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Onsite arsenic detection with a low cost portable microvolume kit

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Arsenic, a harmful contaminant, has a WHO limit of 10 µg/L in drinking water. This work is aimed to develop an on-site detection method for arsenic in micro-volume samples, achieving rapid detection at ~8 µg/L in potable water. The Molybdenum Blue method has been modified to provide rapid and exact total arsenic readings in aqueous samples with concentrations below 10 g/L. Optimizing reagents allowed micro-volume detection, tolerating up to 200 ppb of phosphate interference. The reaction produces a unique blue colour, indicating the formation of a complex called arsenomolybdate, which confirms the presence of arsenic in the sample. The colour intensity exhibited variations corresponding to arsenic concentration, providing a visual indicator of its presence. An easiest qualitative based sensor has been created utilizing porous materials to assess the concentration range of arsenic in the sample by using Low Cost Portable Microvolume (P-µV) Kit. The device exhibited an impressive response time of approximately 1 min for checking arsenic concentrations in samples, with a limit of detection (LOD) at 8 µg/L. Furthermore, the device yielded satisfactory results when checking to field samples. Its versatility allowed for both qualitative assessments and alignment with atomic absorption spectrometry results.

Keywords: Arsenic detection, Colorimetric detection Micro-volume sample, On-site technique

Introduction

The global occurrence of arsenic toxicity affects thousands of individuals, with arsenic recognized as a well-known poison and one of the most precarious heavy metals[1-6] . Estimations in year 2014-15 highlighted elevated arsenic concentrations in groundwater in specific Indian states, particularly in West Bengal, Assam and Bangladesh, raising significant concerns[7]. Arsenic, existing as a metalloid in crystal form, occurs as arsenite (As^{3+}) and arsenate (As^{5+})(Ref.3,5,6). Its presence in water stems from natural occurrences in groundwater, surface water, and human activities such as untreated industrial effluent disposal, pesticide use, and treatments involving leather and wood. The WHO acclaims a threshold value of 10 µg/L for arsenic contamination in potable water. Various health issues, including skin, lung, and bladder cancer, as well as skin hyperkeratosis, are associated with the consumption of arsenic-polluted water. Traditional laboratory methods like Atomic Absorption Spectroscopy (AAS) and others offer precise arsenic detection but are impractical for on-site use due to their complexity and the need for trained personnel.

There are two main categories of arsenic detection methods: laboratory and portable. While laboratory methods are highly accurate, they require expensive equipment, making them less accessible. Therefore, this work focuses on portable techniques. These methods offer advantages like affordability, quick results, user-friendliness, and the ability to test on-site. However, their effectiveness depends on the specific technology used.

Ravula *et al.*[7] reviewed various portable detection methods and their limitations. Laboratory techniques, on the other hand, can be broadly divided into spectroscopic (e.g., using light or sound to analyze the sample) and electrophoretic methods (separating molecules based on their size and charge). Spectroscopic methods, like AAS[8-12] or Mass Spectrometry (MS)[11-14], are highly accurate and can detect very low arsenic concentrations (down to 1 µg/L or less) with good repeatability (less than 10% variation). Electrophoretic methods[15], including isotachophoresis[16] and capillary electrophoresis, can also be accurate but may struggle with measuring concentrations in the µg/L range[17].

There are four main types of portable methods: colorimetric[18-22], electrochemical[23-25], biological[26,27], and surface sensing methods[28-30]. Electrochemical methods, despite concerns about the cost and fragility

of electrode materials, offer the benefit of being small in size and providing highly accurate results[24]. Modification of electrodes with various nanomaterials, including carbon nanoparticles[31] and noble metallic nanoparticles, enhances sensitivity[7,32,33]. For instance, a chitosan (CT)-modified glassy carbon electrode (GCE) with built-in silver nanoparticles (Ag-NPs) has been developed for direct arsenic (As (III)) detection without requiring additional arrangements. Biological sensors, a widely used category, are known for their high selectivity and accuracy, although challenges exist in handling biosafety and security issues[27]. Surface-modified nano-sensors, based on the interaction between gold nanoparticles (AuNPs) and thiol groups, demonstrate the ability to sense very low concentrations of arsenic[21,22]. However, the main challenge lies in developing suitable optical sensors capable of distinguishing colour intensity at both very low (pico-nano) and very high levels (sub-milligram onwards).

