rice mill wastewater on local ecosystems, particularly its negative impact on earthworm populations, soil health, and biomass, and advocated for wastewater treatment before its use in agriculture [8]. Similarly, Arpitha et al. (2023) recommended placing rice mills away from populated areas and adopting eco-friendly practices to mitigate environmental damage [9].

However, existing literature often overlooks key aspects of rice mill pollution. Most studies focus on short-term health and crop productivity effects, neglecting long-term consequences such as chronic diseases and soil degradation [7]. Additionally, many studies have limited geographic scope, making their findings less applicable to regions with different agricultural or climatic conditions. The effectiveness of current regulations in mitigating rice mill pollution is also often ignored. Furthermore, there is a lack of comparative analysis between traditional and automated milling technologies, which may offer opportunities for better pollution control [10]. Many studies also rely on self-reported data, introducing potential biases, and fail to incorporate objective pollution measurements [11]. In conclusion, while rice milling significantly contributes to environmental pollution, the most severe effects are often felt within 500 meters of the mills. This highlights the urgent need for stronger regulations and better management practices to reduce pollution and its associated risks. Future research should explore the long-term consequences of rice mill pollution, assess the effectiveness of existing regulations, and compare traditional and automated milling technologies to better mitigate the environmental and health impacts in Bangladesh.

STUDY AREA AND DATASET

Study Area

To assess the impact of rice mill pollution on crop productivity and human health, it is crucial to determine the number of rice mills in Rangpur Sadar. However, studying all the mills in a short time is challenging. Therefore, my research focuses on Pulhat area in Dinajpur district, known for its rice mills. Dinajpur district consists of 13 upazilas, with Dinajpur Sadar, covering 354.73 km² and home to 94,188 people and 111,779 households, selected for this study. The place is located between latitudes 25°28' and 25°48' north and longitudes 88°34' and 88°46' east as shown in Figure 1.

Data Collection

The data for the research is collected mainly from primary sources through the field survey, Interview and secondary data was collected from government offices, public documents and published papers. A range of methods are used in the field to collect primary data. Crop Production data are collected from Farmers and health related data are collected from the residents near the rice mill areas. Some data is collected from government offices and hospitals. And all data was valued by local government agricultural extension office and civil surgeon.

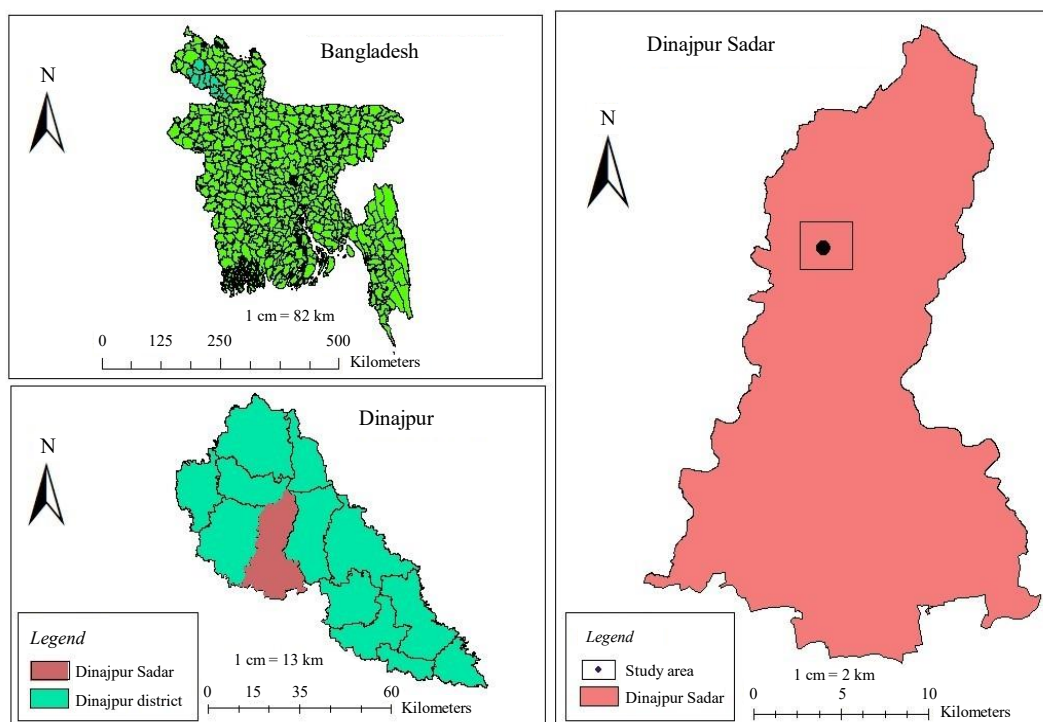


Figure 1. Study area in Dinajpur Sadar Upazila.

