Potential of Synthesized Silica Nanoparticles (Si-NPs) using Corn Cob for Arsenic Heavy Metal Removal

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Abstract. According to recent studies, millions of people are suffering from Arsenic (As) toxicity contamination. Arsenic is one of the most toxic and carcinogenic chemical elements and its contamination in paddy field has become a chronic problem. In the agricultural sector, arsenic-contaminated water irrigation has a higher level of arsenic contamination on the top soil, which can affect the quality of crop production such as rice plants. Rice plant requires a considerable amount of water to complete its lifecycle. In Asean countries like Malaysia, Indonesia and Thailand, Arsenic intake from rice is significantly higher, as rice plants have a special ability to take up arsenic from the soil and water used for irrigation. The transfer of arsenic from soil to plant systems is a serious issue that leads to considerable human exposure. Nanotechnology application plays vital role for any field work and research. In this research, the implementation of nanotechnology approach such as silica nanoparticles are able to remove the Arsenic heavy metal contamination. This paper focused on arsenic heavy metal removal using silica nanoparticles analysed using spectrophotometric method.

1. Introduction
According to recent studies, millions of people are suffering from Arsenic (As) toxicity contamination. Arsenic is one of the most toxic and carcinogenic chemical elements and its contamination in paddy field has become a chronic problem. Long-term exposure to paddy rice containing arsenic can give rise to cancers of skin, lungs, liver, kidney and bladder, as well as hypertension and cardiovascular disease [1].
The major crop like rice requires a considerable amount of water to complete its lifecycle. In Asean countries like Malaysia, Indonesia and Thailand, Arsenic intake from rice is significantly higher, as rice plants have a special ability to take up arsenic from the soil and water used for irrigation. The transfer of arsenic from soil to plant systems is a serious issue that leads to considerable human exposure [2].

Increased level of Arsenic in soil accrued from both geogenic and anthropogenic activities, which include, metal mining and smelting, use of arsenic-containing pesticides, herbicides, and irrigation with arsenic-contaminated water. Environmental Protection Agency (EPA) classified Arsenic as a potent human carcinogen and a leading cause of serious health problems, including cancers of the skin, lung, bladder, liver, and kidney, as well as adverse effects on cardiovascular, neurological, haematological, renal, and respiratory systems [3]. Other than that, Arsenic is a heavy metal that can severely impede plants’ growth by arresting biomass accumulation, reducing reproductive capacity through impaired fertility, yield, and fruit production [4].

Rice is the only staple crop grown under the conditions of flooded soil. Under anaerobic conditions, arsenic in soil is readily converted to mobile arsenite, resulting in Arsenic being about 10 times higher in rice grain than in other crops. Rice grain Arsenic levels are further elevated when grown in anthropogenic contaminated soils such as: use of arsenic pesticides, base and precious mining and smelting soils and contaminated water irrigated soils. Si's relationship with Arsenic has been noted in recent years as it helps to reduce the toxicity of Arsenic [5].

In the agricultural sector, arsenic-contaminated water irrigation has a higher level of arsenic contamination on the top soil, which can affect the quality of crop production [2]. Large crops such as Oryza sativa, also known as rice plants, require considerable water to complete their lifecycle. Arsenite tends to be the key As species transported from the root cortical cells to the xylem vessels, accounting for 60-100% of the total As and Arsenite accumulation was also found to be higher in flooded environments than non-flooded areas [6].

Rice plants may accumulate arsenic from the field, especially inorganic arsenic (As), in various parts of the body, including grains. Different transporters have been reported to assist in the accumulation of arsenic in plant cells; for example, Arsenate (As5+) is absorbed through phosphate transporters and Arsenite (As3+) through Nodulin 26-like intrinsic protein (NIP) through silicon transportation pathways and plasma membrane aquaporins intrinsic protein [5]. The main arsenic compounds in the agricultural sector are arsenite (As3 +), arsenate (As5 +), and arsenic cause cancer of the kidney and liver, lung cancer for consumers [7].