As of literature, there are various methods and technologies for on-site arsenic detection in water samples. Such as (i) Colorimetric Test Kits: Many field-based arsenic detection kits use colorimetric methods[18-22,29,34]. These kits typically involve adding a reagent to the water sample, and a colour change indicates the presence and concentration of arsenic. The colour change is then compared to a colour chart or analyzed using a portable spectrophotometer. (ii) Test Strips: Arsenic test strips operate on a similar principle to colorimetric kits[35]. They contain a reactive substance that changes colour in the presence of arsenic. Users can visually compare the colour change to a reference chart to determine the concentration. (iii) Portable Instruments: Some field instruments, such as portable spectrophotometers, allow for quantitative analysis of arsenic in water. These instruments often provide more accurate and precise measurements compared to colorimetric methods. (iv) Electrochemical Sensors: Electrochemical sensors are another technology used for on-site arsenic detection[36-39]. These sensors measure the electrical changes that occur when arsenic interacts with specific electrodes. (v) Field-Deployable Laboratory Equipment: Some organizations deploy portable laboratories equipped with more sophisticated analytical instruments for on-site testing. These may include atomic absorption spectrometers or inductively coupled plasma mass spectrometers.

However, the aforementioned methodologies provided onsite techniques for arsenic detection, but each has its own set of advantages and disadvantages, such as sensitivity, specificity, sample volume, detection time, and user-friendliness. There is no such study to check the concentration of arsenic based on micro volume at a low cost for the most recent information.

This study aims to develop a low cost Portable Microvolume (P-μV) arsenic kit for user-friendly arsenic detection with a rapid method (LOD ~8 μg/L) in potable water. The modified molybdenum blue method enables precise total arsenic readings below 10 g/L. The optimized scheme performs well with phosphate interference up to 1 ppm. The reaction produces a distinctive blue colour, indicating arsenic presence with colour intensity correlating to concentration. A user-friendly qualitative sensor (P-μV Kit) prepared by utilizing porous materials, demonstrated a 5 min response time with an 8 μg/L limit of detection. The device's versatility was evident in satisfactory field sample results from rivers and groundwater, aligning with AAS outcomes.

Experimental Section

Materials

Sodium arsenate heptahydrate ($Na_2HAsO_4 \cdot 7H_2O$), ammonium molybdate tetrahydrate, L-ascorbic acid, and sodium dihydrogen phosphate were all analytical grade and purchased from Sigma-Aldrich, India, without further purification. Stock solutions and dilutions were prepared systematically using Milli-Q grade water throughout the experiments, unless otherwise specified.

Preparation of Reagents

Arsenic Stock Solution (1 mg/L): 0.0173 g of sodium arsenite was dissolved in 1 L (1000 mL) of deionized water to create a stock solution containing 1 mg of arsenic per litre.

Diluted Arsenic Solutions: 100 μg/L and 1 μg/L solutions were prepared by diluting the 1 mg/L stock solution with deionized water according to specific ratios (mention ratios if needed).

Ammonium Molybdate Solution: 8.9 g of ammonium molybdate heptahydrate was dissolved in 100 mL of water to prepare the ammonium molybdate solution.

Potassium Permanganate ($KMnO_4$) Solution: A 0.8 g/100 mL $KMnO_4$ solution was prepared by dissolving 0.8 g of $KMnO_4$ in 100 ml of water. This solution is used to convert arsenic(III) to arsenic(V).

Ascorbic Acid Solution: 11.1 g of ascorbic acid was dissolved in 100 mL of water to create a concentrated ascorbic acid solution.

Acid Solutions (HCl and H_2SO_4): Different concentrations (2M, 3M, 4M, 4.5M, 5M, and 6M) of hydrochloric acid (HCl) and sulfuric acid (H_2SO_4) were prepared by diluting concentrated forms of these acids with deionized water.

Optimization of reagent's mixing scheme for molybdenum blue method

Molybdenum blue method for arsenic detection

The molybdenum blue method is a reliable test for confirming the presence of arsenic (As(V)) in liquid samples. This method hinges on the formation of a blue-coloured complex called arsenomolybdate.

