KPU International Journal of Engineering & Technology
Volume 2, Issue1, March 2022
e-ISSN:2790-0819, p-ISSN:2790-0800
Date Received: 2022-02-03
Date Accepted: 2022-02-20
Date Published: 2022-03-30
Original Research

Investigation of Adsorption Performance In The Removal of Waste Water Contaminants By Nanostructures From Electro-Oxidation of Different Metals

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Abstract

Water pollution with various pollutants, including heavy metals, is a serious environmental challenge for the world. Most of the methods available for removing contaminants from contaminated water generally show their effectiveness at high concentrations and are not responsive to low concentrations (concentrations below 100 mg / l). They are also not affordable. Therefore, it is necessary to use a method that in addition to being low cost, its performance is also effective in refining heavy metals. Adsorption is a very rich process with scientific and experimental background due to its many advantages. This study is a review of the study and collection of information regarding the adsorption of metal contaminants from contaminated water by nanoparticles produced by electro-crystallization. Then, at the end, the effect of increasing the oxidation voltage and consequently the effect of reducing the size of nanoparticles resulting from electro-oxidation of various metals in the removal efficiency of contaminants has been investigated. According to the results of studies in this field, increasing the voltage has reduced the size of nanoparticles produced, which has resulted in an increase in the efficiency of adsorption of heavy metals from contaminated water, which in some cases even the absorption rate has reached over 90%.

Keywords: Adsorption, heavy metals, contaminated water, removal efficiency, voltage

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1. Introduction

Water pollutants generally include colored compounds, heavy metals, organic pollutants, pesticides and herbicides. Water pollution with various pollutants is a serious environmental challenge for the world. The amount of these pollutants is increasing due to the increase in urban population and the development of industrial and mining activities. The most important water pollutants are mainly heavy metals and paints. Heavy metals are elements whose atomic mass is greater than the atomic mass of iron (55.8 g / mol) or has a density greater than 5 g / cm3. These metals are elements with high stability, non-degradable in the body and have the ability to bioaccumulation in the food chain and have the ability to be transmitted to humans. Water pollution by heavy metals is one of the major challenges in maintaining the health of human society [1-3]. Heavy metals in effluents include antimony, lead, cobalt, cadmium, nickel, beryllium, chromium, copper, mercury, selenium, thallium, zinc, and arsenic. Some of these metals are highly toxic. Chromium and arsenic, for example, are carcinogenic, and mercury, lead, cadmium, and chromium are among the most dangerous metals. Due to the toxicity of heavy metals, their disposal into the environment is considered a serious threat to human health and ecosystems.

Therefore, the separation of these heavy metals from aquatic environments is extremely important and for this purpose, many methods have been used to remove them from the effluents. The most important methods used to remove and separate heavy metal ions from aqueous solutions can be chemical deposition, ion exchange, reverse osmosis, filtration, membrane processes, evaporation, Solvent extraction, electro flotation, biological methods and adsorption on adsorbents. Most of these methods have significant disadvantages such as the need for high energy and therefore the cost of the process, low efficiency, the need for special chemicals, etc. [4-12]. Adsorption of metals by nanoparticles is an environmentally friendly technology that has been studied in recent years as an effective agent for removing organic contaminants and heavy metal ions from water and wastewater. The reasons for the widespread use of nanoparticles in surface adsorption are high active surface area, high adsorption efficiency, high reactivity and the ability of nanoparticles to disperse in aqueous solution. Because nanostructures show higher reactivity and adsorption capacity than normal size of the same materials. In other words, today, due to the crisis of lack of available safe water resources, it is necessary to take measures to remove pollutants from the combination of wastewater and polluted water, with high efficiency.

While the methods mentioned above have a low efficiency in the removal of heavy metals (such as deposition methods) or show their best performance in concentrated wastewater containing heavy metals (such as methods Ion exchange and solvent extraction) and therefore is not suitable for removing low concentrations of heavy metals from industrial effluents and bringing their quality to existing standards, and since heavy metals are not eliminated in nature. The process requires new technologies to remove them from the effluent. The study of the removal of heavy metals from industrial wastewaters by nanoparticles has received much attention in recent years. Cobalt and cadmium, nickel and copper are among these

heavy metals that enter the environment, the body of plants and finally the food chain of humans and animals through various sources and cause serious damage [3, 13 and 14].

