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Utility of Foldscope in Biological Research

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Abstract

The foldscope is an origami portable and affordable microscope that can be used as a high-end frugal technology for teaching science. Our local environment is fulfilling with various microorganisms which affect our community. It is impossible to identify them at the spot without sampling in laboratory. However, this can be done in spot with the help of a foldscope. The aim of this study was to isolation bacteria from arsenic contaminaed sites of Lakhimpur districts, Assam. The study estimated that arsenic concentration in water samples of the study area found higher by (0.26±0.04mg/L) than the permissible limit as prescribed by WHO. Total 10th morphologically completely different arsenic resistant bacteria isolated from water samples bacterial cultures were observed by performing staining at various time intervals. The slide was placed in the foldscope interfaced with a mobile phone. After staining the cells were observed under foldscope and recorded the images.

Keywords: foldscope; arsenic resistant bacteria; water samples; Lakhimpur.

Introduction

The foldscope (Figure-1) is an optical microscope that can be easily assembled from a origami based flat sheet of paper. It was developed by Dr. Manu Prakash from Stanford University, USA[1]. The magnification of foldscope ranges from 140X to 430X with diameter 2.4mm and 0.8mm which provides resolution up-to 2.2µm and 1.44µm respectively with LED modules[2]. In the developing world, it is a part of the "frugal science" movement[3]. It can be easily attach with a smartphone and allows the user to take pictures of the samples. This cost effective paper microscope is used as research tool in different field of research. Prakash B. *et. al.*[4], focuses to address the concerns using foldscope as a public tool in water quality assessment and to educate the local people and tribal community of Dakshina Kannada about the use of foldscope and cleanliness, hygiene and on water borne disease. They studied the total coliform bacteria through foldscope present in water sources of that area[4]. The study on diagnosis of fungal leaf spot diseases in Sikkim through foldscope was done by Lhanjey P. *Wangdi et. al.*[5]. The study on the feasibility of blood cell counting was done by A.S.M. Waliullah[6]. Ranu Kumar, Kapildeo Prasad determined the white blood cells using foldscope with smartphone[7]. Shailaja M. *et. al.*, studied on malaria parasite detection-employability of foldscope in malarial diagnosis[8]. Jayateertha D. *et. al.* assessed the agro biodiversity through the foldscope[9]. Buragohain M. *et. al*., used foldscope in identification of bacteria present in water samples of Lakhimpur district of Assam[10,11]. Sharma I. *et al* produced biofilm and its development was viewed through foldscope[12]. Rathod D. (2019), studied to identify the microorganisms/ organisms Protozoans / Rotifers / Helminths / Crustaceans Bacteria / Viruses etc.) with the help of foldscope found in waste water[13]. Mastanamma T *et. al.*, focused that food borne bacterial pathogens commonly detected in street foods are *vibrio cholera, bacillus cereus, clostridium perfringens, staphylococcus aureus and salmonella* species which are the causatives of food borne diseases like cholera, typhoid, diarrhea, food poisoning etc. They emphasized to understand and confirm the presence of microbial organisms associated with street foods by using Foldscope as a tool and to create awareness about hygiene among street food vendors and consumers[14]. Juvatkar P. V. *et. al.*[15] used foldscope as a research tool to evaluate microscopically, histology and powder characteristic of some drugs. They proposed that foldscope is a paper microscope which is handy research tool to differentiate closely related species. They suggested that microscopical evaluation is the promising method for evaluation of crude herbal drugs[15]. Gogoi M. and Saikia D.[19] used foldscope for environmental monitoring. They had taken the images of the dust deposited on substrates under foldscope with a standard scale of list count 0.01mm by a Sony IMX 519 camera with 16 megapixels, pixel size 1.22µm and aperture: f/1.7. Measurement of the size has been carried out by the help of relative measurement method in which they have used PVC 0.85mm thick slides of 0.5mm grid size as a reference for measurement. They proposed that foldscope is a useful tool to monitor the air quality effectively by designing suitable substrate to capture the suspended PM in air[16]. Thus from above literatures it is clear that uses of foldscope is one of the cheapest and easiest technology in visualization of microorganisms in different field of research. So foldscope is an advanced technology developed in microscopic world that will help the people to understand the microscopic world troublessly. This study aims to isolation and

characterization of the arsenic resistant bacteria from arsenic contaminaed sites of the study area and images is to viewed through foldscope.