METHODOLOGY

Method of the Study

The entire study focuses on Dinajpur Sadar Upazila. The research method involves several steps, beginning with the selection of a sample size using random sampling. A survey is then conducted with farmers in the study area to evaluate their perceptions of the impact of rice mill pollution on crop productivity. Interviews are also held with local residents to understand how these pollutants affect their health. Additionally, government officials and health experts are interviewed to gather data on health-related issues caused by pollution. The findings of the analysis of the gathered data using a range of statistical techniques are presented in a variety of formats.

Methodology Procedures

A study conducted in Dinajpur Sadar Upazila selected nine rice mills randomly from a list of 365, with 104 participants, including rice mill workers and nearby residents. Data on environmental conditions, agricultural production, and human health were gathered at varying distances (0 m, 100 m, 500 m, and 1000 m) from the mills using a multi-stage random sampling method. The influence on the environment, agriculture, and human health was the emphasis of the dependent variables, whereas the independent variables comprised age, education, family size, farm size, gender, organizational engagement, annual income, and knowledge. Data analysis was performed using Excel and SPSS, and a 20-point knowledge scale and a 32-point attitude scale were used to assess respondents' perceptions. Similar research by Mannan et al. (2022) utilized structured questionnaires to evaluate community perceptions of rice mill pollution's impact [7]. Following data collection, a report was prepared based on the findings, employing arithmetic methods, statistical techniques, and Geographic Information Systems (GIS) for analysis. Tools like Microsoft Office and ArcMap 10.5 were used for data modeling, and the information was organized into texts and various forms of data. Various statistical tools, such as pie charts and bar diagrams, were used to present the results clearly. The data analysis focused on evaluating the effects of rice mills on the environment, agriculture, and human health, grouping respondents by their proximity to the mills. A scoring system from 0 to 48 was used to quantify health impacts, while scales measured attitudes and knowledge. Tables 1-6 and figures 1-6 were used to present the findings after the data was compiled using descriptive statistics including frequency, mean, and standard deviation.

RESULTS

Annual Income

From Table 1, the findings showed that while 26.92% of respondents had medium incomes, 23.08% had very high incomes, 11.54% had low incomes, and only 7.69% had very low incomes, the majority (30.77%) of respondents were in the high-income group. Higher income often motivates individuals to demonstrate integrity, achieve better performance, and enhance their social standing.

Organization Participation

The respondents' scores on organizational participation ranged from 1 to 20, with a possible range of 0 to 36. 13.87 was the average score, and the standard deviation was 4.50. Based on the observed scores, the respondents were divided into three groups: low participation (5–11), medium participation (12–18), and high participation (above 18). Table 2 shows the respondents' distribution based on how they participated in the organization.

Knowledge on Rice Mill

Table 3 presents respondents' knowledge scores on rice mills, which ranged from 4 to 19, with a mean of 12.92 and a standard deviation of 3.47. Respondents were categorized as having inadequate (4–9), moderate (10–15), or adequate knowledge (15+). Most had moderate knowledge (58.65%), followed by adequate (25.00%) and inadequate knowledge (16.35%). Similar findings in another study showed moderate knowledge (38.89%) as the largest category, followed by inadequate (31.11%).

Table 1. Distribution of respondents according to their annual income.

Categories	Respondent (%)	Range: (000 taka)		Mean	Standard deviation
		Min	Max		
Very low income (<15)	7.69	12	120	55.46	28.07
Low income (15–25)	11.54				
Medium income (26–50)	26.92				
High income (51–75)	30.77				
Very high income (>75)	23.08				
Total	100				

Table 2. Distribution of respondents according to their organizational participation.

