ABSTRACT

A SOCIO-ECONOMIC STUDY ON ARSENICOSIS AFFECTED INHABITANTS IN MALDAH DISTRICT, WEST BENGAL

Introduction

Arsenic (As) concentration in groundwater is a significant environmental issue for the different parts of the Ganga basin. In 1984, groundwater arsenic contamination was detected in lower Ganga Plain of West Bengal (Garai et al., 1984). Maldah district is one of the worst Arsenic affected district of West Bengal and severe contaminated blocks of Maldah district are Kaliachak-I, Kaliachak-II, Kaliachak-III, Manickchak, English bazar Ratua-I, and Ratua-II, which have contained beyond the permissible limit of arsenic in groundwater (0.05 mg/ l, Indian standard). In these contaminated blocks, the maximum concentration level of Arsenic in a shallow tube well varies between 0.072 mg/l to 0.929 mg/l (Source: PHE, Maldah). The rest of the blocks contain an insignificant amount, i.e., the permissible limit of Arsenic in groundwater. Moreover, a considerable number of tube wells were contaminated with Arsenic. So, the Department of Public Health Engineering and the Government of West Bengal has arranged to supply Arsenic-free safe water to the Arsenic affected people. However, there are still many pockets in this district where no Arsenic-free safe water supply is available. Hence, extensive groundwater arsenic contamination has become a major issue of concern, where the water supply is profoundly reliant on groundwater (Madhuvan and Subramanian, 2006) extracted from the shallow aquifers. Common trace of Arsenic in drinking water causes significant health risk, and public health is severely endangered for its high toxicity and its ability to induce skin cancer after a long-term ingestion (Panigrahi, 2016), responsible for the socio-economic demolition. Arsenic pollution has been thought to be a menace for the population of Maldah district (Panigrahi, 2016) which is really of significant concern. Therefore, it is necessary to determine the causes and consequences of arsenicosis in Maldah district and to study the socio-economic conditions of the people suffering from arsenicosis. Present researcher has also tried to find out the suitable alternatives to overcome the problems of arsenicosis by estimating the public WTP (willingness to pay) for access arsenic-free safe water by installing the different arsenic free water supply sources across the

different Arsenic risk zones of the study area. Hence, the following **objectives** are sets for this purpose

1. To study the spatial distribution and causes of arsenic concentration in groundwater in Maldah district
2. To study the socio-economic status of the arsenicosis inhabitants in the study area
3. To study the socio-economic determinants of arsenicosis in the study area
4. To assess the impact of arsenicosis on the health and socio-economic condition of the inhabitants in the study area
5. To find out the present status of demand and supply of arsenic-free safe water in Maldah district
6. To suggest some remedial measures to overcome the problems of arsenicosis

The present studies try to prove the following research **hypothesis**, either true or false:

1. The prevalence of arsenicosis varies with some socio-economic determinants.
2. The impact of arsenicosis is related to some socio-economic variables.
3. Willingness to agree with mitigation strategies depends on the socio-economic condition of the respondents.

In order to full fill the mentioned objectives several **methodologies** have been used

A. The present study utilized both primary and secondary data sources. Primary data was collected from arsenic-affected areas within the study region, using a survey employing both schedule and questionnaire methods. The multi-stage random stratified sampling design was adopted to select a sample of households, with a sample size of 300 determined by using Cochran's method (Cochran, 1963).

B. The level of prevalence of arsenicosis patients was assessed using the Technique for order of preference by similarity to ideal solution (TOPSIS) (Hwang and Yoon, 1981). To examine the prevalence of respondents' knowledge (10), attitude (4), and practices (5) regarding arsenicosis, (19) criteria were considered. Then these criteria are categorized into two groups, beneficial and non-beneficial, and an equal weight (0.042) has been assigned to each criterion to rank the different dimensions. The Euclidean distance from ideal best (S^+) and ideal worst (S^-) has been calculated for each criterion. Finally, the performance score (Pi) of the level of their prevalence about arsenicosis was calculated, where a lower value indicates poor condition and a higher value indicates the good prevalence of arsenicosis.

C. The socio-economic and health impacts of arsenicosis are assessed using a scaling technique. Specifically, a five-point Likert scale is employed to collect data on individuals' perception levels of the impacts related to both arsenicosis illness and arsenic contamination. The Likert scale is also used to measure the social, economic, and health-related impacts, with scores assigned to each statement.