Four key reagents are essential for this reaction: primarily Potassium permanganate ($KMnO_4$), this oxidizes any As(III) present in the sample to As(V), the form that reacts with the other chemicals. Followed by Ammonium molybdate heptahydrate, this reacts with As(V) to form the blue arsenomolybdate complex. Then Hydrochloric acid (HCl) or sulfuric acid (H_2SO_4): These acids provide the optimal acidity level (pH) for the reaction to occur efficiently. Finally, Ascorbic acid, this acts as a catalyst, accelerating the formation of the arsenomolybdate complex. The intensity of the blue colour formed is directly related to the concentration of arsenic in the sample. Therefore, by measuring this colour intensity, we can determine the arsenic concentration.

Optimizing Reagent Order and Concentration

It is crucial to note that the order in which these reagents are mixed and their specific concentrations significantly impact the accuracy of the test. This section aims to identify the optimal mixing sequence and reagent concentrations for achieving the most accurate results. Fig. 1 illustrates three possible mixing sequences. Only sequence shown in Fig. 1c produces the desired blue colour, indicating the successful formation of the arsenomolybdate complex. This complex acts as a kind of "liquid sensor" for arsenic. The formation of the complex was confirmed using UV-visible spectroscopy. As mentioned in Ravula et al.[40], the other two sequences (Fig. 1a and 1b) do not produce the blue colour, signifying the importance of proper mixing order.

Experimental procedure

The principal objective of the experiments conducted in this study was to detect the concentration

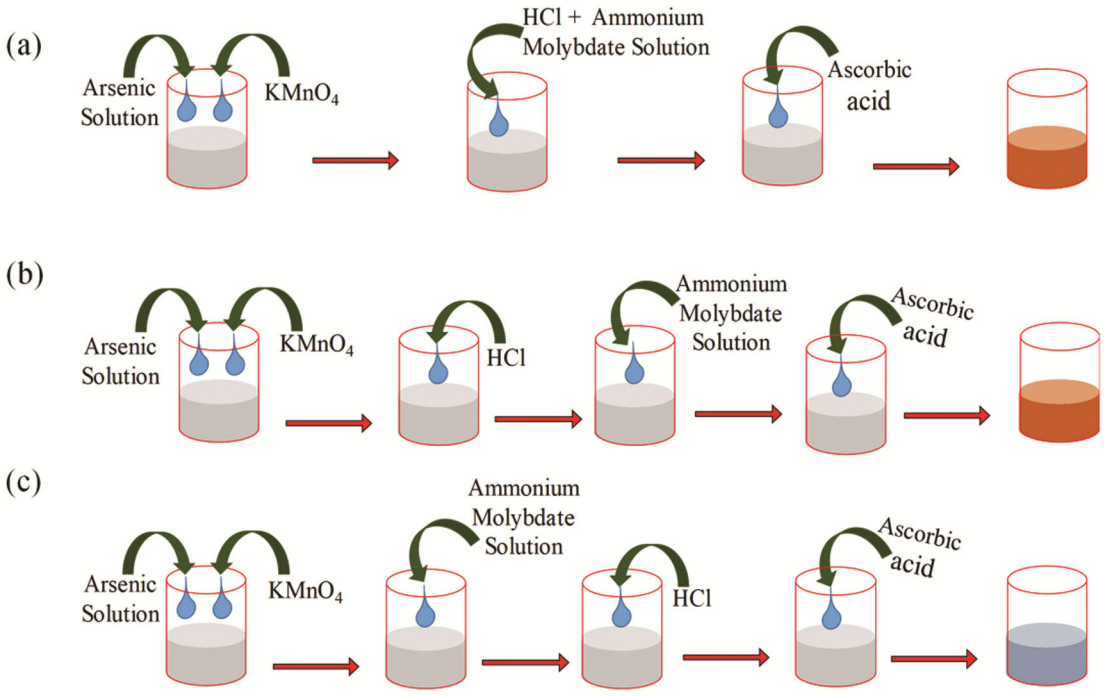

Fig. 1 — Mixing Sequences for Molybdenum Blue Complex-Based Liquid Sensor and Impact on Arsenomolybdate Complex Formation: (a) and (b) the mixing order fails to generate an arsenomolybdate complex. In case (c), the correct mixing order results in the formation of the arsenomolybdate blue complex