Categories	Respondent (%)	Range: (000 taka)		Mean	Standard deviation
		Min	Max		
Low participation (5–11)	36.62	5	24	13.73	4.72
Medium participation (12–18)	46.15				
High participation (>18)	19.23				
Total	100				

Table 3. Distribution of respondents according to their knowledge on rice mill.

Categories	Respondent (%)	Mean	Standard deviation
Poor knowledge (4–9)	16.35	12.59	3.36
Moderate knowledge (10–15)	58.65		
Adequate knowledge (>15)	25.00		
Total	100		

Attitude Towards Rice Mill

Table 4 illustrates respondents' attitudes towards rice mills, with observed scores ranging from 8 to 30 out of a possible 0 to 32. The standard deviation was 5.94 and the mean score was 16.35. Respondents were categorized as having low (8–15), medium (16–23), or high favorable attitudes (above 23). Half (50.00%) exhibited low favorable attitudes, 34.62% had medium attitudes, and 15.38% showed high favorable attitudes. Similarly, HERA (2017) found 48.89% of workers demonstrated low favorable attitudes.

According to Table 1, the majority of respondents (30.77%) in this study were from high-income families, which supports honesty in achieving better performance and demonstrating one's own elevated social standing, but in Table 2, it was found that the largest percentage of study region respondents (46.15%) had medium organization participation, followed by low involvement (34.62%) and low participation (19.23%). Although the respondents knew a little bit about rice mills, it was not enough, as shown in Table 3. Increased organizational participation is necessary to enhance their knowledge and information about rice mills, which will help them reduce environmental pollution and protect themselves from health hazards.

Impact of Rice Mill Based on Distance

Based on self-reported information gathered through field surveys and interviews, the effects of rice mills on the environment, agriculture, and human health were evaluated at different distances (0 m, 100 m, 500 m, and 1000 m). Respondents provided opinion scores regarding crop productivity, environmental conditions, and health status. The scores ranged from 8–47 at 0 m, 9–47 at 100 m, 9–47 at 500 m, and 20–47 at 1000 m, within a potential range of 0–48, reflecting the perceived impact of rice mills. Respondents were categorized into three groups according to these scores: low impact (<20), medium impact (20–40), and high impact (>40). Figure 2 illustrates the distribution of respondents by their perceived level of rice mill impact.

Rice mill pollution impact on Crop Productivity

Rice mill pollution significantly affects crop productivity through dust and particulate matter settling on crops, which reduces photosynthesis by blocking sunlight. The impact varies with distance from the source, with areas closer to rice mills experiencing higher exposure to pollutants like dust, particulate matter, and chemical residues. These pollutants degrade soil quality, hinder plant growth, and lower crop yields. On the other hand, pollutant concentrations fall with increasing distance from the mill, reducing the effect on crops. Respondents' opinion scores regarding agricultural impacts ranged from 8–47 at 0 m, 9–47 at 100 m, 9–47 at 500 m, and 20–47 at 1000 m, within a possible range of 0–48. These scores categorized respondents into low (<20), medium (20–40), and high (>40) impact groups.

As illustrated in Figure 2, the current study shows that the largest percentage of participants (57.69% at 0 m from the rice mill) experienced a high impact on crop productivity, compared to 26.92% who reported a medium impact, and only 15.38% who faced a low impact. At a distance of 100 m, 46.15% of respondents experienced a high impact, 30.77% a medium impact, and 23.08% a low impact on agriculture. At 500 m, 38.46% of respondents reported a high impact, 34.62% a medium impact, and 26.92% a low impact. However, at 1000 m from the rice mill, the majority (42.31%) experienced a medium impact, 38.46% reported a low impact, and only 19.23% experienced a high impact on agriculture.

Table 4. Distribution of respondents according to their attitude towards rice mill.