2. Methodology:

Today, due to the crisis of lack of available safe water resources, it is necessary to take measures to remove contaminants from the composition of wastewater and contaminated water, with high efficiency. Therefore, it is necessary to use a method of low cost with effectively performance in refining heavy metals. This is a review study and collected information regarding the adsorption of metal contaminants from contaminated water by nanoparticles produced by electro crystallization. This process is based on performing reduction and oxidation reactions in the liquid phase by applying the appropriate voltage. To apply this, we use Figure 1; it is necessary to have three components, anode, cathode and electrolyte. The anode and cathode materials are selected according to the desired nanoparticles. At the end, the effect of increasing the oxidation voltage and consequently the effect of reducing the size of nanoparticles due to electrooxidation of various metals in the removal efficiency of contaminants has been investigated.

3. Surface Absorption

In the adsorption process, a component of the gas or liquid phase is transferred to the solid surface. The term adsorption is used to describe the fact that molecules adsorbed on a solid surface are larger than the gas or solution phase. Adsorption occurs due to the gravitational force of atoms or molecules on the solid surface. In practice, adsorption of various forces, both physical and chemical, is effective and its amount depends on the nature of the adsorbent and the adsorbent.

Therefore, it can be said that adsorption is a physical and chemical action that these two types have differences with each other, including that in chemical adsorption, chemical bonds cause adsorption, but in physical adsorption, it is weak van der Waals forces that cause Performing the action is absorbed. In physical adsorption, the amount of adsorption is one of the characteristics of the adsorbed body, while in chemical adsorption, the amount of adsorption is one of the characteristics of both bodies. Physical adsorption is such that with increasing pressure of the adsorbed body, the amount of adsorption per unit area increases, but in chemical adsorption is the opposite [15 and 16]. Nowadays, it has been proven that among different water treatment methods, surface adsorption is a suitable method because it has high efficiency and is an economically cheap and inexpensive method. The adsorption method can both separate a variety of contaminants, including heavy metals and dyes, from the wastewater, and also does not change the water quality and toxic products (sludge left in other methods). It also does not show that these cases show the superiority of the adsorption method over other methods. Many studies have shown that different types of toxic chemical contaminants are easily removed from the effluent by the adsorption process, while the removal of these contaminants by other methods is very costly and difficult. Therefore,

adsorption is a physicochemical process that is very effective in removing water pollution [13 and 14].

3.1. Attractor

The solid on which the adsorption occurs is called the adsorbent and the substance that is adsorbed on the surface of this solid is called the adsorbent. In general, all solids are inherently capable of absorbing some gas or solute. Of course, the amount of adsorption depends on various factors such as contact surface, concentration, temperature, type of adsorbent and adsorbent and the state of adsorbent and adsorbent. The best adsorbents should be such that the maximum amount of pollutants is separated from the effluents. An adsorbent should generally have characteristics such as high surface-to-volume ratio, high adsorption capacity, mechanical stability, environmental compatibility, availability, cheapness, and so on. In adsorbents, the higher the contact surface, the higher the amount of adsorption, in which case it can be said that the smaller the particle size, the higher the contact surface and consequently the higher the adsorption rate. In most cases, adsorption occurs better at lower temperatures [14, 15]. Of course, the type of adsorbents depends on the type of adsorbent. It is not that one adsorbent can absorb all the contaminants.

