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Use of Silver Nanoparticles for Detection of Arsenic Trioxide Contamination of Water

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Abstract: *Arsenic trioxide is a potent contaminant of groundwater. Itis highly toxic, causing chronic poisoning, skin lesions, and skin cancer. It`s permissible limit in drinking water in India it is less than 0.05 ppm. Several methods have been proposed for the detection of arsenic. Present research investigates the use of silver nanoparticlesfor the detection of Arsenic trioxide contamination in water. Silver nanoparticles were synthesized using $AgNO_3$solution and plant (Epipremnum aureum) extract. Standard Arsenic trioxide solution was prepared in 0.005M NaOH solution and its known aliquots were prepared in distilled water. Constant volume of Silver- Nanoparticles was allowed to react with different concentrations of Arsenic trioxide. Color change was observed showing absorption maxima at 353 nm with an increase in absorbance with Arsenic trioxide concentration from 1 ppm to 100 ppm.Use of silver nanoparticles is a rapid and cost-effective method for detection of Arsenic trioxide contamination of water.*

Keywords: Arsenic Trioxide, Water Contamination, Silvernanoparticles, Green Synthesis

I. INTRODUCTION

Health concerns regarding Arsenic trioxide [As (III)] have been elevating globally and affecting millions. The major source of contamination are natural geological processes. It leaches into aquifers, and thus contaminate water. The other source of Arsenic contamination in water includes semiconductor manufacturing industries, pharmaceutical industries, paint industry, wood preservatives, and insecticides. Arsenic trioxide is known to exerts its toxicity by inactivating several enzymes involved in energy yielding pathways and enzymes of DNA replication and repair. In acute cases it leads to nausea, vomiting, abdominal pain and chronically it causes encephalopathy, peripheralneuropathy, and skin cancer (1). It is a well-documented human carcinogen. The permissible limit of Arsenic in drinking water in India is less than 0.05 ppm. There are two forms of Arsenic based on its oxidation states; pentavalent form, arsenate (As_2O_5; As V) and trivalent form, arsenite (As_2O_3; As III). The trivalent form Arsenic trioxidehas significantly higher toxicity than its pentavalent form. (2). The first objective of As contamination management is to detect the presence of Arsenic (As) in drinking water reservoirs and thereby reduce their ingestion. Methods involving spectroscopy, chromatography, microscopy, colorimetric and refractometry principals have been employed for detection of Arsenic (As) (16)

There are several reports, during the last decade, siting newly affected regions and leading to concern over global scenario of arsenic contamination. It was estimated that about 108 countries are affected by arsenic contamination of groundwater with concentration beyond maximum permissible limit (10 ppb) recommended by the World Health Organization (WHO) (8). Many developed and developing countries have problem of drinking water contamination with arsenic. The problem is of major concern in the USA—for example, the arsenic content of drinking water from public and private sources in Millard County ranges from 14 to 166 parts per billion (ppb). (4). The Environment Protection Agency (EPA) lowered the permissible level of arsenic in drinking water in the USA in 2001 from 50 ppb to 10 ppb. Bangladesh and West Bengal (India) are recognized as worst affected region by arsenite contamination in the world. In 51 districts of these two regions, more than 120 million peopleare exposed to groundwater arsenic concentrations that are above the WHO maximum permissible limit (5). In these areas, the source of arsenic was geological in origin, and it contaminated aquifers which was providing water for over one million tube-wells (6). In West Bengal, the arsenic concentration in some tube-wells was as high as 3400 ppb. (3).

The present work focuses on the use of silver nanoparticles synthesized using plant extract for detection of Arsenic contamination. Due to their unique physical and chemical properties, silver nanoparticles have wide utility in the fields like medical, food, health, consumer, and industrial arena.

II. Methodology

A. Preparation of Leaf Extracts from *Epipremnum aureum* (Money Plant) Leaves

Fresh leaves of money plant were collected from local garden. Leaves were thoroughly washed in running water to remove the dust from the surface and chopped into fine pieces. 20 g of finely chopped leaves were added to 100 ml of double-distilled water and boiled for 10 min. The extract was cooled and filtered using Whatman filter paper no 1 and used for green synthesis of silver nanoparticles.

B. Synthesis of Silver Nanoparticles

In 250 ml conical flask, 9 ml of 1mM Silver nitrate solution was mixed with 1ml of extract of money plant leaves (15). The flask was incubated at room temperature till it showed significant change in colour from colourless to brown–yellow, which is an indication for the formation of silver nanoparticles.