Categories	Respondent (%)	Mean	Standard deviation
Low favorable attitude (8–15)	50.00	16.27	5.04
Moderate knowledge (16–23)	34.62		
Adequate knowledge (>23)	15.38		
Total	100		

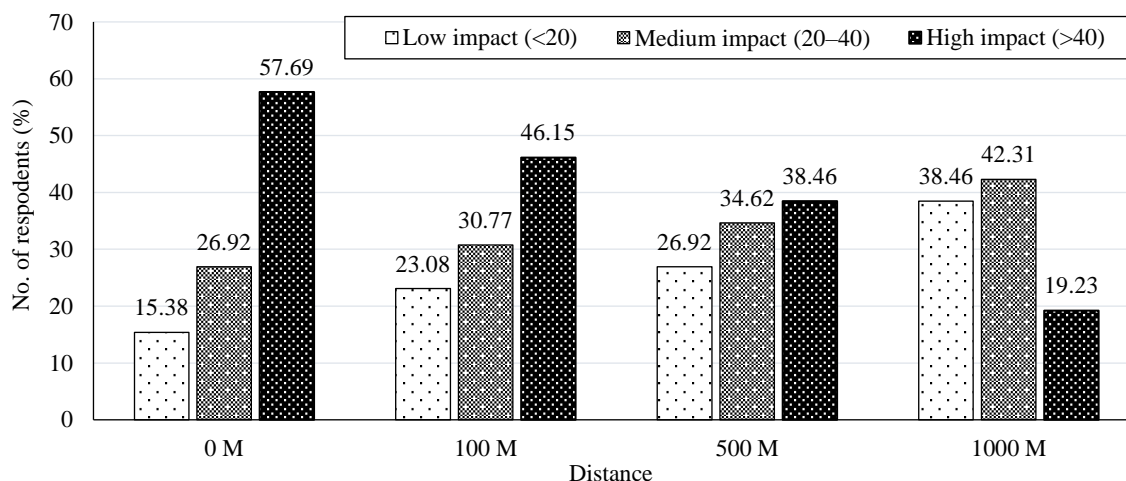


Figure 2. Distribution of respondents according to the impact of rice mill towards crop productivity at 0 m, 100 m, 500 m and 1000 m from rice mill.

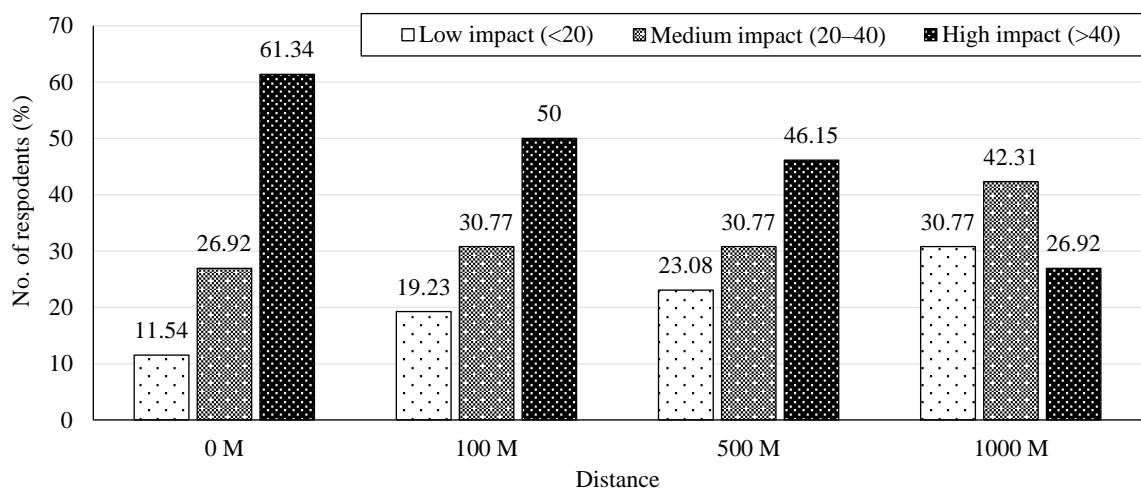


Figure 3. Distribution of respondents according to the impact of rice mill towards health at 0 m, 100 m, 500 m, and 1000 m from rice mill.

The data clearly demonstrate that the impact of rice mill pollution on agriculture decreases as the distance from the mill increases. The highest impact was observed at 0 m, while the lowest was at 1000 m from the rice mill.

