MINAR International Journal of Applied Sciences and Technology
ISSN: 2717-8234
Article type: Research Article

Received: 15/04/2022 **Accepted:** 12/052022 **Published:** 01/06/2022

TREATMENT OF Cr (III) CONTENT IN WATER USING COLD ATMOSPHERIC PLASMA TECHNIQUE

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Abstract

Contamination of water with heavy metals is considered to be one of the important problems in the worlds. Scientist made many experiments and researches in order to remove these pollutants as minimum as possible. In the present work, a new method to remove one of the heavy metals element which is Cr (III) from the water was done. Standard samples were prepared in the lab and diluted to achieve samples of known concentrations (0.1, 0.05, 0.025, 0.02, and 0.01) mg/L. Each sample was exposed to a cold plasma source for different exposure times. Cr (III) concentration was examined after each exposure time (5 sec – 10 min) step 5 sec. Results show that removing heavy metals elements to about 90% - 95% from water samples in a little period of time. From these results and by comparison with other methods, the cold atmospheric plasma jet is a more effective method for the removal of heavy metals than other methods.

Keywords: Heavy Metals, Water, Purification, Cold Plasma, Cr Removal.

http://dx.doi.org/10.47832/2717-8234.11.24

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Introduction

Introduction Studying trace elements such as heavy metals is nowadays take important global interest. Heavy metals are metals and metalloids, which include iron, manganese, lead, chromium, arsenic, mercury, and copper, which have a relatively high density. These elements spread around us in our life and can be harmful to human as their concentrations across the limits. Metal ions can pollute the atmosphere, water, and soil and are considered as poisonous even if their concentrations are very low. Water could be the more effective and more in touch with human so the removal of contaminations from it is necessary thing. This matter nowadays becomes in world considerations since there is increasing and release in the industrial factories. The existence of these elements in human life resources sometimes being risky since it causes several kinds of diseases, such as liver damage, disorders to the generative system, kidney failure and can lead to death [1-4]. The standard treatment methods have been employed for reducing or removing of these pollutants from wastewater. Some of these methods are with biological basis or chemical basis as adsorption of Cr [5 - 8], precipitation using chemicals [9], coagulation [10], reverse osmosis by plants or chemicals [11], and filtration by membrane [12] used. Some of these strategies have been traditionally used in industry processes. Scientists made many experiments to find the most popular method that is efficient and not release or leave behind any other pollutants. For chromium removal one of the best available technologies are specifically reverse osmosis and membrane technology [13-14]. Amiri et al used powder of elaeagnus angustifolia fruit in the adsorption of Cr (VI) and some other metals and compared that with two adsorption models. they found that Langmuir isotherm model is best fit with them work. Their experimental work shows that natural biosorbent was best for the pollutants removal [15]. Lutfor Rahman et al studying heavy metals removal from wastewater of electroplating process by some cellulosic materials which were obtained from two waste fiber [16]. For physical methods, Sayma & Nobuya used dielectric barrier discharge plasma to remove metal ions in water. They calculate the removal rate for the work and get a maximum value of about (29%) of zinc ion from water treatment time of 10 min [17].

Since chromium is one of the most broadly used in industry applications, it is grow to be one of the most largely existing element in water sources such as groundwater and drinking water production. Although the previous methods for removing heavy metals such as Cr are practicable, still there is requirement to regard the more effectual and non-expensive method that could be applied to various treatments. In the present work, a novel method to remove Cr from water with more than 90% percent. This make this method the most effective way.

Materials and Methods

Method of work begin with the preparation of sample solutions that are with known concentrations of Cr. This was done by weighting certain weight and dissolving 0.1414 g of sulphate dichromate in purified water then diluted to 100 mL; i.e. each 1 ml of Cr equals 500 µg. The solution was diluted again to make another standard solution of concentrations (0.1, 0.05, 0.025, 0.02 and 0.001) mg/L. These solutions considered as standard solutions and each one of theme was exposed to cold plasma at different time periods. Then the standard solutions for each time period was analyzed using UV/Vis spectrophotometer.

The plasma source used in the present work is a plasma jet. It consists of tube of stainless steel with dimensions (20×3) mm which is the flow guide of discharge gas. The guide shielded with a Pyrex tube. High voltage power supply source used of 2.5 kV and a frequency of 20 kHz. At the outer end of the tube a sheet of copper with width (10) mm was used. This sheet be in order that the second electrode of power supply connected. Over the external copper electrode silicon was used. The silicone is essential to prevent direct discharge. The discharge gas used was argon gas. The flow rate of Ar (argon) was 5(l/min). The samples exposure time begins from 5 seconds until reach 10 min step 5 seconds. Figure 1 shows the cold plasma system used in the work.

Figure 1. The cold atmospheric plasma system used in the experiment.

