RESEARCH PAPER | Economics | Volume : 4 | Issue : 5 | May 2014 | ISSN - 2249-555X

Estimation of Health Cost Due to Groundwater Arsenic Pollution in Jorhat District of Assam, India Using 3SLS

KEYWORDS: arsenic, groundwater pollution, health cost

Jayashree Chowdhury
Department of Economics, Handique Girls' College, Guwahati-781001, Assam, India

Ratul Mahanta
Department of Economics, Gauhati University, Guwahati-781014, Assam, India

ABSTRACT *Arsenic polluted water consumption has not only lead to serious health consequences but has significant economic impact on the society. The study tried to estimate the health cost due to the consumption of arsenic polluted water. The study comprised of 175 households from six villages of Titabar block in Jorhat district of Assam, India. The household production function approach and 3SLS method was used for this purpose It was found that a representative household would gain by Rs. 961 per month and Rs.11,532 per annum per household if the arsenic concentration level is reduced to permissible limit level of 50ppm.*

Introduction
Arsenic poisoning via groundwater has become a worldwide problem with 21 countries experiencing arsenic groundwater contamination (Perason et al., 2011). Arsenic is one of the most toxic and carcinogenic of all the natural groundwater contaminants. Chronic exposure to arsenic has been linked to carcinogenic effects in both humans and animals. These include cancer of the various skin and various internal organs (lung, bladder, liver and kidney) reproductive and developmental effects; cardiovascular disease. There are some claims that chronic exposure of arsenic may also cause diabetes development and prostate cancer (Naidu et al., 2006; Bramer et al., 2009 and George et al., 2013). Short term effect of arsenic contaminated water and food consumption are abdominal pain, changing in skin colour, vomiting, dryness in throat, thirst, convulsions, cramps, clammy sweat etc. (Thakur et al., 2013). Medical expenses associated with treatment costs of pollution-induced diseases, lost wages, defensive expenditures to prevent the occurrence of pollution induced-illnesses, disutility arising from the illness due to lost opportunities for leisure, and changes in life expectancy due to illness on exposure to pollution are all economically quantifiable aspects of environmental health (Dasgupta, 2004).

Among the Northeastern states of India, maximum level of arsenic has been reported in Jorhat, Lakhimpur, Nalbari, and Nagaon districts of Assam (Chakraborti et al., 2004). No work has been attempted to analyze its effects from the economic point of view from Northeastern pocket of India. In this study, attempts have been made to estimate the health cost due to groundwater arsenic pollution in the Jorhat district of Assam. The study has been designed to measure the economic affects afflicted by arsenic polluted water on the health of the residents in this district.

Methodology
Sample design:
Samples were collected from both primary and secondary sources. The sources of secondary data were pollution control board, Public Health Engineering Department, Govt. of Assam, Ministry of drinking water and sanitations, Govt. of India, etc. Primary data were collected based on questionnaires which was prepared keeping the specific objectives in mind. The multi stage sampling procedure was applied for the study.

Study area:
The study area for the present study encompasses six villages of the Jorhat district of Assam. Titabar in Jorhat had the highest number of arsenic affected habitations. Six villages (Mirigaon, Kharikatia grant, Abhaypuria, Tanti gaon, Mohinating grant and Defalating habi) from Titabar were selected and based on the concentration of arsenic as available from the secondary data, two villages each were chosen comprising high, moderate and low level of arsenic affected habitations. A total of 175 households were selected from Titabar block comprising of 50% of the households of each habitation. The duration of the survey was from July to September 2013.

The household health production function model comprising of a household health production function was used in the study. It also consists of household demand functions for extenuating and averting activities to estimate the health cost with respect to the concentration of arsenic in ground water. The Data analysis was conducted using the STATA to execute the 3SLS method. SPSS 16.0 was used for further household characteristics analysis.

Estimation of the Production and Demand functions
The Household Production Function Approach was used which involves a household health production function and a household demand function, for extenuating and averting activities. A simultaneous equation system consisting of three equations in three endogenous variables in terms of sick days, medical expenditure and averting expenditure was also considered.