Materials and methods

Profile of the study area: The study area, Lakhimpur district (Figure-2) 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 2277Sq km out of which 2257Sq km is rural and 20sq km is urban. 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 1551.3mm per year[17].

Standardization of foldscope: To standardize foldscope for identification of bacteria, preliminary procedures such as preparation of pure bacteria cultures and gram staining were performed in the laboratory. This was followed by recording, enumerating and comparing the images between the test and the standard instrument. The bacteria smears on the slides were marked with a tip of a marker and the area close to the mark was observed both under the microscope and foldscope. All images were recorded in duplicates. Images of bacteria from the slides were captured by using a cell phone camera (Samsung, Galaxy A-6^{+} infinity) by adjusting zoom and focusing of camera. Images captured using foldscope (magnification of 140x) were compared with the images captured using a microscope (magnification of 400x).

Isolation of arsenic resistant 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^{0}C on nutrient agar slants.

Figure-1: Front view of Foldscope[11].

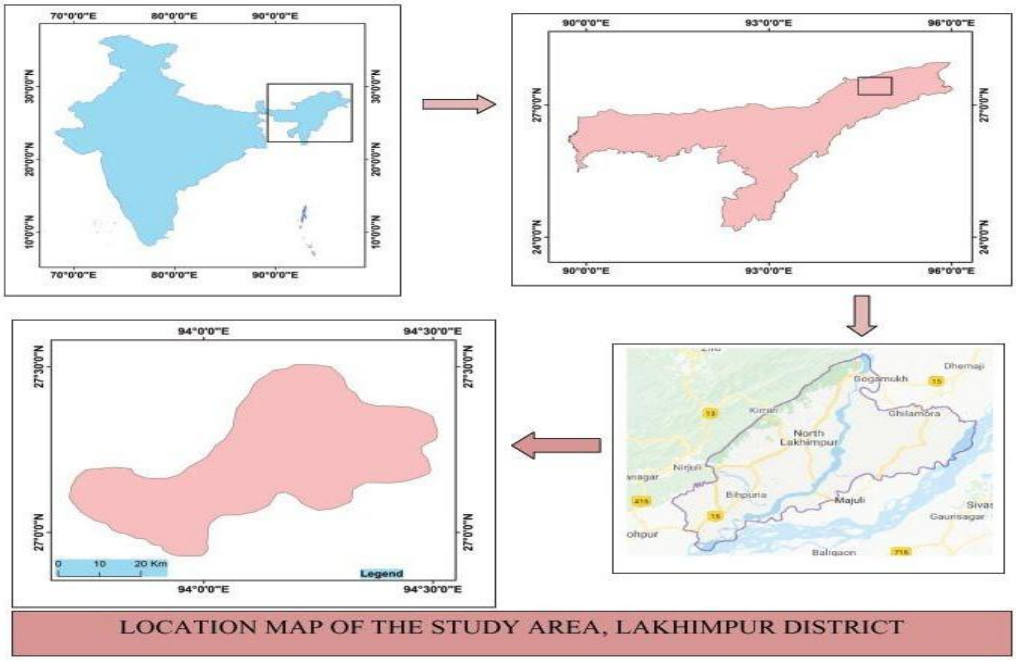

Figure-2: A cross sectional view of the study area[10].

Results and discussion

Physiochemical analysis of water sample: The water temperatures of the analysed samples ranged from 17^0C to 23^0C and pH ranged from 5.0 to 7.9 and arsenic from (0.0042±0.06 mg/L) to (0.26±0.04mg/L) which are shown in Table-5a. The highest content of arsenic was found in a Panigaon region (0.26±0.04mg/L) which was higher than the permissible limit (10µg/L) of WHO[18].