Rice Mill Pollution Impacts on Health

The observed opinion scores on the impact of the rice mill on respondents at 0 m, 100 m, 500 m, and 1000 m distances were 8-47, 9-47, and 20-47, respectively, within a possible range of 0 to 48. The respondents' overall score indicates how the rice mill affected their health. Based on these scores, the respondents were split into three groups: low impact (scores >20), medium impact (20-40), and high impact (scores >40). The distribution of respondents by the impact of the rice mill on health is illustrated in Figure 3.

The survey found that the majority of respondents (61.34%) who lived 0 meters away from the rice mill experienced the highest health impact from it, with 26.92% reporting a medium impact and only 11.54% faced low impact of the rice mill towards health. At a distance of 100 m from the rice mill, half of the respondents (50.00%) reported experiencing a maximum impact on their health, while 30.77% experienced a medium impact and 19.23% reported a low impact. Conversely, at 500 m, the highest percentage of respondents (46.15%) faced a significant impact, with 30.77% reporting a medium impact

Table 5. Multiple linear regression model.

Independent variable		Dependent variable
Categories	Standard deviation	Health impacts scores
Income	28.07%	30.77%
Knowledge	4.72%	25
Attitude	3.36%	15.38
Participation	4.72	19.23

Table 6. Multiple linear regression of health impact score on distance, income, knowledge, attitude and organizational participation

Independent variables	Dependent variable: health impact score					
	Coefficient	Std. Dev	t-value	p-value	[95% CI]	
2.8	28.07 %	0.3	0.3	0.8	-139.9	-7.11
	4.72%				145.6	7.0
-0.1	3.36%	-0.1	-0.1	0.93	-139.9	-7.1
	4.72				145.6	7.0
Constant (Intercept)	0.3					
Model F	0.01					
Prob > F	0.93					
R ²	0.01					
Adjusted R ²	-1.0					
Observations	3					

and 23.08% experiencing a low impact on their health. At a distance of 1000 m from the rice mill, the majority of respondents (42.31%) reported a medium impact on their health, compared to 30.77% experienced a low impact and only 26.92% faced a high impact as shown in Table 5.

Multiple Linear Regression Model

The purpose of this analysis is to investigate how the independent variables relate to the dependent variable, the Health Impact Score. The regression equation is expressed as: $Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \epsilon$ Here, Y represents the dependent variable (Health Impact Score), X_1, X_2, X_3, X_4 denote the independent variables (Income, Knowledge, Attitude, and Participation), β_0 is the constant (intercept), $\beta_1, \beta_2, \beta_3, \beta_4$ are the regression coefficients, and ϵ refers to the error term as shown in Table 6.

Income evaluates financial status, categorized into Very Low (reference category), Low, Medium, High, and Very High. Knowledge assesses awareness levels, with Poor as the reference category, followed by Moderate and Adequate. Attitude captures perceptions of health impacts, categorized into Low Favorable (reference), Moderate, and Adequate. Participation measures organizational involvement, with Low as the reference, followed by Medium and High as shown on Figure 4. The outcome variable, Health Impact Score, reflects the health impacts attributed to various factors.

The regression analysis reveals that for Income, Low-income individuals have a coefficient of -139.9, a standard deviation of 28.07%, a t-value of -7.11, and a p-value of 0.93, indicating a statistically insignificant negative relationship as shown in Figure 5.

For Knowledge, individuals with Moderate knowledge show a coefficient of 145.6, a standard deviation of 4.72%, a t-value of 7.0, and a p-value of 0.01, suggesting a statistically significant positive effect on health impacts. Attitude for Moderate favorability yields a coefficient of -0.1, a standard deviation of 3.36%, a t-value of -0.1, and a p-value of 0.93, indicating no significant influence shown in Figure 6. Data for Participation is incomplete. The intercept coefficient is 0.3, though further statistical details are not provided.