C. Characterization of the Synthesized Silver Nanoparticles

The spectral analysis of silver nanoparticles was done in the wavelength range of 300nm to 700nm (10) in the UV spectrophotometer (Shimadzu UV-1800). The plant extract solution was used as blank.

D. Evaluation of silver nano particles' potential to detect different heavy metal ions and Arsenic trioxide in solutions

In 0.005M NaOH solution, 1000 ppm Arsenic trioxide stock solution was prepared. It was used to prepare different aliquots in distilled water (100 ppm, 10 ppm, 1 ppm) in triplicate and allowed to react with fixed concentration of silver nanoparticles. Intensity of colour developed was measure at 353 nm against plant extract blank using UV-visible spectrophotometer (11). To further evaluate the potential of silver nanoparticles to detect other heavy metal contaminants, 0.5g of lead acetate,lead nitrate and Mercury chloride was added to 5ml of prepared silver nanoparticle solution for test and in control distilled water was added instead of heavy metal.

III. Result And Discussion

For the preparation of silver nanoparticles, the method of Roy et al (2017) was employed. The leave extract solution changed color from colourless to brown – yellow after adding $AgNO_3$ solution (Fig.1). This colour change is an indication of formation of silver nanoparticles. Color changes are possible because aqueous silver ions are reduced by aqueous extract of plant parts to generate extremely stable silver nanoparticles in water **(9)**. The UV-Visible spectrophotometry was used to monitor the formation of reduced silver nanoparticles in the solution.

The UV–vis spectra showed maximum absorbance at 353 nm, in which plant extract was used as blank, peaks were noticed at 353 nm which corresponds to the surface plasmon resonance of silver nanoparticles (13).

Qualitative detection of presence of heavy metal ions such as Pb^{2+} from lead acetate and lead nitrate, Hg^{2+} from mercury chloride and Arsenic trioxide was done using the prepared silver nanoparticles. The following heavy metals exhibited considerable colour change in silver nanoparticles solution as opposed to control. It was observed that silver nanoparticles have potential to detect these potential heavy metal contaminants (Fig.2).

As the focus of present study was detection of Arsenic trioxide (As III) in ground water. The minimum detectable concentration of Arsenic trioxide ions in aqueous solution determined by adding different concentrations of Arsenic ions into bio-synthesized silver nanoparticles showed visible observations (Fig. 3). The biosynthesized silver nanoparticles were able to detect the presence of Arsenic trioxide ions in the environmental sample as low as 1ppm with a mean absorbance of 0.071 with a standard error of 0.0024 (Fig 4).

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As Arsenic trioxide As(III) is one well documented human carcinogen and According to the World Health Organization (WHO), arsenic in drinking water at a concentration of >10 ppb is highly unsafe to community health (7). Globally, intake of arsenic (III) and arsenic (V) ions via food and drinking water has dramatically increased, as per several recent reports (12). Approximately 200 million people worldwide are affected by arsenic toxicity (14). Colorimetric analysis of Arsenic trioxide in water is one of the simplest approaches amongst other developed strategies. A nanoparticle based colorimetric detection is useful for on-site arsenic detection. Aliquots of Arsenic trioxide were prepared which was reacted with constant concentration of prepared silver nanoparticles and intensity of colour developed was measured at 353 nm using UV-Visible spectrophotometer(Fig3 and Fig4). Green synthesized silver nanoparticles have potential to detect small concentration of Arsenic trioxide. It serves as eco-friendly system that has rarely been explored for their metal ion sensing abilities.

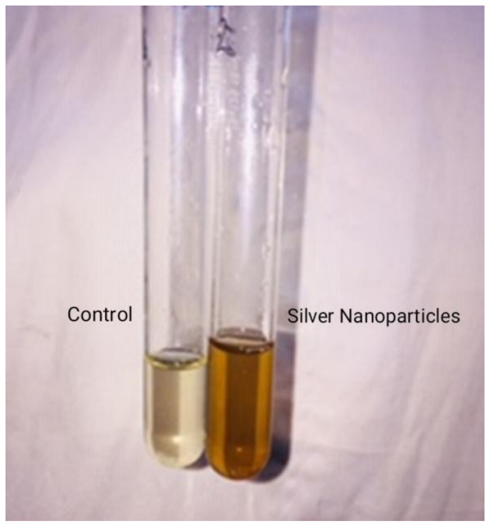

Figure 1: Colour change in the extract and silver nitrate solution after incubation (A)Control, (B) Silver nanoparticles.