Therefore, different types of adsorbents are used for different adsorbents. To put it more clearly, some adsorbents have a higher adsorption capacity than a particular adsorbent, while they may have a lower adsorption capacity than another adsorbent. In order to control the amount of pollutants, researchers have made great efforts to build and modify various attractions and study their performance. Among these, surface adsorption by nanostructures is an environmentally friendly technology that has been used in recent years as an effective agent for the removal of organic pollutants, heavy metal ions from water and wastewater [16]. In the adsorption process to select the adsorbent, the following parameters need to be considered:

- High adsorbent efficiency to remove contaminants
- Biodegradability of adsorbents
- Ability to retrieve attractions for reuse
- Consider the economic costs of providing low-cost attractions
- Ability to design and use adsorbents for industrial systems

Accordingly, it is necessary to use some kind of attractants in the adsorption process that in addition to being the most efficient, are also economically viable. Nanostructures are a good option for separating contaminants from contaminated water. In the meantime, a method should be sought to enable the production of nanoparticles with precisely controlled size that also have unique properties [17]. Electro-crystallization method is an effective method in the production of different types of nanostructures.

In this regard, we can specifically refer to the research of Musivand et al [18-28]. The variety of nanoparticles produced in this way is very high and by adjusting the factors affecting the laboratory system, nanoparticles with controlled size can be

produced. In this paper, the adsorption of heavy metals from contaminated water by nanostructures produced by this method is investigated. The adsorption mechanism is such that first the mass of the soluble molecules presents in the solution (here we mean water contaminants) is transferred to the surface of the adsorbent particles and then the adsorbed molecules into the pores. The adsorbent is introduced and finally a surface adsorption is performed by creating a layer of adsorbed molecules on the pores. Absorbs play a key role in the adsorption system. Accordingly, today, after much research, researchers first predetermine the desired adsorbent in terms of structure, pores, porosity, surface energies and other parameters, and on this basis, the adsorbents are produced and for special cases. Are used. The adsorption action is actually due to the gravitational force that the molecules on the adsorbent surface have with the adsorbed molecules [15-17].

4. Electro-crystallization and the action of surface adsorption

So far, different nanoparticles have been synthesized in different ways. The method of making nanoparticles is very important because the use of different methods leads to the production of particles with different properties and characteristics, and even in a particular method, the use of different amounts of raw materials or changes in conditions Fabrication and effective parameters produce particles with different sizes and properties. This study investigates the adsorption performance of heavy metals from contaminated water by nanoparticles produced by electro-crystallization method. The advantages of this method can be low cost, high production speed, production of various oxide and hydroxide particles, simplicity of the process, no need for complex and expensive equipment, as well as the ability to properly control and microstructure of the final product by controlling laboratory conditions and Effective parameters noted. The basis of this process is based on performing reduction and oxidation reactions in the liquid phase by applying the appropriate voltage.

To do this, according to Figure 1, it is necessary to have three components, anode, cathode and electrolyte. The anode and cathode materials are selected according to the desired nanoparticles. For example, aluminum electrodes are used to produce aluminum hydroxide nanoparticles. Through the oxidation of the anode atoms, its metal ions enter the electrolyte and are regenerated near the cathode of the aqueous electrolyte, producing hydrogen ions and hydroxides. The reaction between these ionic species produced around the anode and cathode produces the desired nanoparticles. The electrolyte used in this process is the same water contaminated with heavy elements. In other words, in the electrochemical cell, both the desired nanoparticles are produced and the adsorption of heavy metals in the electrolyte solution is performed simultaneously by the produced nanoparticles. So far, nanoparticles of iron oxide, tin oxide, titanium oxide, zinc oxide, nickel oxide, manganese ferrite, cobalt ferrite, aluminum oxide, aluminum hydroxide and nickel hydroxide have been reported by electro-crystallization [18-28].