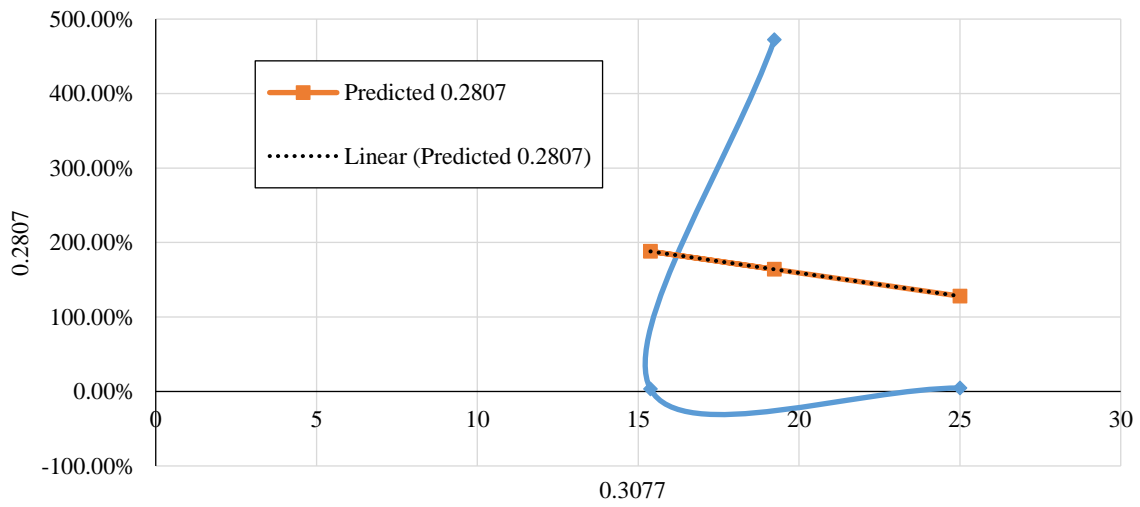


Figure 4. Line fit plot.

