Effect of Arsenic contaminated ground water on the developmental phenomena of primary-school children in Assam

Ananta Kumar Jena, Munmi Barman, Somnath Gupta, Jaishree Devi, Satarupa Bhattacharjee and Sabina Yeasmin Barbhuiya

Department of Education, Assam University, Silchar 788 011, Assam, India

ABSTRACT

Cognitive development is a part of neuroscience related with development of human being. The study aimed to assess the effect of consumed arsenic contaminated ground water on the developmental aspects of children in Jorhat, Assam. In this case-control study, 225 primary school children from 20 schools of Jorhat, Assam, India, participated who consumed expected moderate and low levels of arsenic contaminated groundwater getting from tube well both inside and outside the school campus. The amount of arsenic present in the sample was determined through spectrophotometer and arsenic assessment kits. The complex relationship among the latent constructs and their behaviour influenced due to the effect of arsenic in the groundwater level was analyzed through path analysis by using AMOS version 21. It was resulted that there was a significant positive relationship between arsenic and the developmental phenomena of primary school children.

Introduction

The ground water status of Assam is out of imagination, students' performance also poor as compared to other states. Always, people of Assam have directly and indirectly consumed the ground water. Not only that rice consumes more water and absorbs more water and mineral those directly go to the body and mind. We assumed if people are consuming arsenic in most of the time then is there any affect of these on the cognitive development is a part of neuroscience related with working memory, inhibitory control, and cognitive flexibility of human. Arsenic affects the cognitive development and it directly affect the inhibitory control has a direct relationship with brain development could be stud-ied through brain imaging and mental chronometry (Houdé and Borst, 2014). In a study, It was found that the groundwater of Assam is alarming having heavy metals and unused minerals (Bhuyan, 2010). Not only that millions of people are suffering from diseases related to heavy metals (Chetia *et al.*, 2011) and the people of most part of the Assam are using low, medium and high arsenic contaminated water (Borah *et al.*, 2010). However, cognitive development of children has positive relation with environment, which affects the inhibition control, working memory, and cognitive flexibility (Jena *et al.*, 2019). Arsenic is available in the ground water of Assam those are verified and tested by the national and international agencies suggested to take precaution against the hazardous elements (Dutta, 2013). How-

ever, the distribution of fluoride has evidenced less concern with respect to environment and human health as the concentration is much lower than the prescribed tolerance level of WHO and BIS (Saikia, 2017). Moreover, awareness on community sanitation might be helpful to maintain environmental sustainability in Assam (Jena, 2018b). In addition, literature found that arsenic could damage the genetic structure and help to dysfunction the metabolic activity *(Wasserman et al.,* 2016). Arsenic exposure could result into cardio vascular diseases, brain inflammatory, and Alzheimer disease (Gong and O'Bryant, 2010). The consumption of arsenic damages the DNA and causes other related aspects of neurologic problems (Brinkel, *et al.,* 2009) but this will influence language acquisition, and logical reasoning, skills of pre-school (Jena, 2018a). In a recent studiy, it was found that Bangladesh is highly exposed to arsenic and it is negatively related to the performance and cognitive development of kids (Wasserman *et al.,* 2014). Most likely, the intellectual function of youngsters from exposure to Arsenic is severe (Wang, 2007). Not only that but also it was found that environmental factors are mostly responsible for the intellectual development of children (Jena and Paul, 2016).

