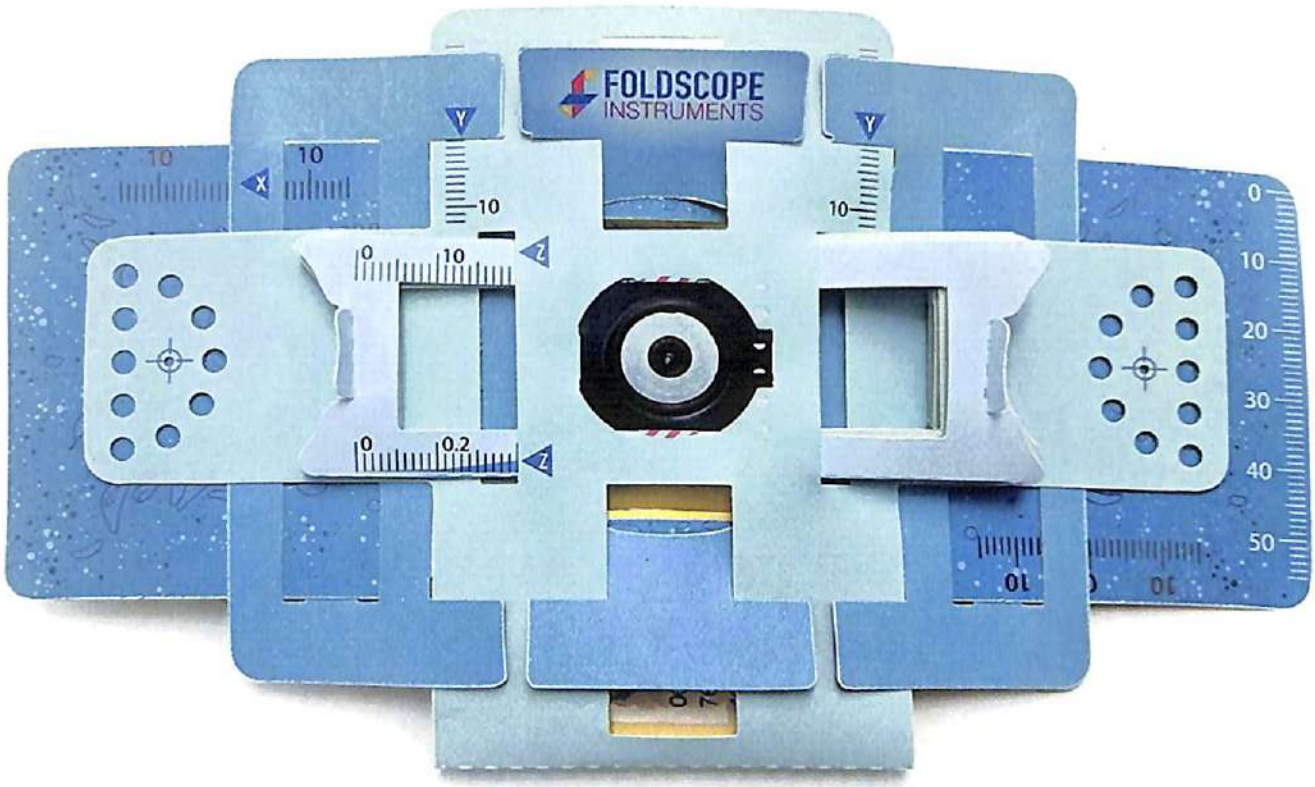
FOLDSCOPE AND ITS APPLICATIONS



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PREFACE

A Foldscope, a low-cost science tool, is an optical microscope that can be assembled from simple components, including a sheet of paper and a lens. It was developed by Dr. Manu Prakash and designed to cost less than US$1 to build. It is part of the "frugal science" movement which aims to make cheap and easy tools available for scientific use in the developing world. The Department of Biotechnology (DBT), Government of India and the Prakash Lab at Stanford University, USA signed an agreement to bring the Foldscope to India to encourage curiosity in science. It is being used as a teaching tool for the students in biology, chemistry, physics and many other streams. Keeping these facts in the background, the editors and authors of the book have tried to compile their research and review outlook about Foldscope usage and its various applications. The aim of this book is to facilitate the adoption of Foldscope as an educational and research tool by students, teachers, scholars, scientists and the general people. Many authors who are also Project Investigators and recipients of the Foldscope research grant acknowledge Department of Biotechnology, Government of India. The authors hope that this book will not only provide pleasant reading but also practical knowledge which can be utilized by the user of this book in the area of Foldscope microscopy.