D. A self-created S.E.H.V.I (Socio-Economic Health Vulnerability Index) has prepared in chapter five (5) to measure the perception level of the respondents regarding the overall (social, economic, health) impact of arsenicosis. The respondents' perception level about the vulnerability in different domain (social, economic, health) can be assessed through Socio Economic Health Vulnerability Index (SEHVI). Analysis of these different vulnerability (social, economic, health) among arsenicosis patients in Maldah district highlights the socio-economic impact of arsenicosis. For this purpose, individual S.V.I (Social Vulnerability Index), E.V.I (Economic Vulnerability Index), and H.V.I (Health Vulnerability Index) have been prepared. Then social, economic, and health vulnerability scores have also been calculated through the scaling technique and consolidated efficiently through a Socio-Economic Health Vulnerability Index. Each vulnerability (social, economic, and health) is assessed at five stages. They are 1. Strongly disagree 2. Disagree 3. Neutral 4. Agree and 5. Strongly agree.

E. One-way ANCOVA is used to explore the relationship between each of the social, economic, health impact and a variable by measuring the effect of the socio-economic status of the arsenicosis inhabitants. Several independent socio-economic variables are selected for this analysis, including family size, age, household monthly income, and marital status. Social, economic, and health impacts are considered as the dependent variables.

F. Karl Pearson's product-moment coefficient of correlation was employed to assess the relationship between the indices of different hazard indexes, including the Social Hazard Index and Economic Hazard Index, Social Hazard Index and Health Hazard Index, and Economic Hazard Index and Health Hazard Index. The 't-test' technique was then used to determine the level of significance of the observed correlations.

G. A binary probit model was used to investigate the factors that may have influenced the respondents' willingness to pay for installing the community Arsenic-free water supply sources. Respondents' Willingness to Pay (WTP) was defined as a binary variable with two categories: zero and one. A response of 'zero' indicated that the respondent was unwilling to pay, while a response of 'one' indicated that the respondent was willing to pay. The dependent variable was the respondents' WTP, while the independent variables were the socio-economic factors that may influence people's WTP, including age, sex, marital status, number of years spent in formal education by the respondent, households' average monthly income, marital status, presence of PHED pipeline, identification of the danger level of 'As' in individuals' tube well, and inadequate stand posts. For testing the hypothesis, three tests, likelihood ratio test (-2 Log (Like.)), the Score test and the Wald test were performed.

The study has been arranged in to seven chapters. **Major findings** of the present research work are as follows

The study is organized into seven chapters, with the first chapter covering objectives, hypotheses, literature review, and methodologies. The second chapter focuses on the spatial distribution and causes of groundwater arsenic concentration in Maldah district. The study found that the regional and spatial distribution of arsenic concentration is not uniform, with the Diara and southwestern parts of the Tal region being more vulnerable. This heterogeneity is attributed to various geogenic factors, including geology, geomorphology, elevation, slope, characteristics of the river, and soil texture.

In the third chapter, the socio-economic status of the arsenicosis inhabitants in Maldah district is discussed. The findings suggest that the socio-economic status of these inhabitants is generally poor, with the illiterate, male, and aged (>40) respondents being more vulnerable to arsenic pollution than the female, young, and less educated inhabitants. The lack of an arsenic clinic in their village has also contributed to their suffering, with financial constraints, unawareness, and dissatisfaction with the treatment hindering their ability to seek proper care.

In the fourth chapter, the socio-economic determinants of arsenicosis were analyzed using TOPSIS method. The study found that demographic, social, and economic factors significantly influence arsenic toxicity. The key social and economic determinants of arsenicosis were identified as age, sex, education status, household income, poverty level, and health infrastructure. The prevalence level among the respondents was categorized into five classes based on the TOPSIS results, namely Very low (value <0.2), Low (value 0.2 - 0.3), Medium (value 0.3 - 0.4), High (value 0.4 -0.5), and Very High (value >0.5). To test the hypothesis that "the prevalence of arsenicosis varies with some socio-economic determinants," education status and household income were selected as the main social and economic determinants. A paired t-test was performed between the prevalence score and education status, and between the prevalence score and household income. The results showed that the prevalence of arsenicosis varies with the educational status and monthly household income of the respondents, with the corresponding two-tailed p-value being less than 0.05. Therefore, the research hypothesis is accepted, and it is concluded that the prevalence of arsenicosis varies with the educational status and monthly household income of respondents. This finding is significant as household income and literacy rates vary considerably across the study area.