Status of ground water in Assam

Hydro-geographically, Assam can be partitioned into three units such as specific combined development, semi united arrangement and unconsolidated development. More than 75% of the state is underlain by unconsolidated development embodying dirt, residue, sand, rock, stone, and rocks. The Bhabar belt is around 11 to 15 km wide; the tube wells yield 27 to 59 m³/hr in this zone. The Tarai zone takes after quickly down slant of the Bhabar zone where the yield of the wells ranges between 80-240 m³/hr. The surge fields take after the Tarai in Brahmaputra valley where the shallow tubewells yield between 20-50 m³/hr and profound tubewells between 150-240 m³/hr. In the semi merged arrangements of Cachar area, the yield of the tubewell ranges between 50 to 100 m³/hr. UNICEF discovered 18 areas of Assam has Arsenic sullying in ground water in and fluoride tainting in five districts. Based on data from Chief Engineer (PHE) of the State Government, a UNICEF study has discovered arsenic and fluoride defilement, Minister of State for Water Resources, Vincent H Pala said in a Rajya Sabha answer to an inquiry by Naznin Faruque. The regions influenced by arsenic pollution incorporate Baska (44 residences), Barpeta (119), Bongaigaon (47), Cachar (139), Darrang (105), Dhemaji (43), Dhubri (81), Goalpara (14), Golaghat (278) and Hailakandi (28), Jorhat (364), Karimganj (66), Morigaon (30), North Lakhimpur (54), Nagaon (one), Nalbari (238), Sivasagar (109) and Sonitpur (109).The five areas influenced by flouride defilement incorporate Golaghat (four homes), Karbi Anglong (140), Kamrup 36), Karimganj (three) and Nagaon (358). The ground water status of Assam is out of imagination and the people of Assam are consuming the ground water, directly and indirectly. Not only that rice consumes more water and absorbs water and mineral those directly go to the body and mind. Question is whether arsenic has relationship with the cognitive development of primary school children. If so then is there any relationship with arsenic and human growth and development aspects? We aimed to assess the effect of consumed arsenic contaminated ground water on the cognitive developmental phenomena of primary school children and it was assumed that there would be a significant positive relationship between the consumed arsenic contaminated ground water and the developmental phenomena of primary-school children.

Methodology

Study area

The study area, Jorhat is located in the north eastern region of Assam having DMS 26° 452 03 N, 94° 132 123 E. The total population of Jorhat according to 2011 census was 1,092,256 with density 380/km² (990/sq mi). In this case-control study, 225 primary school children from 20 schools of Jorhat, Assam, India, was the participants of the study who were continuously consumed arsenic contaminated ground water getting from tube well both inside and outside the school campus.

In Jorhat area, the arsenic level in the drinking water was 10 mg/d to 60 mg/d but in the average northeastern part of Assam is ranged from 0.10 µg/L to more than 100 µg/L. Before investigation, the consent was taken from the parents and the students of respected schools. In addition, a proper approval and suggestions was taken from the ethical committee of Assam University, Silchar to conduct the experiment.

Materials and Procedure

1) Arsenic kits

In most of the field testing, powdered zinc responded with the provided powdered structure to make a decreasing state of the water where arsenic diminished into arsine gas exposed to mercuric bromide to make arsenic-mercury halogenides. The shading change of range from yellow to darker depends on the amount of arsenic inside the water. An examination is framed against the shading on the testing strip with a shading scale gave inside the unit, to give a semi-quantitative estimation of the inorganic arsenic inside the water. The fluctuated units contrast in their introduction of the reagents (fluid, powder, or tablets), the type of the response vessel, the appearance of the response vessel top where the testing strip or the channel is embedded, and consequently the evacuation of the obstruction of sulfides. Two or three packs offer advanced readout of the shading range as opposed to the visual correlation. The unit is utilized to recognize the nearness of inorganic arsenic in water in fixation beginning from 10 to 500 ppb and from 10 to 4000 ppb after weakening with the weakening the estimating extent will become: 0, 35, 75, 175, 500, 1500, 4000 ppb.

2) Cognitive Development scale

This cognitive development scale was a standardized scale (Das and Jena, 2017) has six sub-areas was administered among the sample to assess the developmental phenomena of children who were exposed to arsenic. The memory aspects of the scale has five classes things for example listen perception, oral articulation, understanding cognizance, phonological preparing, and article naming staff things. In social-aptitude sub-scale, there are five sorts of things in regards to gathering, regard to instructors,

and method for living, submission, and companion bunch connection. The language obtaining sub scale has linguistic blunder, associational familiarity, and information about language, recognizing language mistake and embracing language. Sub-scale sensible thinking contains letter naming, word acknowledgment familiarity, and numerical investigation, knowledge about heading and knowledge about connection. Critical thinking scale is restricted with five zones like; receiving issue, geometrical information, thinking theoretical, numerical calculation, and control circumstance. Validity and reliability of the scale is .82 and .80 respectively. This cognitive development scale was administered at the end of all other experiment, and data was collected.

Data collection

In this case-control study, 225 primary school children from 20 schools of Jorhat, Assam, India, participated who were consumed groundwater getting from tube well both inside and outside the school campus. Ground water status of these areas was tested with arsenic kits to estimate the amount in ppb. The cognitive development scale was a standardized scale has six sub-areas was administered among the participants to assess their status of development who were exposed to arsenic. This cognitive development scale was administrated at the end of all other experiment, and the data were collected for final analysis and interpretation.