Images of bacteria in water samples through foldscope: The slides were prepared by simple staining for selected colonies. On the basis of cell wall composition to differentiate the bacteria whether it belongs to Gram positive or Gram negative, Gram's staining was done and the visualization of clinical isolates under foldscope was done (Figure-3). Bacterial cultures were observed to find gram negative and gram positive bacteria by performing staining at various time intervals. The slide was placed in the foldscope interfaced with a mobile phone. After staining the cells were observed under foldscope and recorded the images (Figure-4).

Conclusion

The foldscope functioned well in the field by being easily transported with no concerns to weather conditions or to concerns about breakage. It was useful for observing the microorganisms in different samples of environment to be easily observed. Using the smartphone attachment made it very easy to document the samples. The aapplication 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 to the fields and further enhancing scientific temperament among the masses. Moreover, during field study, the foldscope travels easily, works well and is easily synced with smart phones for photographs of the organisms observed. Breakage and storage is no problem when using the foldscope. This knowledge of using foldscope will further help in biological research.

Table-1: Temperature, pH and Arsenic concentration of water samples.

Sites	Temperature (^{0}C)	pH	Arsenic Concentration (mg/L)
Khelmati	19.6	6.5	0.015±0.07
Nakari	18.5	7.0	0.14±0.07
Panigaon	20.5	7.2	0.26±0.04
KB Road	20.7	7.9	0.05±0.07
Chetia Gaon	23.0	7.4	0.20 ± 0.03
Pohumora	17.4	6.9	0.07±0.02
Boginodi	18.6	7.4	0.09±0
Kodom	18.3	6.8	0.0042±0.06
Azad	21.4	6.2	0.07±0.09
Lillabari	21.2	7. 1	0.119±0.05

*Each sample was analyzed in triplicate and the values were presented mean ±SD.

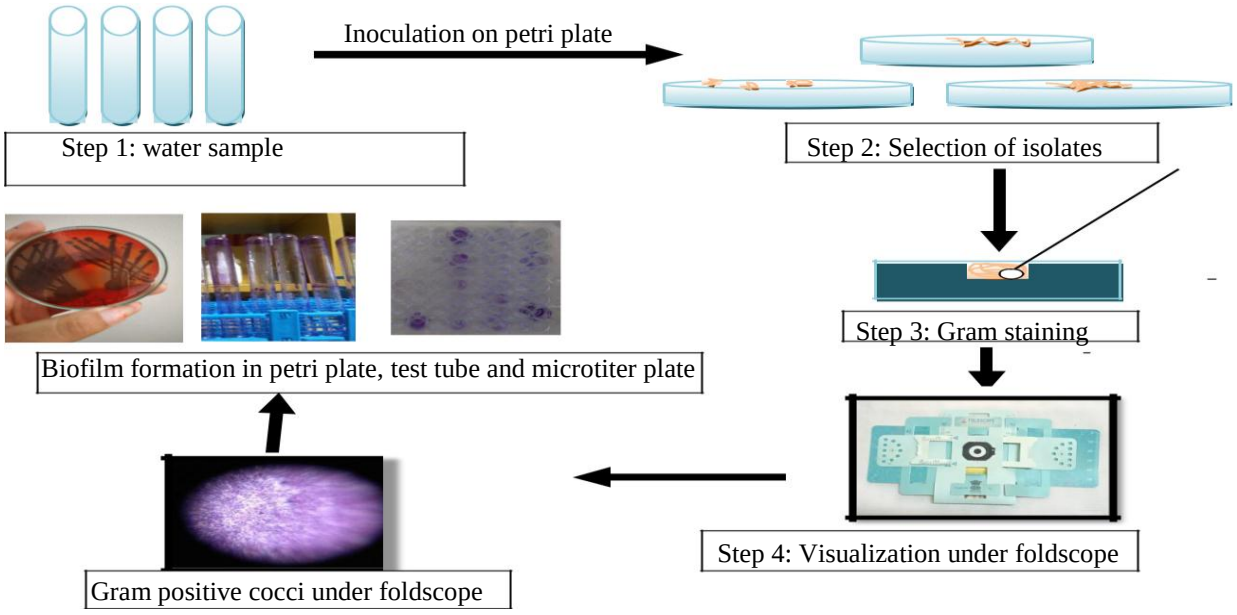

Figure-3: Visualization of clinical isolates under foldscope[12].