of arsenic in microvolume samples, with the ultimate goal of minimizing potential adverse effects on both the environment and human health. To achieve this, the molybdenum blue test was employed for microvolume-based detection. Initially, the experiments were carried out using 2000 µL beakers as the reaction vessels. In these beakers, a combination of reagents was introduced, including 500 µL of 0.4 wt% L-ascorbic acid, 500 µL of ammonium heptamolybdate tetrahydrate, and 500 µL of the prepared arsenate stock solution. The reaction that ensued involved the formation of molybdenum oxides, which combined with arsenate to create a heteropolyacid. This reaction led to the generation of the antimonyl–arseno–molybdate complex. Under reductive conditions and in the presence of L-ascorbic acid, this complex transformed into molybdenum blue, as described by Eqs (1) and (2). The resulting arsenate molybdate complexes exhibited a Keggin-like chemical structure within the solution, as depicted in Fig. 2(a). The confirmation of the presence of the antimonyl–arseno–molybdate complex in the sample was achieved through UV-visible spectrophotometry.

Taking the investigation further, the same reaction was scaled down to microvolume levels. The reaction mixture, comprising only 10 µL, was utilized for this purpose, as illustrated in Fig. 2(b). This microvolume experiment demonstrated the feasibility of the molybdenum blue test in detecting arsenic concentrations in significantly smaller sample sizes. Such microvolume-based detection methods are crucial for reducing the impact on the environment and human health, making the analytical process more efficient and environmentally conscious.

$$AsO_4^{3-} + 12(NH_4)_2MoO_4 + 24H^+ \rightarrow (NH_4)_3AsO_3.12Mo + 6O_3 + 21NH_4 + 12H_2O \quad \ldots (1)$$

$$AsO_4.12Mo^{+6}O_3 + (Reductant) \rightarrow (Molybdenum\ blue) + (weaker\ reductant) \quad \ldots (2)$$

However, certain limitations were identified in the experiment, namely, the phosphate concentration in the arsenic salt solution and the L-ascorbic acid concentration in the reaction mixture. The World Health Organization (WHO) sets the maximum allowable limit for phosphate in drinking water at 0.1 ppm. Phosphate samples were also prepared to assess interference with arsenic in the test, as phosphate can form the same blue-coloured complex with ammonium molybdate. To optimize the acid concentration, varying levels of ascorbic acid were employed for the blank test, as well as against phosphate and arsenic solutions, to study interference and determine the optimum percentage of ascorbic acid (weight per volume) for the test.

Development of a Portable Micro-Volume Kit (P-µV Kit)

The goal was to create a P-µV Kit for the molybdenum blue test using a common sponge (porous material) to store the ammonium molybdate solution and acid mixture, which is unstable in open atmosphere. The initial step involved taking a small piece of sponge with dimensions of 1 cm³, as depicted in Fig. 3. This P-µV Kit leverages the absorbent nature of the sponge to facilitate the controlled release

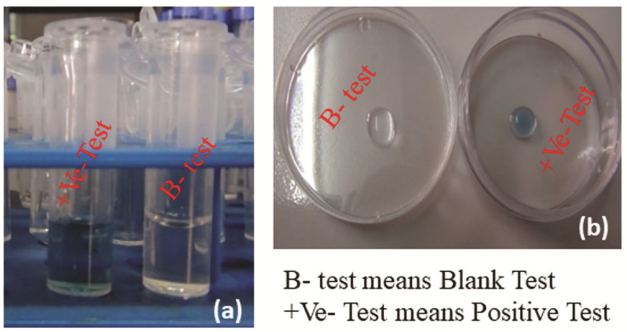

Fig. 2 — Molybdenum blue test for detecting arsenate (a) displays the results for the positive test and blank test, while (b) demonstrates the results in microvolume range