Analysis and results

We analyzed the complex relationship between the latent constructs and their behaviour influenced due to the effect of arsenic in the groundwater level consumed by 225 primary school students of Jorhat, Assam. We evaluated the initial model of arsenic (ppb) which included arsenic amount consumption in relation to the structural equation model of developmental condition of students. Model CMIN (NPAR 17, CMIN/DF 2.112 $p<.05$) and the baseline comparison (CFI .091 $p < .05$) was significant. Parsimony–adjusted measures model (PRATIO .476 and PNFI .044 $p< .05$) was significant. NCP (11.116 $p< .05$) was significant. FMIN model (.089 $p< .05$) and RMSEA (.068 $p< .05$), AIC model (55.116 and 56.146 $p< .05$), and ECVI (.232 is $< .05$) was significant. Thus, we obtained the final structural model that adequately explained the relationship among the latent constructs when formulating one exogenous and 4 endogenous variables (Figure 1). Arsenic

(ppb) was exogenous variable affected the factors of cognitive development phenomena of primary school children while the endogenous variables are explained by other constructs via structural equation model relationships. As shown here, arsenic (ppb) was significantly determined the relationship with memory (b .01 p< .001), social skills (b=.00, p<.05), language acquisition (b= -.02, p< .05), logical reasoning (b= .01, p< .05), and problem solving (b= .00, p< .05) while counting for R_1 of 14.61 in the memory construct, R_2 of 10.24 in the social skills construct, R_3 of 14.48 in the language acquisition construct, R_4 of 9.64 in the logical reasoning construct, and R_5 of 9.32 of problem solving construct. Additionally, arsenic ppb) and memory contributed the students with deterioration of memory and correlated positive experience (arsenic ppb/ memory reported path with p< 0.05). The path coefficient, illustrating correlation between the other constructs, showed significant influence between arsenic ppb/ social skill (b= .01, p<.001), arsenic ppb/ language

acquisition (b= -.02, p< .001) and arsenic ppb/ logical reasoning (b= .01, p< .001), and arsenic ppb/ problem solving (b= .00, p< .05). Therefore, arsenic has significant effects on the cognitive developmental phenomena of primary school students who were consuming arsenic contaminated tube well water in their schools as well in their home found positive relation with developmental aspects of children.

Results and Discussion

We claimed that there was a complex relationship between the exogenous and endogenous constructs. Since last five years, the primary school students of Jorhat have been consuming the ground water through their school tube well and it was found that there was a positive relationship between the consumption of Arsenic (ppb) and the developmental phenomenona of children. It was found that arsenic has direct relation as well as the predictor of the re-
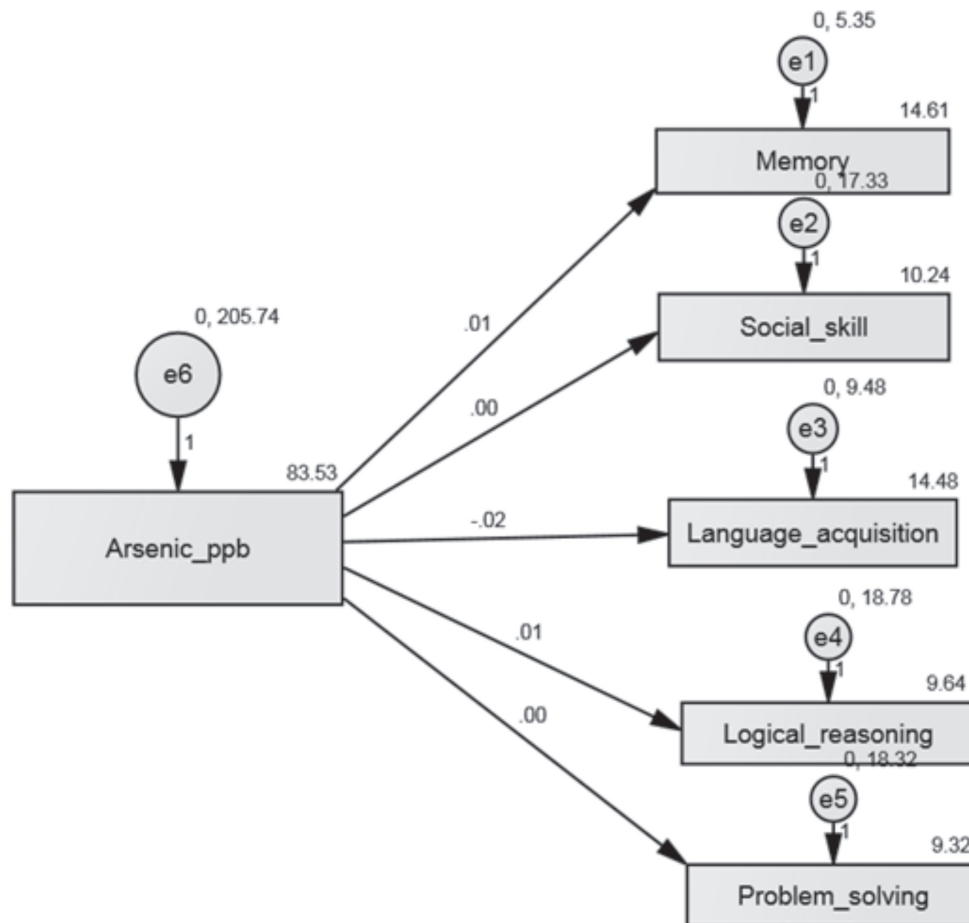