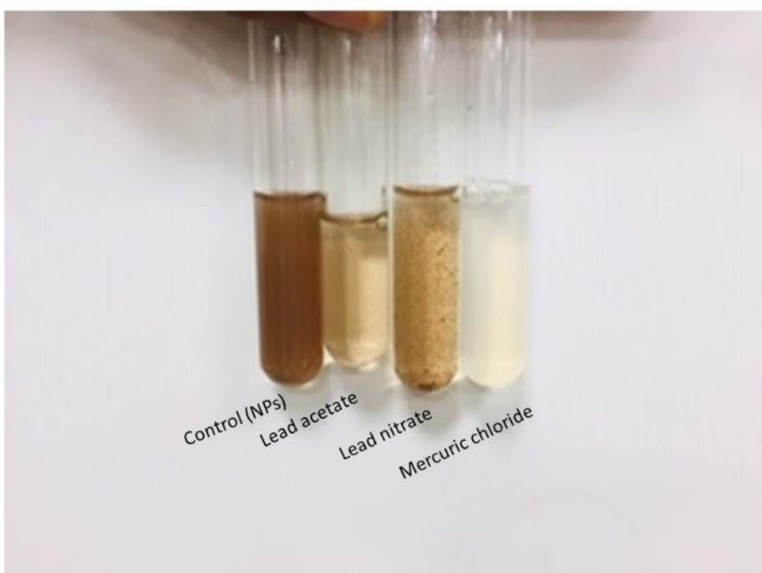

Figure 2: Silver nanoparticles binds to heavy metal ions such as $Pb2^{+}$, $Hg2^{+}$ and showed colour change**.**

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A. 1ppm

B. 10ppm

C. 100ppm

D. 1000ppm

Figure 3: Visible colour change of silver nanoparticles solution by addition of Arsenic trioxide solutions of different concentrations. A. 1ppm, B. 10 ppm, C. 100 ppm, D. 1000 ppm.

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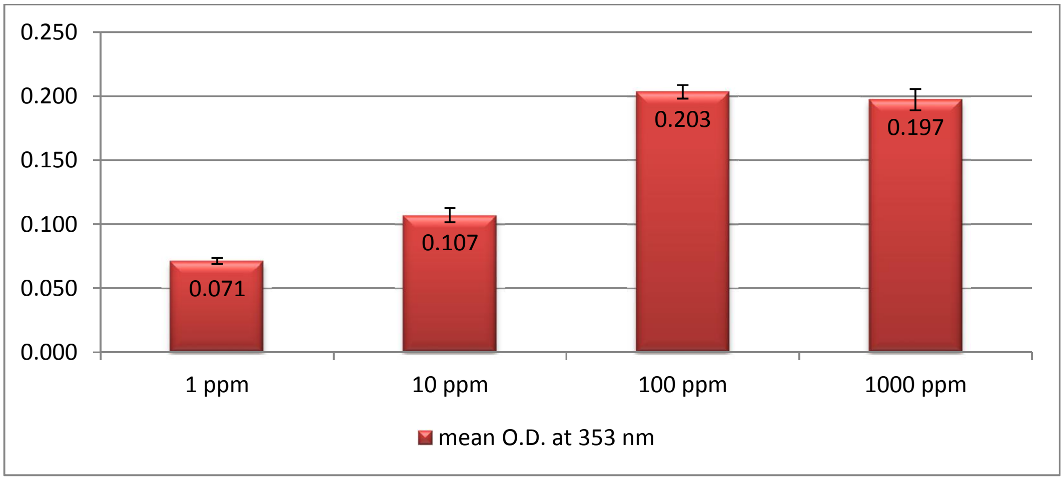

Figure 4: Effect of Arsenic trioxide concentration on colour intensity of silver nanoparticles. 1ppm concentration of Arsenic trioxide showed detectable change in colour intensity at 353 nm

IV. Conclusion

Biosynthesized Silver nanoparticles have been proven to be economically sustainable means for developing biosensor for detection of arsenic in environmental samples. Epipremnum aureum (money plant) leaves can serve as abiding source for production of silvernanoparticle instead of chemicals. The study shows detection limit of arsenic up to 1 ppm. These nanoparticles are proposed to be employed for development of biosensor for heavy metal detection as well.

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