The system of simultaneous equations with three equations in three endogenous variables is:

$$\ln Y_1 = \Sigma\beta_{1j}\ln X_{1j} + \Sigma\, \beta_{1j}\ln Y_{1j} + u_1 \text{ .... (1)}$$

$$\ln Y_2 = \Sigma\beta_{2j}\ln X_{2j} + \Sigma\, \beta_{2j}\ln Y_{2j} + u_2 \text{ .... (2)}$$

$$\ln Y_3 = \Sigma\beta_{3j}\ln X_{3j} + \Sigma\beta_{3j}\ln Y_{3j} + u_3 \text{ .... (3)}$$

Where Y and X shows the vector of endogenous and exogenous variables appearing in i (=1, 2, 3) equation. The explanatory variables in Y and X vector are shown by j. Equation 1 represents the household health production function expressing the health status given in terms of number of sick days in a household. Equations 2 and 3 represent household demand for adaptive expenditure and averting activity.

4.6 Estimation of the Health Cost from Arsenic contamination
The MWTP is estimated to obtain the health cost due to arsenic contamination using the following equation. The value is based on regression analysis.

Volume : 4 | Issue : 5 | May 2014 | ISSN - 2249-555X

$$Wc = MWTP = w\ \frac{\partial\ (sick\ days)}{\partial\ (exposure\ to\ arsenic)} + \frac{\partial (\ medical\ expenses)}{\partial\ (exposure\ to\ arsenic)} + \frac{\partial (\ averting\ activity)}{\partial\ (exposure\ to\ arsenic)} \ldots\ldots\ldots\ldots. (4)$$

$$Wc = MWTP = w\ \frac{\partial\ (msickd)}{\partial\ (hexpa)} + \frac{\partial (\ mmed\ exp)}{\partial\ (hexpa)} + \frac{\partial (\ avert)}{\partial\ (hexpa)}$$

Results and discussion

The empirical result of 175 household's basic characteristics surveyed in the Jorhat district was analyzed. The average age of the household surveyed was 47.76 years. The average monthly household income was observed to be Rs. 5438.29. The average monthly expenditure on food was Rs. 2128.57 and the average monthly expenditure was Rs.3514.29. The average family size, educational attainment and years of residing of each household were recorded to be 3.4, 5.9 and 35.9 respectively.

The average water consumption per day of each household was recorded to be 15.37 liters. The average monthly averting expenditure of each household was Rs. 53.14. Again the average number of sick days of each household tends to be 4.81 and the number of persons sick in a household is 2.27. The average monthly medical expenditure for each household was Rs. 275.54.

Information on educational status of the heads of each household recorded in terms of years of schooling revealed that 94(53.7 %) of the people had schooling up to 5 years. Again 56(32 %) of the people had 6-8 years of schooling, and 16(9.1%) had 8-10 years of schooling. Also only 8(4.6%), and 1(.6%) persons had 11-12 years and 13-15 years of schooling.

The study revealed a few preliminary symptoms like abdominal pain, hypertension, frequent fever among the respondent's family member, which might be the direct or indirect effect of exposure to arsenic. It was surprising to record that 70.3% households (123) were not aware of the presence or of arsenic in the source of water they used. Filtering is the common (70.6%) water treatment method while 19.4% household boiled the water before consumption.

Empirical estimation of production and demand function

The parameter estimates of the structural equations using 3SLS estimation was given in Table 1. The result implies that higher the income, the higher is the averting expenditure. Similarly, with the increase in education, the averting expenditure also increases. The estimate also shows that the medical expenditure increases positively with the increase in households' exposure to arsenic.

Table 1. Parameter Estimates of the Model

Equations/ Variables	Coefficient	Std Error	Z	P>|Z|
Variables				
Equation 1 (sickdays)				
Persick	-0.1629071	0.0990972	-1.64	0.100***
Avertexp	0.204965	0.2942313	0.70	0.486
Age	-0.708403	0.1758381	-4.03	0.000*
Expfood	-0.1352249	0.1881539	-0.72	0.472
HIS	-0.040059	0.030939	-1.29	0.195
Fmsize	0.1727599	0.0897308	1.93	0.054**
hexpoAs	-0.1991897	0.0734383	-2.71	0.007*
Hincome	-0.1479413	0.3267136	-0.45	0.651
Constant	6.872152	1.401033	4.91	0.000
Equation 2 (medical expenditure)				
Sickday	-0.4323	0.5349	-0.81	0.41
Avertexp	-.7676	.3737	-2.05	.04**
Expfood	-.1425	.1886	-.76	.45
Age	-.5228	.4093	-1.28	.20
HIS	.0055	.0310	.18	.85
Awrenss	.0002	.1004	.00	.99
hexpoAs	.3204	.0782	4.10	.00*
Hincome	.4525	.3460	1.31	.91
Constant	6.24	3.619	1.73	.08
Equation 3(averting expenditure)				
Sickday	.177	.15	1.16	.24
Medexp	-.419	.24	-1.65	.09
Awrenss	.011	.06	.16	.87
hexpoAs	.095	.133	.71	.47
Hincome	.58	.098	5.90	.00*
Education	.21	.098	2.13	.03**
Constant	-.014	1.32	-.01	.99