Fig. 1. Structural model of Arsenic(ppb) and the latent constructs of cognitive development phenomena

duced cognitive developmental phenomena of children. This result was supported by Bhuiyan, (2010); Borah *et al.*, (2010); Chetia *et al.*, (2011). Compared to other districts of Assam, the population of Jorhat is under the stress of contaminated ground water having unessential components. Nobody can imagine the impact of ground water on the physical development of different community starting from upper class to lower class people. However, the upper class people are purifying the water with available machines like Pureit, Kant, Aqua Guard etc. but still in different primary schools, there is no water purifying plant for the children. So it is important to take precaution from the suffering of arsenic effect. The result was (Evans *et al.,* 2010) found that there was a significant relationship with cognitive development and maternal responsiveness is important for cognitive development among children of 36-month-old. Similarly, gene and environmental transaction is the important factors of an early childhood cognitive development and parental cognitive stimulation (Tucker-Drob, 2012). However, contaminated ground water and cognitive development among the children of low-income families is low due to the reciprocal influences nutrition. A study conducted by Jabar and Cahan (2014) found that the schooling effects on cognitive development in a difficult environment. Browers *et al.,* (2006), conducted a study and found that schooling and everyday cognitive development among Kharaar children in India was interrelated. Solso, (1995) found that schooling is not a unitary process for cognitive development. Research on Piagetian studies of cognitive development in India found that the cognitive development only focuses on age related changes in cognition but the catch-up growth does not associate with the cognitive development in Indian school (Jena, 2016).

Conclusion

It was resulted that the primary school children of Jorhat were consuming arsenic contaminated water has significant relation and the determinant of the reduced rate of the developmental phenomena of primary school children. Moreover, people of the most of the part of Assam are exposed to Arsenic through contaminated drinking water, in food preparation and during irrigation and with the food crops. Now a day, farmers are continuously using pesticides in the agricultural land those are directly

exposed to drinking water causing cancer in the skin, lungs, bladders and kidney. However, arsenic can be removed from water by using water cooler with reverse osmosis including chemical precipitations and ion exchange process. But, lime softening, activated alumina, and reverse osmosis are not so much cost effective and therefore people should think and rethink about the natural remedies, the approaches to survive from the suffering (Deb, 2015).

References

Bhuyan, B. 2010. A study on arsenic and iron contamination of groundwater in three development blocks of Lakhimpur district, Assam, India. *Report and Opinion*. 2(6): 82-87.

Borah, K.K., Bhuyan, B. and Sarma, H.P. 2010. Lead, arsenic, fluoride, and iron contamination of drinking water in the tea garden belt of Darrang district, Assam, India. *Environmental Monitoring and Assessment*. 169(1-4): 347-352.

Brinkel, J., Khan, M. and Kraemer, A. 2009. A systematic review of arsenic exposure and its social and mental health effects with special reference to Bangladesh. *International Journal of Environmental Research and Public Health*. 6(5): 1609-1619.

Brouwers, S. A., Mishra, R. C., van de Vijver, Fons, J. R. 2006. Schooling and Everyday Cognitive Development among Kharwar Children in India: A Natural Experiment. *International Journal of Behavioral Development*. 30 (6): 559-567.