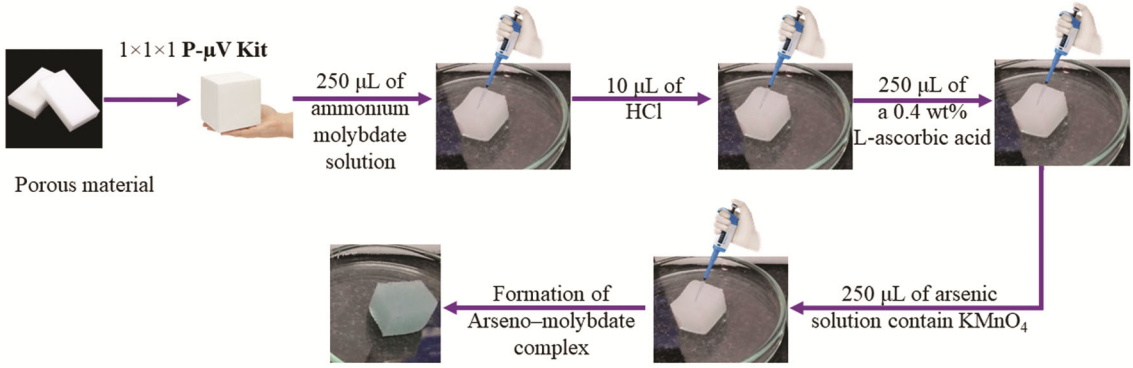

Fig. 3 — Procedure for Molybdenum blue test used to detect arsenate using a P-µV Kit

of the reactants, enabling a simplified and compact setup for on-the-go arsenate detection. Based on the optimized compositions of the Molybdenum blue test, 250 µL of ammonium molybdate solution and 250 µL of a 0.4 wt% L-ascorbic acid mixture were carefully placed on the sponge. Due to the capillary action of the sponge, it absorbed the mixture efficiently. By this process P-µV Kit was ready to use. After that P-µV Kit has to store in the closed container in black clotted box until further usage. Subsequently, 250 µL of the prepared arsenate stock solution was added to P-µV Kit. Then it will process the colorimetric reaction to identity the arsenic presence/ concentration ranges in the sample.

In this reaction, molybdenum oxides formed a heteropolyacid with arsenate, resulting in the creation of the antimonyl–arseno–molybdate complex, which transforms into molybdenum blue in the presence of L-ascorbic acid under reductive conditions, as illustrated in Fig. 3.

Results and Discussion

Development of portable micro-volume kit, for detection of arsenic in water

Initially, a blank test was performed by treating ascorbic acid of varying concentrations with ammonium molybdate in an aqueous solution to observe any colour change. The colours were noted for each concentration to determine a positive or negative result for the blank test. A negative result indicates that no colour change was observed when ascorbic acid was added to the ammonium molybdate solution. As molybdate changes colour at higher concentrations of ascorbic acid, this test was conducted to determine the optimal concentration of ascorbic acid, as described in Table 1.

A phosphate test was conducted by testing different concentrations of phosphate with varying concentrations of ammonium molybdate to detect any interference. The presence of phosphate was confirmed by a greenish-blue colour. The concentration of ascorbic acid with a lower limit of phosphate interference was considered optimal, as described in the Table 2. Based on these observations, it was determined that in order to make the test more flexible (i.e., to allow for greater phosphate concentration interference), lower weight percent ascorbic acid, specifically 0.3 or 0.2 wt%, was the most effective option, followed by 0.4 wt% ascorbic acid and then 0.5 wt% ascorbic acid. "More flexibility" in this context refers to the test's ability to tolerate a larger amount of phosphate interference without impacting the detection of arsenic.

After selecting the weight percentages of ascorbic acid, they were then tested for arsenic concentration using the molybdenum blue test. It is evident from this study (Table 3) that in order to detect arsenic up to the WHO limit, the optimized concentration of ascorbic acid was determined to be 0.4 wt%. This concentration allows for a phosphate concentration interference allowance of up to 200 µg/L.

Fig. 4a shows a light blue colour, which confirms the presence of phosphate showcasing the phosphate test at 200 ppm The appearance of the blue colour in Fig. 4b signifies the formation of an arsenomolybdate complex, intended for the development of an optical sensor to measure arsenic concentration in samples. Verification of complex formation was conducted using UV-visible spectroscopy, revealing maximum absorbance within the 810-850 nm range, as illustrated in Fig. 4c. The plots in Fig. 4c depict UV absorbance across the concentration spectrum of water, blank sample and 8, 10, 50 100 µg/L arsenic, demonstrating an escalating intensity of absorbance corresponding to increasing solution concentrations.