In the fifth chapter, the impact of arsenicosis on the health and socio-economic condition of the inhabitants of Maldah district was evaluated. The Social Vulnerability Index (SVI), Economic Vulnerability Index (EVI), and Health Vulnerability Index (HVI) were calculated using a composite standard score. The highest mean vulnerability score of the high level of social vulnerability (0.65), high level of economic vulnerability (0.97), and high level of health vulnerability (0.78) suggested that respondents had experienced a high level of vulnerability in social, economic and health perspective. Arsenicosis had a significant impact on social, economic, and health condition, with only one or two indicators showing no significant influence from certain socio-economic variables. The respective 'F' statistics of these impacts were significant at a 95% significance level. Thus, the research hypothesis, "The impact of arsenicosis is related to some socio-economic variables," is accepted.

The sixth chapter delves into the current demand and supply status of arsenic-free water in the Maldah district. The existing arsenic-free water supply system in the study area is inadequate, and therefore, this chapter proposes remedial measures to overcome the problems of arsenicosis by estimating the public WTP for installing arsenic-free water supply technologies to acquire safe drinking water across different arsenic risk zones in the study area. The respondents' WTP was found to be heterogeneous and varied with their socio-economic characteristics. A significant relationship was observed between independent variables such as poverty level, family size, education status, etc., and WTP. The model was found to be statistically significant with a likelihood ratio chi-square of 286.288 and a p-value of 0.0001. The score test and Wald tests were also significant at a 95% confidence interval. Thus, the research hypothesis, "Willingness to agree with mitigation strategies depends on the socio-economic condition of the respondents," is accepted.

In the final chapter, a summary and policy implications are presented. The study highlights several **major problems** related to arsenic contamination and arsenicosis in Maldah district, including:

1. Despite the detection of high levels of arsenic in tube well water (above the permissible limit of 0.05 mg/L), many inhabitants continue to use contaminated water, leading to poisoning.
2. Lack of awareness about arsenic pollution has contributed to the increasing incidence of arsenicosis.
3. Poor health infrastructure, including the absence of arsenic clinics and irregular follow-up systems, has exacerbated the problem.
4. Arsenicosis sufferers have experienced numerous social and economic difficulties.
5. Victims of arsenicosis also suffer from various symptoms and severe health conditions.
6. Irregular supply of arsenic-free water through the Public Health Engineering Department (PHED) pipeline has impacted the inhabitants. Some individuals do not have access to any arsenic-free water sources.
7. The economic poverty of the inhabitants of arsenic-prone regions makes it challenging for them to purchase arsenic-free water regularly.
8. The long distance to arsenic-free water supply sources is another significant problem. It is time-consuming for the inhabitants to travel long distances to collect arsenic-free water.

These issues must be addressed through a combination of policy initiatives and public awareness campaigns to mitigate the adverse effects of arsenicosis and ensure safe drinking water for all. The following **recommendations** are proposed to address the socio-economic and health impacts of arsenicosis in Maldah district:

- Short-term solutions, such as providing safe arsenic-free drinking water and implementing low-cost arsenic removal technologies, can offer immediate relief to affected individuals. Regular testing of tube well water can also prevent long-term exposure to arsenic.
- Long-term approaches, including rainwater harvesting and surface water supply from rivers, ponds, and tanks, can help tackle the issue of arsenic contamination at the community level.
- Ensuring the effectiveness of arsenic removal plants and promoting collaboration between stakeholders can further enhance the success of these initiatives.
- Raising public awareness about the health risks of arsenic exposure and providing access to diagnosis, treatment, and counseling services can help improve the well-being of affected individuals and their families.
- Implementing health policies and education programs can foster positive behavior change and empower communities to address social discrimination and stigma associated with arsenicosis.
- Providing financial support, employment opportunities, and relief measures to affected families can help alleviate the economic burden of arsenicosis.

By implementing these measures, we can mitigate the negative impacts of arsenicosis and improve the overall health and well-being of the people of Maldah district.