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CONTENTS

A FOLDSCOPIC STUDY OF ARSENIC RESISTANCE BACTERIA IN GROUNDWATER SAMPLES OF LAKHIMPUR, ASSAM (INDIA)

Mridul Buragohain

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Abstract

Arsenic pollution in our ecosystem is nowadays a severe risk effecting to human population. Millions of people across the globe unknowingly depends on arsenic contaminated groundwater for drinking purpose and facing serious health hazards. The groundwater is known to be contaminated from different xenobiotic and anthropogenic sources leading to fatal diseases as cancer and skin lesions. Arsenic in the form of arsenate (IV) and arsenite As (III) is toxic in water sources. Presence of microbial biome such as E. coli, Pseudomonas, and Actinobacter helps to reduce the arsenic in ground water. Microscope provides a beneficial instrument for visualization of bacteria. Instead of that, Foldscope- an origami based low cost paper fold microscope provides to visualize such bacteria in water samples at instant. This study mainly focused on the application of Foldscope for investigating gram stained and arsenic resistance bacteria of different ground water sources, where foldscopic images were obtained.

Keywords: groundwater, gram stained and arsenic resistance bacteria, foldscopic view, etc.

Introduction

Rising of urbanization, industrial pollution, burning of fossil fuels elevated the range of arsenic in the biosphere. Concentration of arsenic is found to be high in rainfall thus troubles to groundwater. In Asian countries including India arsenic polluted groundwater is being used for drinking and irrigation[1]. Estimation of fifty million populations in Bangladesh depends on arsenic contaminated tube wells and suffering from severe chronic diseases including cancer[2]. Dissolution of Fe, Mn oxyhydroxide, $NaHCO_3$, DOC and high pH are the main factor of As mobilization in ground water[3]. Elevated form of arsenic in water sources results in a stress livelihood to a society including poverty and a drop of agricultural products[4]. Volcanic eruption and hydrothermal sources cause a major role in arsenic contamination to the environment[5]. In most districts of West Bengal(India), it was reported that water used for drinking and agricultural purpose were elevatedly affected by arsenic. A positive correlation of arsenic concentration between soil and water was also seen[6]. To equalized the arsenic contamination, arsenic resistance gene of bacterial species are found to remain associated with ars operon. These moiety are As(III) genes responsive regulation on (ArsR), As(III) efflux permease (ArsB or ACR3) that expel As (III) from the cell[7]. Bas1 and Bas2 two bacterial strains isolated that can convert the toxin As (III) to non toxic As (V) and is reported to be used in bioremediation process[8] . *Bacillus* species BAR1 was also isolated from arsenic polluted groundwater which reported to be resistant to arsenic and also resitance to other Cu, Cd, Ni, Hg, Zn heavy metals.[9] *Pseudomonas, Bacillus, Psychrobacter, Enterobacter, Vibrio* show a elevated resistance capacity for As with a minimum inhibitory concentration from 2-200Mm [10]. A study in Hetao plain, Inner Mongolia reflected the presence of Pseudomonas and Acinetobacter in a dominated pause of both high and low As groundwater[11]. High As resistant bacterial strains- *Actinobacteria, Microbacterium, Pseudomonas and Rhizobium* were localized in ground water of West Bengal (India) showing minimum inhibitory concentration of about > 10 mM[12]. Arsenate reductase activity is seen to be influenced by *Agrobacterium, Achromobacter, Rhizobium, Ochrobactrum* starins isolated from arsenic contaminated groundwater of West Bengal (India)[13].

Arsenic release in environments occurs due to weathering of rocks, minerals (arsenopyrite) and anthropogenic sources. Mobilization of arsenic in ecosystem is influenced by hydrogeochemical reactions, and redox reactions carried by potential micro biomes. Elevated form of arsenic is found with high concentration of Fe oxide and pyrites[4]. Sulphate and iron reduction isolates *Deltaproteobacteria, Nitrospirae* were found positive in arsenic mobilization[14]. Phosphatase and siderophores play a crucial role in release of As (V) and As (III) is reduced by arsenate reductase to mobilize arsenic in groundwater[13]. Oxalic acid assemblance and As (V) reductase of *Brevundimonas, Flavobacterium, , Rhodococcus, Methyloversatilis, Methylotener, Pseudomonas* and *Polaromonas a* lead to mobilized arsenic in wide range[15]. *Acidovorax, Acinetobacter, Bosea, Bacillus, Brevundimonas,*

Caulobacter Herbaspirillum, Pseudomonas, Staphylococcus, Ralstonia,Rhizobiales, Rhodococcu, Undibacterium found to used the carbon source and grow chemolithotropically enhancing the arsenic mobilization in groundwater[16]. PO4 $^{3-}$, SO_4^{2-}, HCO_3^-, carbonate dissolution and Fe-oxyhydroxides important factor of reduction influences mobilization of arsenic[17]. Arsenic contamination in groundwater is geogenic and may triggered by Fe (III) oxides and sulphide oxidation[18].