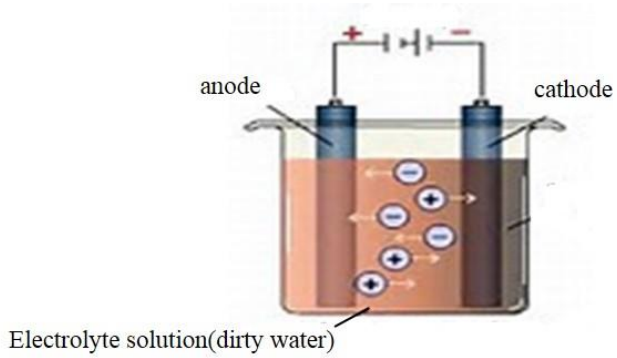


Fig 1. View of an electrochemical cell to perform the electro-crystallization process

In this method, parameters such as the applied voltage, the initial concentration of heavy metal ions in water, the initial pH of the electrolyte and the contact time of nanoparticles with pollutants affect the absorption efficiency, of which the applied voltage is the parameter here. Been paid. After preparing the oxidation cell so that its electrolyte contains a certain concentration of heavy metal elements, several different voltages are applied to the electrochemical cell at certain times to check the removal efficiency. After the desired time, the electric current is cut off and after the sediments settle, the water on them is analyzed by the Atomic Absorption System (AAS) to determine the concentration of pollutants in it in terms of Determine the ppm before and after the test. To some extent, in most of the findings studied by the authors of this paper, the rate of reactions increases with increasing voltage, so more sediment is produced, so the absorption of contaminants by the nanoparticles produced increases. In other words, the concentration of heavy metals in aqueous solution decreases with increasing voltage. It was observed that the rate of removal of these pollutants is significant in some cases.

In this regard, we can refer to a study conducted by Piri Fatehabad et al [26]. In this research, the efficiency of cobalt and cadmium removal from contaminated water by aluminum oxide nanoparticles prepared by electro-crystallization method under different voltages has been investigated. In this process, the electrolyte is the same contaminated water containing cobalt and cadmium with a concentration of 100 ppm and a pH of about 5.2. Different voltages of 5 volts, 10 volts, 15 volts, 20 volts and 25 volts were applied to the oxidation cell under the same conditions for 30 minutes After examining the results of the atomic absorption device, it was found that 96.3 % of cobalt and 90.4 % of cadmium in contaminated water were absorbed by aluminum oxide nanoparticles under the application of the highest voltage, ie 25 volts, and the amount of contaminants in contaminated water The amount decreased significantly (more than 90%), the results of which are shown in Figure 2. In this figure, C0 and C show the concentrations of contaminants before and after the reaction, respectively. According to these results, it is clear that increasing the voltage has a significant effect on the removal of water pollutants, especially cobalt. As the voltage increases, the speed of the reactions increases, so more sediment is produced that can absorb more particles of contaminants on its surface and thus

reduce the concentration of contaminants in the water. Find. It should also be noted that in this study, it was not possible to apply a voltage higher than 25 volts, because at higher voltages, the anode can corrode, puncture and break.