Source: Author's Estimates
***significant at 1% level,**significant at 5%level, ***significant at 10% level**

Table 2 shows the parameter estimates to arrive at the health cost. The first coefficient, used in estimating the health cost, i.e., the change in sickdays with changing arsenic concentration is statistically insignificant. Hence, we assumed its value to be zero. Thus it shows that the gain from a reduction in 1mg per litre of arsenic is Rs. 4.71 per household per month.

Table 2. Estimating Health Cost

Variables	Coefficients	t	Significance
Constant	-73.121	-.957	0.340
Sickdays in a month	-8.197	-1.310	0.192
Monthly medical expenditure	2.223	14.974	0.000
Monthly averting expenditure	2.488	3.268	0.001

The average of the arsenic level of the 6 villages in the Titabar block was found to be 253.75 ppm. The total health cost was determined by multiplying the cost of reduction in 1 mg per litre (Rs. 4.71) of arsenic with the excess arsenic level value (average level of arsenic in the study area minus permissible level of arsenic concentration), which was calculated out to be Rs. 960.84. Thus, if the arsenic concentration is reduced to permissible limit then the welfare gain to each household is Rs. 961 per month and Rs.11,532 per annum per household. Result of similar pattern was also observed

Volume : 4 | Issue : 5 | May 2014 | ISSN - 2249-555X

by Roy (2008) in her study in West Bengal, which showed an annual welfare gain of Rs. 3573.23.

Conclusion

The study aimed to find out the health cost from consumption of arsenic contaminated groundwater. It was found that the health cost of consumption of arsenic contaminated water in the selected villages of Jorhat turned out to be Rs. 961 per month per household and Rs.11,532 per annum per household. Thus the policy makers can take various steps to provide arsenic safe water to the masses and benefit them from various arsenic related diseases.

REFERENCE

Brammer, H. & Ravenscroft, P. (2009). Arsenic in groundwater: A threat to sustainable agriculture in south and south-east Asia. Environment International 35 : 647-654. | Census (2011). Census of India, Economic survey of Assam, 2011-12, Govt. of Assam. p7. | Chakraborti D., Sengupta M.K., Rahman M.M., Ahamed S., Chowdhury U.K. & Hossain, M.A. (2004). Groundwater arsenic contamination and its health effects in the Ganga-Meghna-Brahmapu¬tra plain. J Environ Monit. 6:74-83. | Dasgupta, P. (2004). Valuing Health Damages from water pollution in urban Delhi, India: A Health Production Function Approach. Environment and Development Economics 9:83-106. | George, C. M., Factor-Litvak, P., Khan, K., Islam, T., Singha, A., Moon-Howard., van Geen, A., and Graziano, J. H. (2013). Approaches to increase arsenic awareness in Bangladesh: An evaluation of an arsenic education program. Health Education & Behavior. 40(3): 331– 338. DOI: 10.1177/1090198112454735. | Pearson, M., Jones-Hughes, T., Whear, R., Cooper, C., Peters, J., Evans E.H., & Depledge, M. (2011). Are interventions to reduce the impact of arsenic contamination of groundwater on human health in developing countries effective?: a systematic review protocol. Environmental Evidence. 1:1-7. | Roy, J. (2008), Economic benefits of arsenic removal from Groundwater: A case study from West Bengal. India. Science of the total Environment 397, 1–12 | Naidu, R., Smith, E, Owens, G., Bhattacharya, P. & Nadebaum, P. (eds.) (2006). Managing arsenic in the environment. From soil to human health. CSIRO, Victoria, Australia. | Thakur, B. K., Vijaya Gupta, V. and & Chattopadhyay, U. (2013). Arsenic groundwater contamination related socio-economic problems in India: Issues and Challenges. pp.163-182. In: S. Nautiyal et al. (eds.), Knowledge Systems of Societies for Adaptation and Mitigation. of Impacts of Climate Change, Environmental Science and Engineering, DOI: 10.1007/978-3-642-36143-2_10, _ Springer-Verlag Berlin Heidelberg. | |