Increasing of anthropogenic and xenobiotic activities by human, arsenic contamination in groundwater is now in elevated form. Infectious health hazards is a stressed for human population that depends mainly on natural water sources. Arsenicosis- nearby uncurable disease includes skin lesions, cancer in lungs , liver, urine and kidney is nowadays a serious issue to humans[19]. Mee lines symptom is mostly occurable in fingernails due to arsenic toxicity resulting in various cardiovascular diseases. Diabetes and pregnancy outcomes such as child mortality is an another cause factor of arsenic toxicity in drinking water. High arsenic exposure to drinking water also leads to chronic respiratory problems such as cough, breathing problem etc. Contaminated arsenic water used for irrigation purpose is passed to our nutritional crops. Cattles feeding on arsenic pollued water sources face a vulnerable death.

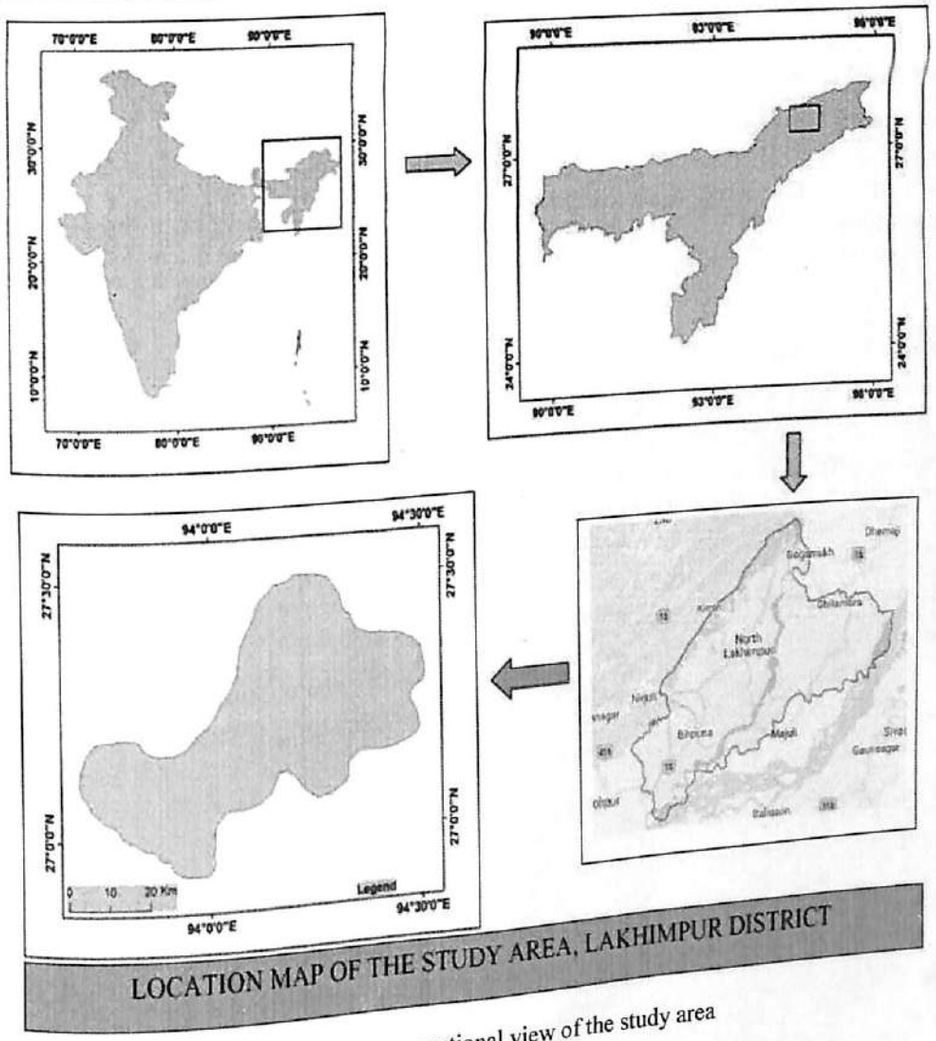
Materials and Methods

A. ***Profile of the study area***

Lakhimpur district (Fig. 1) lies on the North East corner of Assam and at the North Bank of the mighty river Brahmaputra. The district lies between 27.597' Northern latitude and 94.737' Eastern longitude and covers an area of 2277 Sq km out of which 2257 Sq km is rural and 20 sq km is urban. It is bounded on the North by Siang and Papumpare District of Arunachal Pradesh and on the East by Dhemaji District and Subansiri River. The river Brahmaputra along with Majuli district stands on the southern side and Gahpur sub division of Biswanath district is on the West. The area is characterized by a temperature range of 24°C-33°C and with an average humidity of 82%. The annual rainfall of the district is 1551.3 mm per year[23].

B. ***About Foldscope***

A Foldscope is an optical microscope (Fig. 2) which is very easy and affordable for mankind. The Foldscope was developed by a team led by Manu Prakash and his student Jim Cybulski from Stanford University, USA[20]. It is a part of the "frugal science" movement which aims to make cheap and easy tools available for scientific use in the developing world[21]. It can be assembled from a punched sheet of cardstock, a spherical glass lens, a light emitting diode and a diffuser panel, along with a watch battery that powers the LED[22].The idea of creating a low-cost microscope using simple parts struck to Manu Prakash in 2011, when he was having a scientific visit to a field station in Thailand. There, he observed that though expensive microscopes were available in the station, people seldomly used them and were afraid of or apprehended that this costly equipment might go