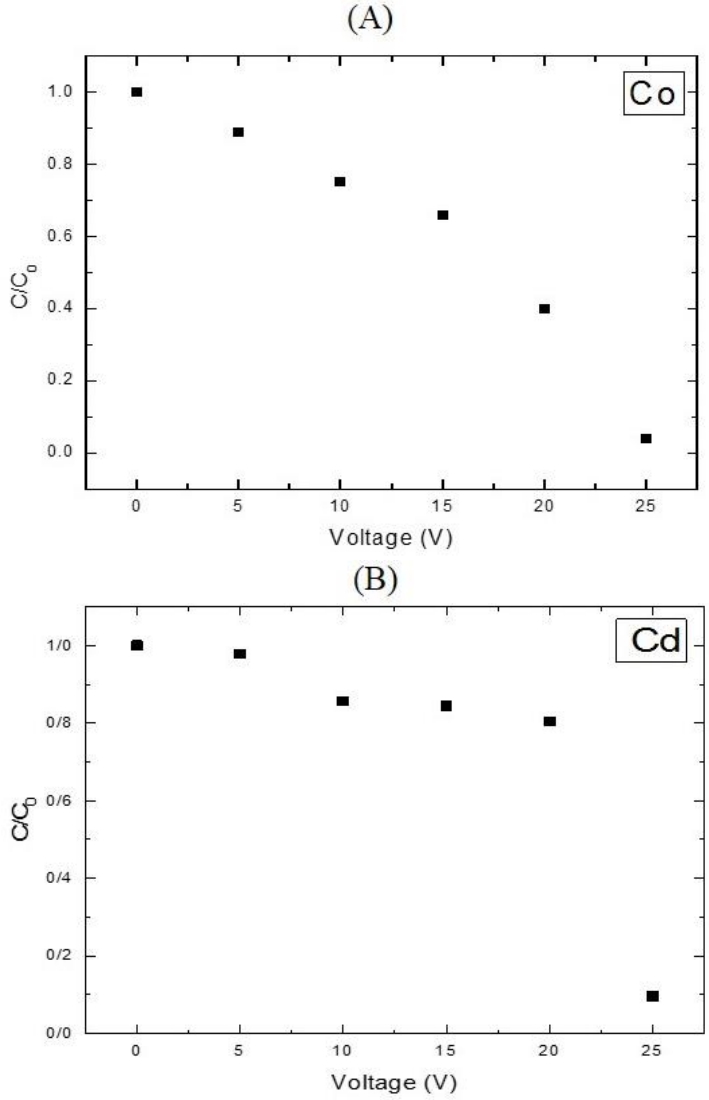
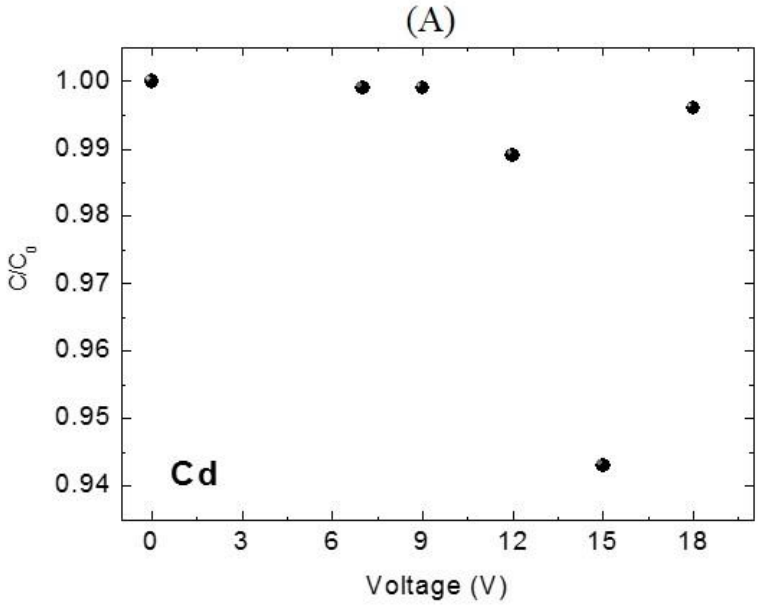


Fig2. Concentration a) Cobalt and b)Cadmium depending on the voltage increase from 5 volts to 25 volts

Adam et al. [19] also concluded in their study that increasing the voltage increases the efficiency of absorption of pollutants from contaminated water. In order to investigate the effect of voltage, under the same conditions, he prepared electrolyte with a concentration of 100 ppm of nickel and cadmium elements and applied five different voltages of 7V, 9V, 12V, 15V and 18V to the electro-oxidation system for 30 minutes to adsorb heavy elements. Examine nickel and cadmium from contaminated water by electrocrystallization of aluminum hydroxide nanoparticles. According to these results, 5.62 % of cadmium and 88.47 % of nickel were removed from the contaminated water by applying a voltage of 15 volts. In other words, with increasing voltage, the absorption of pollutants by aluminum hydroxide nanoparticles has increased and the concentration of cadmium elements, especially nickel in aqueous solution, decreases with increasing voltage. However, as shown in Figures 3 (a) and (b), the concentration of pollutants is increased again by applying a voltage of 18 volts. This could be due to a test error or the occurrence of a desorption phenomenon in which the contaminant separates from the surface of the nanoparticles under very high voltage and returns to the electrolyte solution.