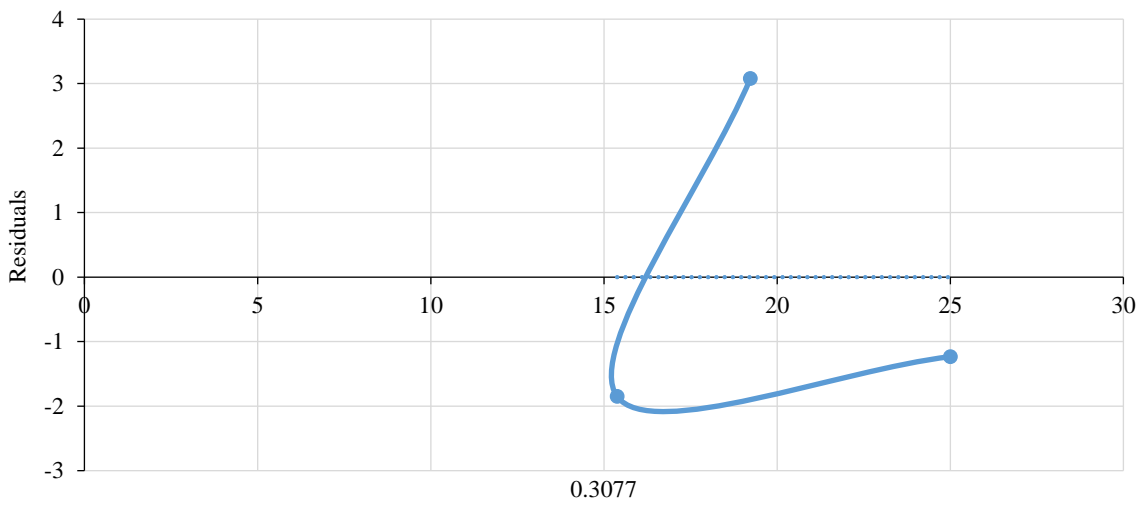


Figure 5. Residual Plot

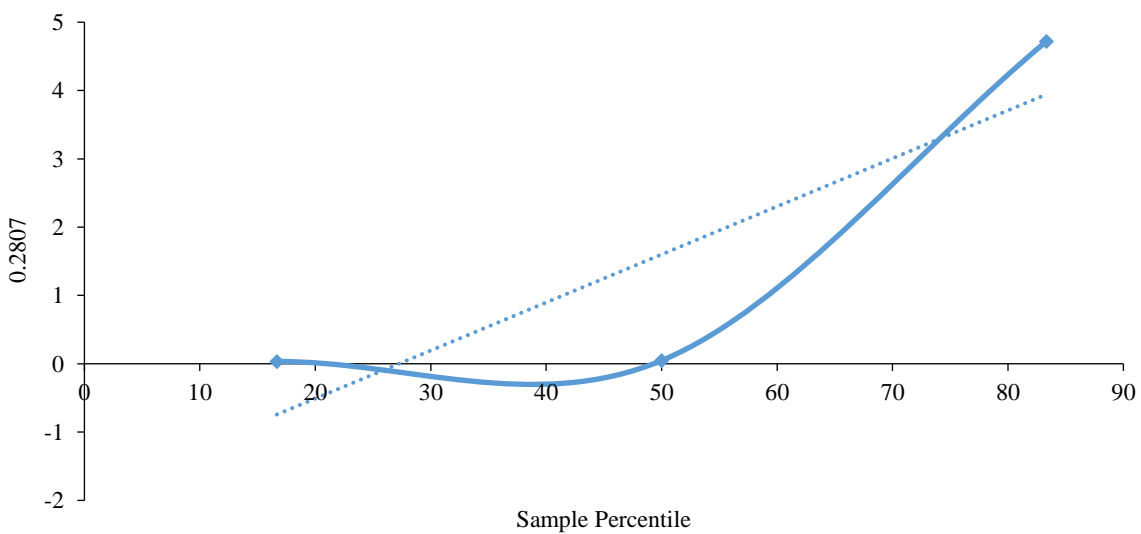


Figure 6. Normal probability plot.

The Health Impact Score's variance is just 1% explained by the model can be explained by the independent variables, as reflected by $R^2=0.01$, with an adjusted R^2 of -1.0, indicating poor model fit. The overall F-statistic is 0.01, with a p-value of 0.93, underscoring the model's lack of statistical significance. Based on the results, Knowledge emerges as the only significant variable, with a p-value below 0.05, indicating a positive relationship with health impact scores. Income and Attitude, however, do not show statistically significant relationships due to their higher p-values. The regression equation can be written as: $Y=0.3-139.9X_1+145.6X_2-0.1X_3$ In this equation, X_1 represents Low Income, taking the value 1 if applicable and 0 otherwise; X_2 represents Moderate Knowledge, assigned 1 if true and 0 otherwise; X_3 represents Moderate Attitude, where 1 indicates its presence and 0 otherwise. The analysis is constrained by the absence of data for Distance and Participation, which restricts the scope of the model. The low R^2 value further highlights the limited extent to which the independent variables may account for the variance in the dependent variable.

DISCUSSION

This study examined the environmental, agricultural, and health impacts of rice mill pollution in Dinajpur Sadar Upazila, Bangladesh. It found a significant correlation between rice mill pollution and factors such as income, knowledge, and attitudes of nearby communities. A linear regression analysis revealed a moderate positive association between health impact scores and these variables, although the results were not statistically significant due to a small sample size. The study's findings were consistent with prior research, which has documented respiratory and other health problems related to rice mill pollution. For example, Choudhury et al. (2023) and Mannan et al. (2022) reported respiratory issues and environmental concerns in regions near rice mills [6, 7]. This study further confirmed that communities within 500 meters of rice mills experienced more severe health and agricultural