bad or broken by their mistakes or mishandlings. It made Manu Prakash think to create a cheap, affordable and versatile device which was sturdy enough to be used in field conditions and people should not have a hitch to use it. He also thought to supply the Foldscope in form of an easy to assemble kit so that people can assemble it themselves. Foldscope can be assembled from a punched sheet of cardstock, a spherical glass lens, a light emitting diode and a diffuser panel, along with a watch battery that powers the LED[22]. Once assembled, the Foldscope is about the size of a bookmark. Its weighs about 8 grams and comes in a kit with multiple lenses that provide magnification from 140X to 2,000X. The kit also includes magnets that can be stuck onto the Foldscope to attach it to a smart phone, which allow the user to take pictures of the magnification[21].



LOCATION MAP OF THE STUDY AREA, LAKHIMPUR DISTRICT

Fig. 1: A cross sectional view of the study area

Fig. 2: Front view of Foldscope

C. ***Sample Collection and Gram's staining***

Water samples were collected from groundwater of different locality of Lakhimpur district, Assam. The samples were smeared in sterilized slides and further processed for gram staining.

D. ***Estimation of Arsenic concentration in watersamples***

Arsenic concentration in the water samples was analyzed by atomic absorption spectrophotometer (model-'240AA by Agilent Technologies').

E. ***Isolation of arsenic resistance bacteria***

About 1ml water samples were spread on nutrient agar plates that contain 5mM As (V), 1mM As (III), for the isolation of arsenic-resistant bacteria. After 24 h of incubation at 37 0 C the growth of bacteria was observed. Individual colonies were picked and streaked on fresh nutrient agar medium and discrete colonies were picked up and were preserved at 4°C on nutrient agar slants.

Results

A. ***Isolation of bacteria***

A total of 10th bacterial strains were isolated from water samples based on their abilities to grow in the

presence of 5mM As (V), 1mM As (III) in the medium. The cultures showing substantial growth were transferred to fresh medium. After three more transfers, discrete colonies were picked up and were preserved at 4 0C on nutrient agar slants. Out of 10^{th} isolates, among one of them GB-18 was (0.86 ± 0.04) highest growth found on acetate minimal mediumsupplement with arsenate and arsenite in one week incubation periods. This isolate was chosen for further study.

B. ***Foldscopic images of Isolated of bacteria***

Foldscopic view of Gram staining (+ ve & - ve) and Arsenic resistance bacteria are given in figure 3 and 4.