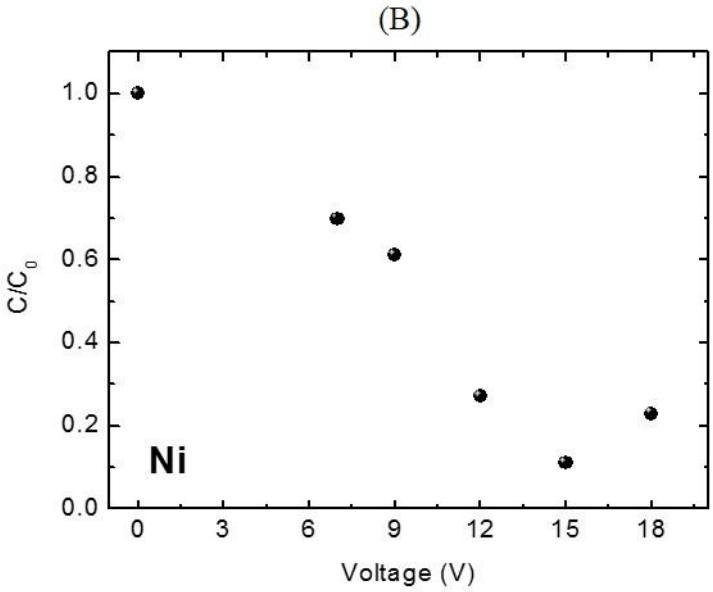


Fig 3. Concentration a) Cadmium and b) Nickel in terms of voltage increase from 7 volts to 18 volts

Similarly, Bagheri and his colleagues [28] used nickel hydroxide nanoparticles to remove the metal contaminants cadmium and cobalt from contaminated water in the same way. For this purpose, five voltages of 8 volts, 12.5 volts, 17 volts, 21.5 volts and 26 volts were considered to be applied to the oxidation system, which were applied to the electrochemical cell under the same conditions for 30 minutes. The electrolyte solution in this process, which is the same as contaminated water, contains the elements cobalt and cadmium at a concentration of 100 ppm. The results of this study show that 26.77% of cadmium and 11.06% of cobalt have been removed from contaminated water under a voltage of 26 volts, 2.25% of cadmium and 13.01% of cobalt under a voltage of 21.5 volts. Indicates the effect of voltage increase on the removal efficiency of contaminants from contaminated water, the results of which are shown in Figure 4.