In today world, nanotechnology plays a crucial role in the vast application such in biosensor [8–11], medical [12–14], agricultural [15–17] etc. For arsenic contamination issues, combination with nanotechnology, this technology providing safe and accessible water and soil to meet human needs through the use of nanoparticles and nano-based adsorbents and their efficiencies in the extraction of arsenic from water and so on. It has been shown that silica nanocomposite is an active adsorbent to remove As [18]. For this analysis, corn cob is used as a raw material for the production of silica nanoparticles to be used as an arsenic surface adsobant. Studies have shown that silica xerogels can be produce using the sol gel method from corn cob ash (CCA) [19]. Researchers also note that a batch adsorption approach used silica nanoparticles to extract heavy metal ions from aqueous solutions [20]. It has been shown that silica nanocomposite is an active adsorbent to remove As [21].

2. Materials and Method

2.1. Production of Silica Nanoparticles using corn cob ash

The production for whole process as shown in figure 1. From the raw material obtained, the corn cob ash is produced by conducting a combustion process of the corn cob until it becomes ashes. From the obtained ashes, extraction of the silica nanoparticles using Sol-Gel method where the corn cob ash will be dissolved with alkali solution to form sodium silicate and lowering pH to 7 by adding hydrochloric
acid to form silica aquagel followed by drying to form silica xerogel. The incinerated corn cob is smashed thoroughly to make it into fine particles for it to dissolve easily into the further added solutions. Then the fined corn cob ash is measured 5 grams for each small tray until it becomes 20 grams. The preparation sodium hydroxide (NaOH) solution is done by using 10 gram pellets with 250 ml of distilled water, and the solution is allowed to be stirred constantly using magnetic mixer. The preparation of the 3N Hydrochloric Acid (HCL) is completed in the ventilated enclosure called fume hood. The 20 gram of corn cob ash is then mixed with sodium hydroxide (NaOH) and let it for constant stirring for one hour with 10.1°C to produce sodium silicate solution. After stirring of the corn cob ash with sodium hydroxide, the solution is cooled down to room temperature and is filtered through whatman No. 41 ashless filter paper and the pH of the solution was reduced with 3N HCL prepared previously to 7.0 with constant stirring, and incubated to promote gel formation. The Silica xerogel is formed and is closed with aluminium lid for ageing.

**Figure 1.** Experimental Setup for Production of Silica Nanoparticles.

### 3. Results and Discussion

#### 3.1. Synthesized Silica bonding evaluation using Fourier Transform Infrared (FTIR) method

In this analysis, the prepared synthesized Silica are evaluate using Fourier transform infrared (FTIR) method to see the chemical bonding and its purity. FTIR instrument also used to monitor the vibrational stretching and bending bands in Silica. The FTIR spectra of the synthesized silica nano powders are shown in Figure 2. The transmission peak was detected at 65 and 800 cm\(^{-1}\) are corresponding to the bond-rocking and symmetric bond of the Si-O elements [22]. While the bands located at 1097.3 are related to the stretching vibration of asymmetric Si-O-Si units [23]. Presence of adsorbed water and free surface silanol groups as well as siloxane linkages can easily be conceived from the IR spectra of silica in the range 450–4000 cm\(^{-1}\).
Figure 2. FT-IR spectra of synthesized Silica nanoparticles.

3.2. Spectrophotometric evaluation on the interaction between Arsenic and adsorption material
Evaluation of the adsorption of silica nanoparticle for Arsenic removal analysis are conducted through spectrophotometric method using UV/Vis machine. This analysis uses spectrophotometric method for the determination of the Arsenic using varamine blue as a chromogenic reagent. Figure 3 shows the 1mg/ml Arsenic concentration reaction towards varies of Silica nanoparticles concentration. The silica concentration ranging from 0 to 2.4 mg/ml. The result shows that high concentration of silica nanoparticles (2.4mg/ml) leads to high percentage of Arsenic heavy metal removal with 96%. This can conclude that Silica nanoparticles that have high concentration are effective in removing Arsenic heavy metal. This results clearly show that, nano composite play a tremendous properties because it has an offer for enhancement with their unique surface area and active sites for adsorption analysis [20].

Figure 3. 1mg/ml Arsenic concentration reaction towards varies of Silica nanoparticles concentration.

4. Conclusion
Silica nanoparticles have proved to be a good adsorbent for arsenic removal using spectrophotometric analysis assay. Moreover, the synthesized and production of this nanomaterial is simple and are able to strive with other commercially adsorbent for arsenic as it uses the waste product to produced.
5. Acknowledgement
The authors wish to thank Universiti Malaysia Perlis (UniMAP) for providing financial and technical staff who support to conduct this research.

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