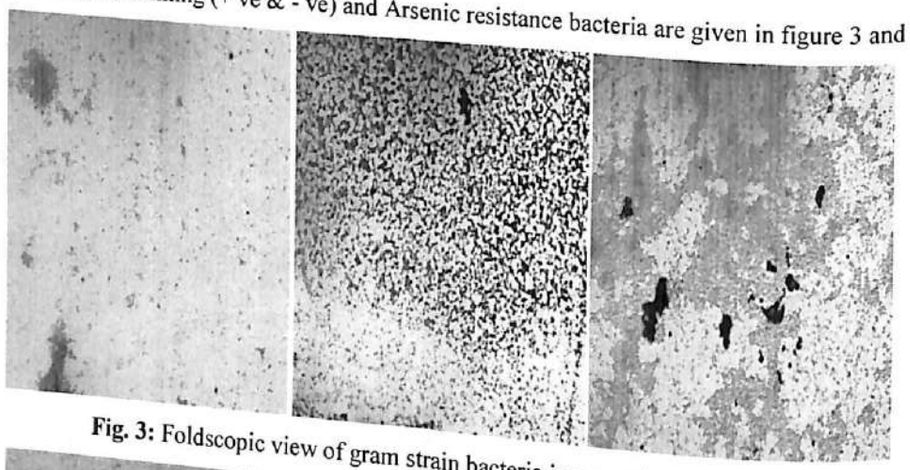


Fig. 3: Foldscopic view of gram strain bacteria in groundwater samples

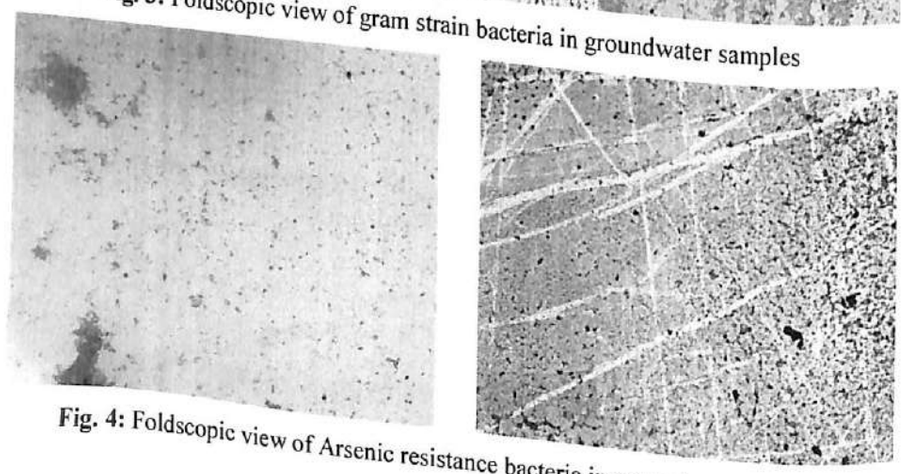


Fig. 4: Foldscopic view of Arsenic resistance bacteria in groundwater samples

Conclusion

Foldscope is a brilliant innovation.It paves ways for other such innovations for replacement of costly scientific instruments. Scientists like Manu Prakash have shown that simple and affordable scientific devices can be designed, was fabricated for the use of common masses and can be made available in the remotest part of the world for scientific exploration which is very very easy, useful and affordable for all mankind. Application of this low-cost microscopy technology to a different domain of microscopic study would help people to better understanding microscopic world around us including microorganisms and micro- structure.

The present study shows a marvelous view regarding the easy handling of Foldscope. The comparative microscopic (10X) and foldscopic view (140X) marks no difference in visualization of the samples. The study reported that uses of Foldscope are one of the cheapest and easiest technology in visualization of bacteria present in water samples. Foldscope is an advanced technology developed in microscopic world that will help the people to understand the microscopic world troublessly.