Table 1 — Optimization of ascorbic acid concentration (wt/vol %) based on blank test

Ascorbic acid (wt %)	Blank test colour (positive/negative)
100	Positive
50	Positive
10	Positive
0.6	Positive
0.55	Positive
0.5	Negative
0.4	Negative
0.3	Negative
0.2	Negative
0.1	Negative

Table 2 — Optimization of Ascorbic acid based on phosphate interference

Phosphate (mg/L)	Ascorbic acid concentration (wt/vol %)			
	0.5	0.4	0.3	0.2
1	Positive	Positive	Positive	Negative
0.5	Positive	Positive	Negative	Negative
0.4	Positive	Positive	Negative	Negative
0.3	Positive	Positive	Negative	Negative
0.2	Positive	Negative	Negative	Negative
0.1	Negative	Negative	Negative	Negative
Blank test	Negative	Negative	Negative	Negative

Table 3 — Optimization of Ascorbic acid (wt/vol %) for arsenic detection

Arsenic (mg/L)	Ascorbic acid concentration (wt/vol %)			
	0.5	0.4	0.3	0.2
0.01	Positive	Positive	Negative	Negative
0.001	Negative	Negative	Negative	Negative

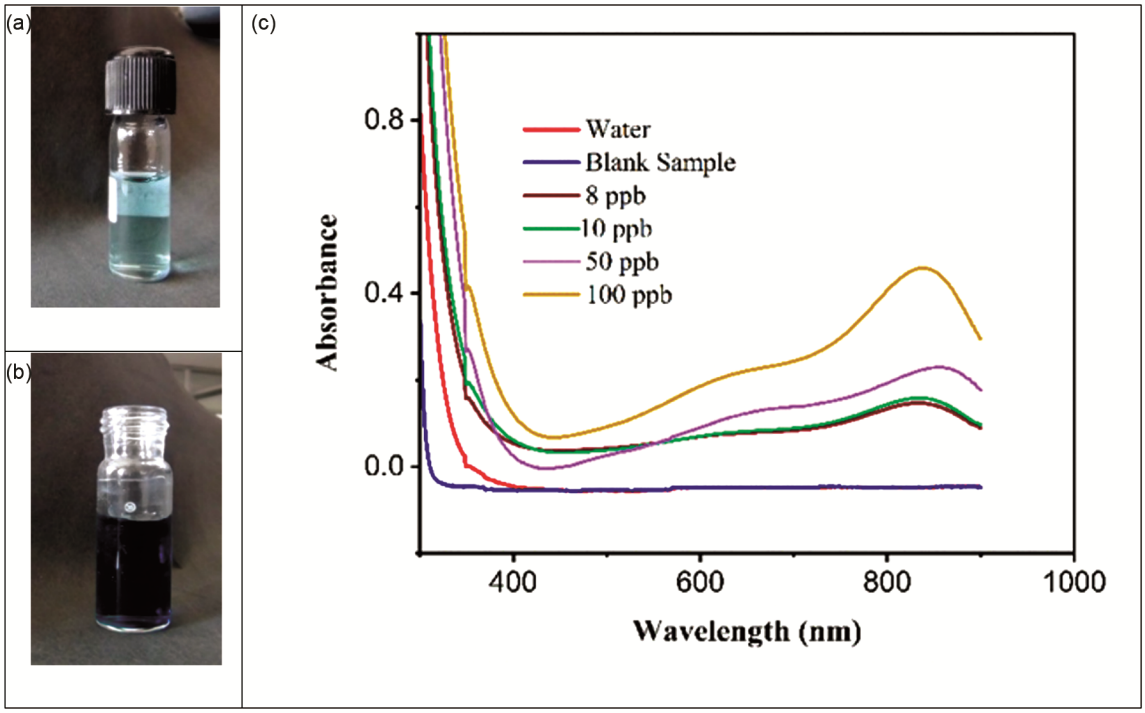

Fig. 4 — (a) Light blue colour confirms the presence of phosphate showcasing the phosphate test at 200 ppm, (b) Blue colour for arsenic detection and (c) UV-visible spectra recorded for Molybdenum blue test