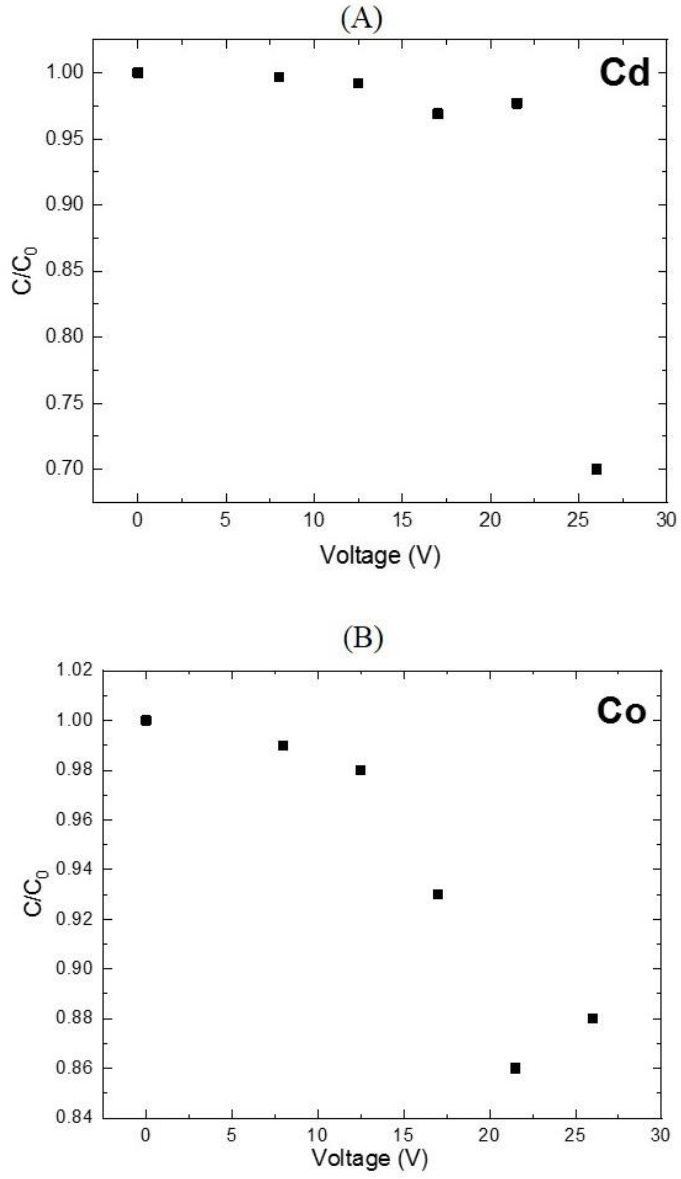


Fig 4. Concentration a) Cadmium and b) Cobalt in terms of voltage increase from 8 volts to 26 volts

In another study by Musivand et al. [27] on the effect of voltage increase on the removal of cobalt and cadmium from contaminated water by iron oxide nanoparticles, five groups of samples applied different voltages from 5 volts to 25

volts under the same conditions with a concentration of 100 ppm Cobalt and cadmium were synthesized at a pH of about 5.2 and lasting 30 minutes. According to Figure 5, 97.9% cobalt at 15 volts and 81.2% cadmium at 25 volts were adsorbed by iron oxide nanoparticles from Contaminated water is removed.

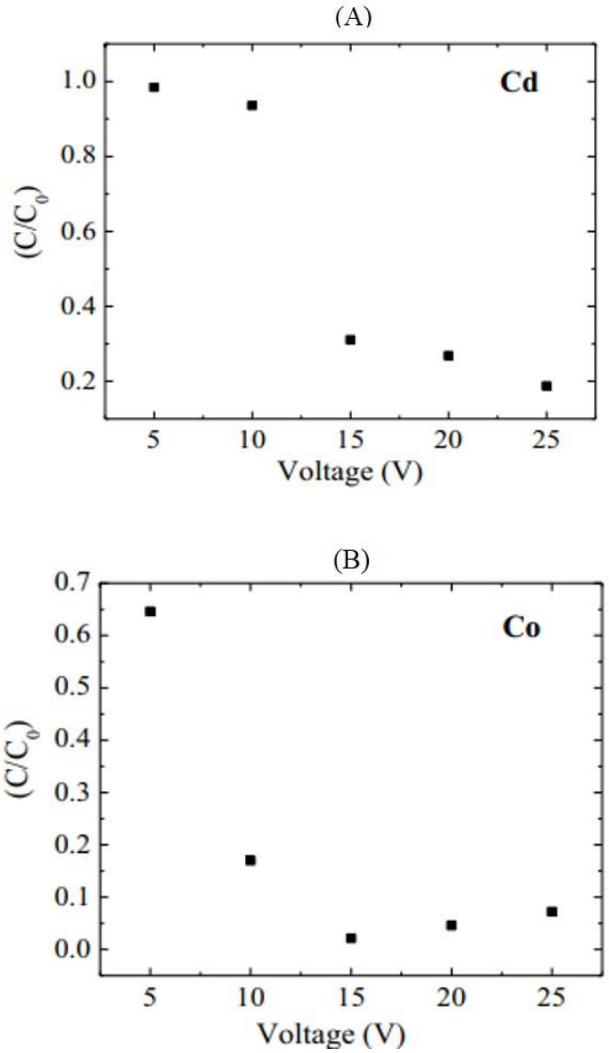


Fig 5. Concentration a) Cadmium and b) Cobalt depending on the voltage increase from 5 volts to 25 volts

Musivand and his colleagues [7] also removed copper and nickel from contaminated water in another study. The method used to remove these

contaminants is the same as adsorption by iron oxide nanoparticles prepared by electrocrystallization method. Three different voltages of 8 volts, 16 volts and 28 volts were applied to the oxidation cell containing copper and nickel elements for half an hour. Contaminated water is absorbed by its surface and settles to the bottom of the container.