Acknowledgement

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References

1. Chakrabarti. D, Singh S.K, Rashid Md. H, Rahman M.M, (2017): Arsenic: Occurrence in groundwater, Encyclopedia of Environmental Health, Elsevier https://doi.org/10.1016/B978-0-12-409548-9.10634-7
2. Ahmad S.A, Khan M.H, Haque M, (2018): Arsenic contamination in groundwater in Bangladesh: implications and challenges for healthcare policy, Risk Management and Healthcare Policy. pp 251-261; https://doi.org/10.2147/RMHP.S153188.
3. Anwar M.H, Akai J, Komaki K, Terao H, Yoshioka T, Ishizuka T, Safiullah S, Kato K (2003): Geochemical occurrence of arsenic in groundwater of Bangladesh: sources and mobilization process (2003) , Journal of Geochemical Exploration, Elsevier. pp 109-131 https://doi.org/10.1016/S0375-6742(02)00273-X.
4. Shankar S, Shankar U, Shikha (2014): Arsenic contamination of Groundwater : A review of sources, prevelance, health risks and strategies for Mitigation, The Scientific World Journal, https://doi.org/10.1155/2014/304524.
5. Dhuldhaj U.P, Yadav I.C, Singh S, Sharma N.K, (2013): Microbial Interactions in the Arsenic Cycle: Adoptive Strategies and Applications in Environmental Management, Review of Environmental Contamination and Toxicology, https://doi.org/10.1007/978-1-4614-5882-1_1.
6. Shrivastava A, Barla A, Yadav H, Bose S (2014): Arsenic contamination in shallow groundwater and agricultural soil of Chakdaha block, West Bengal, India, Frontiers in Environmental Science, https://doi.org/10.3389/fenvs. 2014.00050.
7. Yang H.C, Rosen B.P, (2015): New Mechanisms of bacterial arsenic resistance, Biomedical Journal, pp 5-13, https://doi.org/10.1016/j.bj.2015.08.003.
8. Biswas R, Sarkar A, (2018): Characterization of arsenite-oxidizing bacteria to decipher their role in arsenic bioremediation, Preparative Biochemistry and Biotechnology, https://doi.org/10.1080/10826068.2018.1476883
9. Biswas R, Majhi A.K, Sarkar A (2019): The role of arsenate reducing bacteria for their prospective application in arsenic contaminated groundwater aquifer system, Biocatalysis and Agricultural Biotechnology, Elsevier, https://doi.org/10.1016/j.bcab.2019.101218
10. Liao V H, Chu Y et.al. (2011): Arsenite-oxidizing and arsenate-reducing bacteria associated with arsenic rich groundwater in Taiwan, Elsevier, https://doi.org/10.1016/j.jconhyd.2010.12.003
11. Wang Y, Lil P et.al. (2016): Microbial community of high arsenic groundwater in agricultural irrigation area of Hetao plain, Inner Mongolia, Frontiers in Microbiology, https://doi.org/10.3389/fmicb.2016.01917
12. Paul D, Poddar S, Sar P (2014): Characterization of arsenite-oxidizing bacteria isolated from arsenic-contaminated groundwater of West Bengal, Journal of Environmental Science and Health, https://doi.org/ 10.1080/10934529.2014.937162
13. Sarkar A, Kazy S. K, Sar P (2013): Characterization of arsenic resistant bacteria from arsenic rich groundwater of West Bengal, India, Ecotoxicology, https://doi.org/10.1007/s10646-012-1031-z
14. R.E Danczak, M D Johnston, C Kenah, M Slattery, M J Wilkins (2019): Capability for arsenic mobilization in groundwater is distributed across broad phylogenetic lineages, Plos one, https://doi.org/10.1371/journal.pone.0221694.
15. D Paul , S K Kazy , A K Gupta , T Pal , P Sar (2015): Diversity, Metabolic Properties and Arsenic Mobilization Potential of Indigenous Bacteria in Arsenic Contaminated Groundwater of West Bengal, India, Plos one, https://doi.org/ 10.1371/journal.pone.0118735.

16. G Soma, S Pinaki (2013): Identification and characterization of metabolic properties of bacterial populations recovered from arsenic contaminated ground water of North East India (Assam), Water research, Elsevier, pp 6992-7005, https://doi.org/10.1016/j.watres.2013.08.044.

17. S Bhowmick, B Nath et.al. (2012): Arsenic mobilization in the aquifers of three physiographic settings of West Bengal, India: Understanding geogenic and anthropogenic influences, Journal of Hazardous Materials, Elsevier, https://doi.org/10.1016/j.jhazmat.2012.07.014.

18. H Indika, V Meththika et.al. (2016): Natural Arsenic in Global Groundwaters: Distribution and Geochemical Triggers for Mobilization, Current Pollution Reports, Springer, https://doi.org/ 10.1007/s40726-016-0028-2.

19. Shankar S, Shanker U, Shikha (2014): Arsenic Contamination of Groundwater: A Review of Sources, Prevalence, Health Risks, and Strategies for Mitigation, The Scientific World Journal, https://doi.org/10.1155/2014/304524.

20. Coxworth, Ben;"Folding paper microscope could reduce deaths from malaria". Gizmag. Retrieved 13 March 2014.

21. "A Microscope to Save the World". The New Yorker. Retrieved 2015-12-22.

22. Mathews, Lee (11 March 2014): "Foldscope is a 50-cent paper microscope that magnifies up to 2000 times". Geek.com. Retrieved 13 March 2014.

23. Statistical Hand book, Assam (2017) Directorate of Economics and Statistics, Govt. of Assam, Guwahati-28

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