Chetia, M., Chatterjee, S., Banerjee, S., Nath, M.J., Singh, L., Srivastava, R.B. and Sarma, H.P. 2011. Groundwater arsenic contamination in Brahmaputra river basin: a water quality assessment in Golaghat (Assam), India. *Environmental Monitoring and Assessment*. 173(1-4): 371-385.

Das, J. and Jena, A.K. 2017. Cognitive Development Scale, Assam University, Silchar.

Deb, K.T. 2015. Arsenic Mitigation Processes on Trial and Tested in Barak Valley, Assam, India. *Int. J. Pharm Drug Anal*. 3(1): 12-18.

Dutta, J. 2013. Fluoride, arsenic and other heavy metals contamination of drinking water in the tea garden belt of Sonitpur district, Assam, India. *Int J Chem Tech Res*. 5(5): 2614-2622.

Evans, G. W., Ricciuti, H. N., Hope, S., Schoon, I., Bradley, R.t H., Corwyn, R. F. and Hazan, C. 2010. Crowding and Cognitive Development: The Mediating Role of Maternal Responsiveness among 36-Month-Old Children. *Environment and Behavior*. 42 (1): 135-148.

Gong, G. and O'Bryant, S.E. 2010. The arsenic exposure hypothesis for Alzheimer disease. *Alzheimer Disease & Associated Disorders*. 24(4): 311-316.

Houdé, O. and Borst, G. 2014. Measuring inhibitory control in children and adults: brain imaging and mental chronometry. *Frontiers in Psychology.* 5 : 616-625.

Jabr, D. and Cahan, S. 2014. Schooling Effects on Cognitive Development in a Difficult Environment: The Case of Refugee Camps in the West Bank *International Studies in Sociology of Education.* 24 (2): 165-188.

Jena,A.K. 2018a. Factors relating to Memory, Social Skill, Language Acquisition, Logical Reasoning, and Problem Solving Skills of Pre-school*. International Journal of Research in Teacher Education.* 9 (2): 36-50.

Jena, A.K. 2018b. Effects of Community Sanitation Program on the Awareness of Environmental Sustainability in Assam. *India. International Quarterly of Community health education.* 39(1): 51–61.

Jena, A.K. and Paul, B. 2016. Cognitive developmental phenomena of pre-school children in relation to socio-economic status, anthropometric status, and home environmental status. *Journal on Educational Psychology.* 10 (2): 25-38.

Jena,A.K., Das, J., Bhattacharjee,S., Gupta,S., Barman, M., Devi, J. and Debnath, R. 2019. Cognitive Development of Children in Relation to Inhibition Control, Working Memory, and Cognitive Flexibility. *Journal on Educational Psychology.* 3 (2): 29-48.

Saikia, P.P., Kotoky, P. and Goswami, U. 2017. Distribution of fluoride and arsenic contents in the ground water system, Jorhat District, Assam, India. *Int. J. Sci.*

Res. 6 : 844-847.

Solso, R.L. 1995. Images of mind: A window to the brain. *Behavioral and Brain Sciences.* 18 : 371-371. doi:10.1017/S0140525X00038966.

Tucker-Drob, E. M. and Harden, K.P. 2012. Early Childhood Cognitive Development and Parental Cognitive Stimulation: Evidence for Reciprocal Gene-Environment Transactions *Developmental Science.* 15 (2): 250-259.

Wang, S.X., Wang, Z.H., Cheng, X.T., Li, J., Sang, Z.P., Zhang, X.D., Han, L.L., Qiao, X.Y., Wu, Z.M. and Wang, Z.Q. 2007. Arsenic and fluoride exposure in drinking water: children's IQ and growth in Shanyin county, Shanxi province, China. *Environmental Health Perspectives.* 115(4): 643-647.

Wasserman, G.A., Liu, X., LoIacono, N.J., Kline, J., Factor-Litvak, P., van Geen, A., Mey, J.L., Levy, D., Abramson, R., Schwartz, A. and Graziano, J.H. 2014. A cross-sectional study of well water arsenic and child IQ in Maine schoolchildren. *Environmental Health.* 13(1): 1-10.

Wasserman, G.A., Liu, X., Parvez, F., Factor-Litvak, P., Kline, J., Siddique, A.B., Shahriar, H., Uddin, M.N., van Geen, A., Mey, J.L. and Balac, O. 2015. Child intelligence and reductions in water arsenic and manganese: a two-year follow-up study in Bangladesh. *Environmental Health Perspectives.* 124(7): 1114-1120.