As explained in Ravula *et al.*[40], a blue arsenomolybdate complex, pivotal for the sensor, forms in two steps: α-Keggin formation with HCl or H_2SO_4 and α-Keggin to β-Keggin conversion with ascorbic acid, resulting in the blue colour. Phosphate interference may cause a similar colour, necessitating optimal acid and phosphate concentrations. UV-visible spectroscopy studied the kinetics (Fig. 4c), with reactions using 2-7 M HCl and H_2SO_4 concentrations. Reaction completion time, decreasing with acid concentration, is around 5 min at higher concentrations. Stability tests at 4.5-6 M acid concentrations show a shift in absorption peak below 800 nm after 4-5 h, indicating decreased stability. Optimal acid concentrations are around 4.5 M and 5 M for H_2SO_4 and HCl, respectively, yielding a 5 min response time for the sensor.

$$AsO_4^{-3} + 12\mathrm{Mo}O_4^{-2} + 27H^+ \rightarrow H_3AsO_4(MoO_3)_{12} + 12H_2O \quad \ldots (3)$$

$$H_3AsMo_{12}^{(VI)}O_{40} + Reductant \rightarrow [H_3AsMo_8^{(VI)}Mo_4^{(V)}O_{40}]^{-3} \quad \ldots (4)$$

Fig. 4b presents the outcomes of conducted experiments where a colourless reactant transforms into a blue colour due to the reaction between As(V) solution and ammonium molybdate solution, forming the $AsMo_{12}^{(VI)}O_{40}{}^{-3}$ anion with a keggin-like structure. The reduction of the α-keggin structure to the β-keggin structure is a reversible process, maintaining the anion's overall structure. The deeply coloured valence complex is formed as the $AsMo_{12}^{(VI)}O_{40}{}^{-3}$ anion gains more electrons. The intensity of the blue colour is directly proportional to the arsenic concentration in the solution.

The chemical equation for the reaction is represented as follows:

$$As(V) + Mo(IV) \rightarrow [AsMo_{12}O_{40}]^{3-} \rightarrow [AsMo_{12}O_{40}]^{7-}$$
$$solution\ acid \quad \alpha - Keggin \quad \beta - Keggin$$

Where α-Keggin transforms into β-Keggin.

The detection time is relatively short at 5 min, and the minimum detection limit is 8 µg/L. The study utilized a small volume (20 µL) of reactants to generate the antimonyl–arseno–molybdate complex. The colour intensity of the resulting sponge is indicative of the arsenate concentration in the sample, as illustrated in Fig. 4b.

The study also demonstrated that arsenate detection, utilizing the Molybdenum blue test, is viable on a microscale. The reaction between arsenate and ammonium molybdate, facilitated by porous media kind of hydrogel, resulted in a distinctive blue colour.

Importantly, this method achieved detection at the lowest limit, meeting the WHO recommended value. As a result, this process emerged as the most suitable for developing a P-μV Kit capable of efficiently detecting arsenic concentrations in aqueous solutions.

The provided information from Table S1 indicates the consistent and reliable performance of the portable micro-volume kit (sponge) for detecting arsenic in polluted water across different temperatures and seasons. Here's a summary of the key findings for each seasonal period:

A) From February to May

The P-μV kit consistently provided a positive response at minimum temperatures (10°C to 30°C) throughout all seasons. It demonstrated a positive response up to a maximum temperature of 40°C, except during the summer season (May), where a positive response was observed even at 30°C at lower level and 35°C at above 30 ppb. Up to 3 months, the kit continued to show a positive response at all tested concentrations except at 45°C and 50°C. After 4 months, the kit's response declined, showing a negative response at all tested concentrations.

B) From May to August

The kit exhibited a positive response at temperatures ranging from 10°C to 30°C during the pre-monsoon season. Responsiveness decreased at 35°C, and no positive response was observed at 40°C and above. After 3 months, the kit showed a positive response at all concentrations except at 35°C and above.

C) From August to November

The kit consistently provided a positive response across all temperatures (10°C to 40°C) during the monsoon season. After 4 months, the kit maintained a positive response at all tested concentrations.

D) From November to February

The kit demonstrated a positive response at temperatures ranging from 10°C to 40°C during the post-monsoon and winter seasons. After 4 months, the kit continued to show a positive response at all tested concentrations.