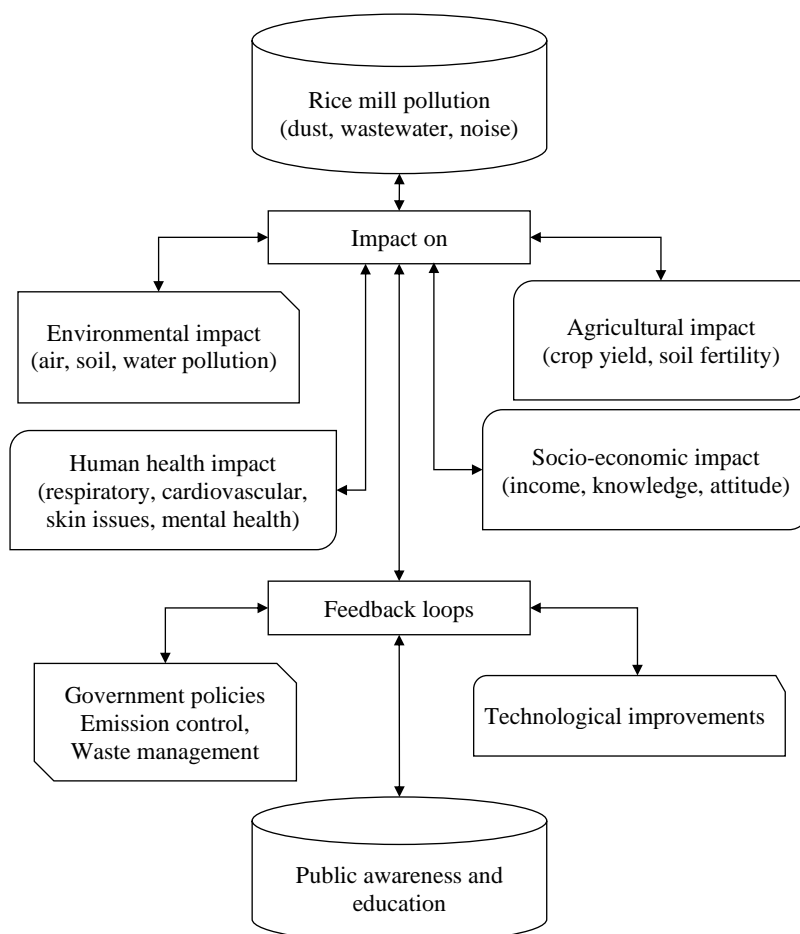


Figure 7. Conceptual model impact of rice mill pollution.

consequences. The study's results also supported the recommendations of previous research, such as those by Padhan and Sahu (2011), who suggested relocating rice mills away from residential and agricultural areas to reduce pollution's impact [8]. In line with this, the study found that health and productivity scores declined as the proximity to the mills decreased. This research emphasizes the importance of addressing the environmental and health risks posed by rice mills, particularly the pollution caused by particulate matter that disrupts photosynthesis and reduces crop productivity. The linear regression model indicated a link between health impacts and changes in income, knowledge, and attitudes, though this relationship requires further investigation with larger sample sizes for more definitive conclusions. For policymakers, the study highlights the need for stricter regulations on emissions, better waste management, and the establishment of buffer zones around mills. Additionally, public awareness campaigns are crucial to mitigate health risks in surrounding communities as shown in Figure 7. One key limitation of the study was the small sample size, which limited the statistical power and reliability of the findings. Additionally, the study used self-reported data, which could introduce biases. Future studies should examine the efficacy of pollution management methods and concentrate on long-term health effects, particularly chronic illnesses that are not immediately apparent. Validation and expansion of the findings would be aided by objective pollution measurements and a wider geographic scope. In the end, even though this study offers insightful information, more investigation is required to create more potent plans for reducing the hazards involved.

CONCLUSION

This study provides a comprehensive analysis of the environmental, agricultural, and health impacts of rice mill pollution in Dinajpur Sadar Upazila, Bangladesh. Through field surveys, interviews, and secondary data, it highlights the negative effects of rice mill pollution on local communities. Proximity to rice mills was found to correlate with increased pollution, which adversely affects crop productivity and public health. A linear regression analysis revealed a moderate positive relationship between health impacts and variations in income, knowledge, and attitudes, indicating that higher pollution levels contribute to greater social disparities. What sets this study apart is its holistic approach, examining not only health and environmental outcomes but also socio-economic factors like income and knowledge. The research uses statistical tools such as SPSS and GIS, adding to the growing body of knowledge on agro-industrial pollution in developing countries. Nevertheless, the study's shortcomings include its dependence on self-reported data, which could introduce biases, and its small sample size of three observations, which lowers the regression model's robustness.

Future studies should concentrate on how rice mill pollution affects people's health over the long run, especially chronic illnesses, and broaden their emphasis to include other parts of Bangladesh or comparable nations. Research evaluating pollution control measures, comparing traditional and automated milling technologies, and using objective pollution data will offer more reliable results. Additionally, exploring the role of public awareness in mitigating pollution impacts will help design effective interventions. In conclusion, further research with larger samples and better data collection methods is essential for developing strategies to mitigate the adverse effects of rice mill pollution on health, agriculture, and the environment.

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