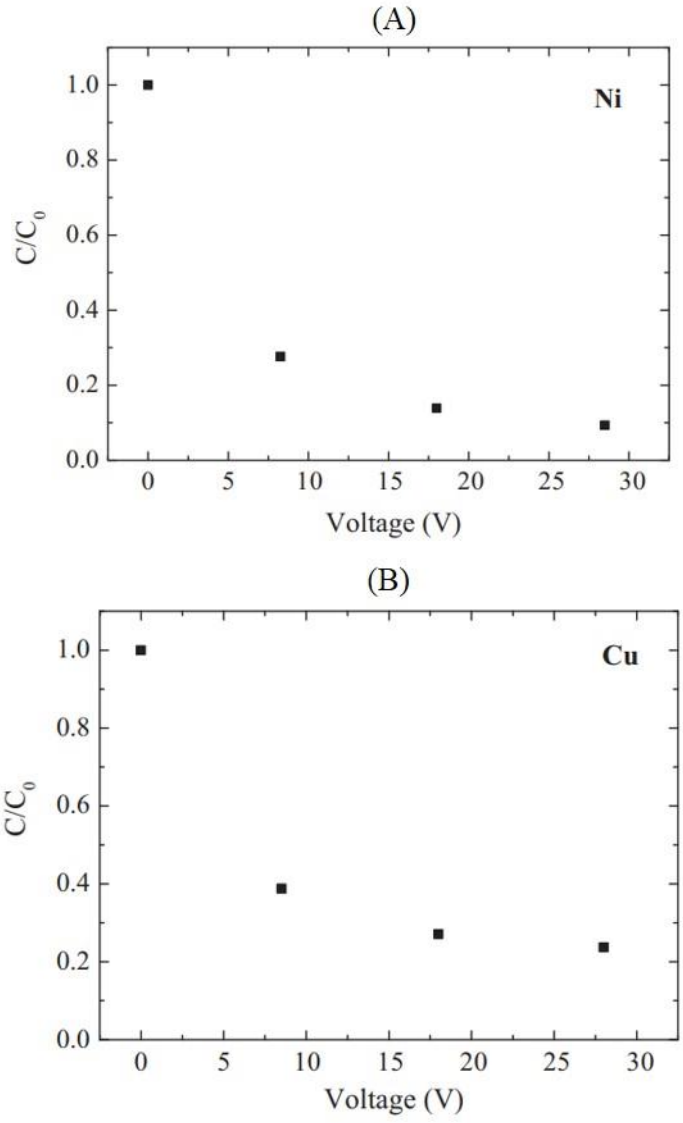


Fig 6. Concentrations (a) Nickel and (b) Copper in terms of voltage increase from 8 volts to 28 volts

5. Conclusion

This study has an overview of the effect of increasing the oxidation voltage and consequently the effect of reducing the size of nanoparticles due to electro-oxidation of various metals in the removal efficiency of metal contaminants such as cobalt, cadmium, copper and nickel. The adsorption of these contaminants was investigated by various metal nanoparticles produced by electrocrystallization method. The advantages of this method can be low cost, high production speed, production of various oxide and hydroxide particles, simplicity of the process, no need for complex and expensive equipment, as well as the ability to properly control and microstructure of the final product by controlling laboratory conditions and Effective parameters noted. The results showed that the increase in voltage leads to the production of larger amounts of nanoparticles and therefore the produced nanoparticles absorb larger amounts of heavy metal elements to their surface and settle to the bottom of the container. Examination of contaminated water before and after atomic absorption spectrometry (AAS) tests indicates the removal of large amounts of contaminants (even in cases above 90%). Therefore, this process is a high efficiency method in removing pollutants from water and wastewater that can be used in various industries.

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