The portable micro-volume kit consistently exhibited responsiveness across various temperatures and seasons, making it a reliable tool for arsenic detection. The positive response at low temperatures and its ability to maintain reliability at temperatures up to 40°C highlight its practical utility. The kit's simplicity of operation, eco-friendliness, and cost-effectiveness contribute to its value in efficient arsenic detection in environmental monitoring. The study's comprehensive evaluation over a year and consideration of different environmental conditions support the practicality and effectiveness of the portable micro-volume kit for arsenic detection in water, emphasizing its potential for widespread use in environmental monitoring efforts.

Field Analysis

Further the P-μV Kit was analysed under the field samples to check the performance, for that water samples were procured from three distinct sources: the Bharalu River Water (BRW) situated at North Amingaon, Guwahati, Assam (coordinates: 26°11'09.700"N 91°43'17.400"E and 26°10'55.200"N 91°41'50.300"E). Among these samples, the Bharalu River Water (BRW) exhibits turbidity due to the presence of various impurities, including heavy metals (Al, Cd, Co, Cr, Cu, Pb, Hg, Ni, Mn, Zn, etc.) and total dissolved solids (TDS). The turbidity levels also vary seasonally. Consequently, BRW samples were collected during three different seasons: Summer (June–July, Sample—S1), Monsoon (September–October, Sample—S2), and Winter (December–January, Sample—S3). To mitigate the turbidity, all BRW samples were subjected to centrifugation before further analysis. Subsequently, the arsenic concentration in all raw water samples was measured to assess the efficiency of kit under diverse field conditions. Following the measurement of arsenic concentration in all raw samples using AAS, it was determined that the arsenic concentration in these raw samples was undetectable. To simulate field conditions, we employed the spiking technique, mixing varying amounts of arsenic with Bharalu River Water (BRW) to replicate arsenic-contaminated field samples. Subsequently, we utilized these spiked samples to assess the performance of our developed P-μV Kit.

Table S2 summarizes the performance of the portable micro-volume kit over a four-month period in detecting arsenic concentrations in filed water samples. The results are organized by sample (1-4) and arsenic concentration (10, 50, and 100 ppb) at various time points (0-4 months). The kit consistently provided positive responses for all samples and concentrations throughout the entire four-month period. Regardless of the arsenic concentration (10, 50, and 100 ppb) in each sample, the kit exhibited reliability in detecting arsenic in water. The kit

initially demonstrated positive responses for all samples and concentrations during the first three months (0-3 months), indicating its reliability in detecting arsenic in water. At the 4-month mark, the kit exhibited a change in performance. The kit is not responding at lower concentration but is responding at higher concentration. The presented field analysis demonstrates the robust and consistent performance of the portable micro-volume kit for arsenic detection in water samples. The kit's ability to provide positive responses across different concentrations and samples, maintained over a four-month period, underscores its suitability for reliable and prolonged use in environmental monitoring efforts. Further studies could explore the kit's performance under diverse environmental conditions and assess its limitations in more detail.

Conclusion

A portable micro-volume kit for arsenic detection in water, was developed by focusing on optimizing ascorbic acid concentration to eliminate phosphate interference in the molybdenum blue test. The optimization process involved a series of tests, including blank tests, phosphate interference tests, and arsenic tests, with varying concentrations of ascorbic acid and phosphate. The study determined that 0.4 wt% ascorbic acid was the optimal concentration for arsenic detection, providing flexibility to tolerate higher phosphate concentrations. The research also delves into the chemical processes involved in forming the arsenomolybdate complex, crucial for the development of an optical sensor. Confirmation techniques UV-visible spectrophotometry were employed to validate the presence of the antimonyl–arseno–molybdate complex in samples. The findings highlight the effectiveness of the developed molybdenum blue test for practical applications in arsenic detection. Moreover, the study investigates the temperature and seasonal responsiveness of a portable micro-volume kit, demonstrating consistent positive responses across various temperatures and seasons. The P-μV Kit's reliability, simplicity of operation, eco-friendliness, and cost-effectiveness make it a valuable tool for efficient arsenic detection in environmental monitoring.

Supplementary Information

Supplementary information is available on the website http://nopr.niscpr.res.in/handle/123456789.

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