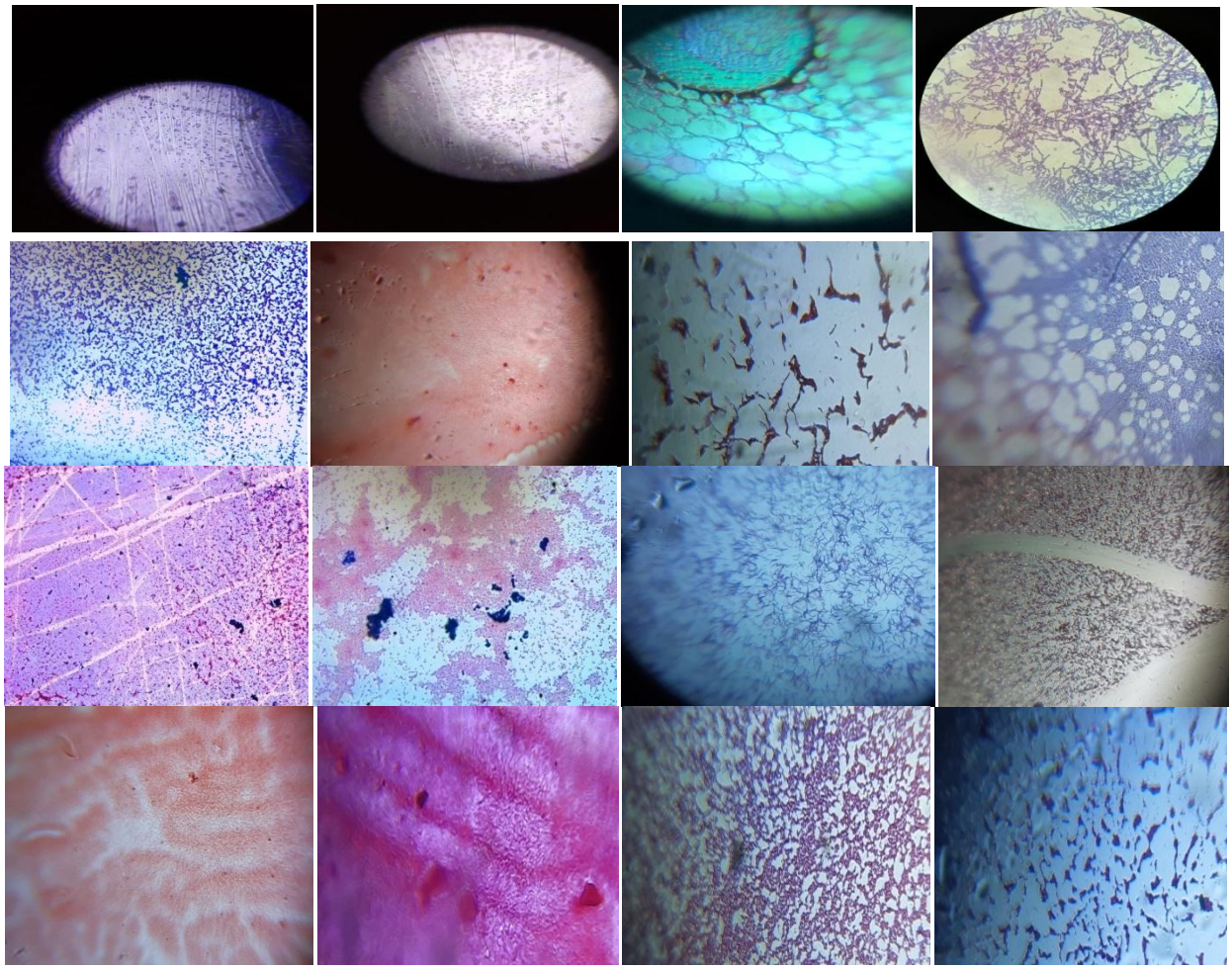

Figure-4: Gram staining observation of *bacteria* in water samples through foldscope (Magnification: 140 X).

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