Results and Discussion

The chosen of cold plasma to remove heavy metals is not a random test. This due to that its inexpensive system and doesn't leave any pollution or other waste to be treated again. And the chosen of Cr ions in this work is due to that it is the element used in many industries. In the present paper, results show that and for all standard samples in time of exposure to plasma equals (5 – 15) sec there were no charge in chromium concentrations. As the time reaches 20 sec the removal of the element begin. For 0.5 ppm of Chromium, the process seems to be slower than other concentrations. Table (1) shows the Cr removal concentrations (in ppm) with time of exposure to cold plasma.

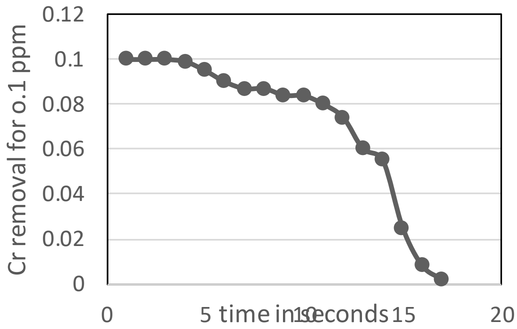
Table 1 Chromium concentrations (in ppm) with Time of exposure to cold plasma (in sec).

Time (sec)	Concentration (ppm)				
	0.1	0.2	0.3	0.4	0.5
5	0.1	0.2	0.3	0.4	0.5
10	0.1	0.2	0.3	0.4	0.5
15	0.1	0.2	0.3	0.4	0.5
20	0.099	0.18	0.299	0.388	0.499
25	0.095	0.156	0.29	0.357	0.48
30	0.09	0.111	0.27	0.345	0.479
35	0.087	0.078	0.265	0.321	0.476
40	0.084	0.065	0.2	0.306	0.466
45	0.0838	0.034	0.145	0.304	0.463
50	0.08	0.0302	0.122	0.278	0.42
55	0.074	0.0234	0.103	0.211	0.37
60	0.06	0.0101	0.086	0.08	0.304
120	0.055	0.0104	0.028	0.05	0.178
240	0.025	0.01	0.0166	0.0205	0.117
360	0.008	0.009	0.006	0.004	0.09
480	0.002	0.006	0.003	0.0035	0.06
600	0.001	0.003	0.0024	0.0034	0.005

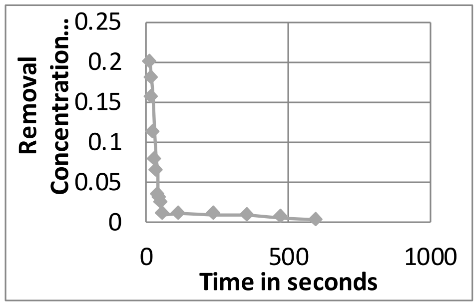
Figure 2 shows the removal rate of Cr concentration (in ppm) with time. From figure, the recurrent behavior of the Cr removal curves with time of exposure to cold plasma shows that when increasing time of exposure to cold plasma, the removal rate takes the same behaves for all concentrations. At time reaches 10 min, the removal rate increased rapidly.

For the first Cr concentration (0.1 ppm) the removal rate was quietly slow at the beginning, this is due to the fact that the concentration is little and the discharge of argon may need more time to increase the activation of species.

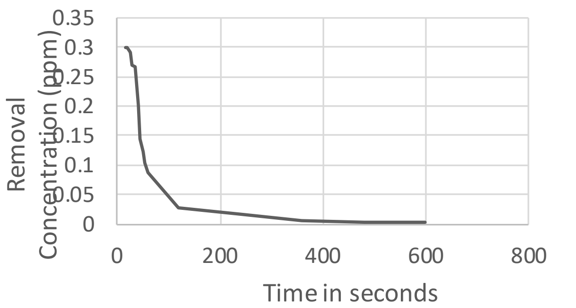
The research also studies the removal speed in all concentrations (0.1 – 0.5 ppm). It is clear that the speed was slow at the beginning and increased rapidly at a certain time. Increasing concentration leads to increasing the accelerated activated species. Also from the present results, the effect of discharge on the solution so that it becomes more acid than before discharge. This due to the creation of H_2O_2 in the solution with high rates, about four times in Ar discharge than other gases [18]. By comparison of our results with other researches [19 - 21], the present results are semi close to others in removal behavior with some differs due to the work conditions between this work and the others like discharge gas, current.. etc, while this method gives a more effective removal percentage in a little period of time in comparison to ref [22].



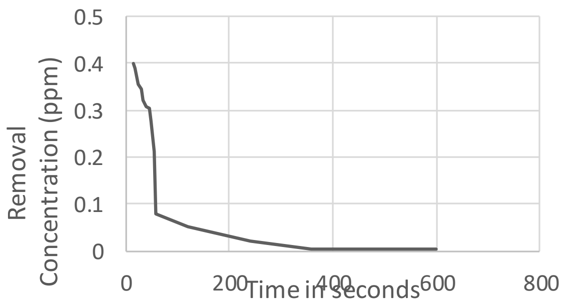
a. Cr removal rate for (0.1) ppm concentration



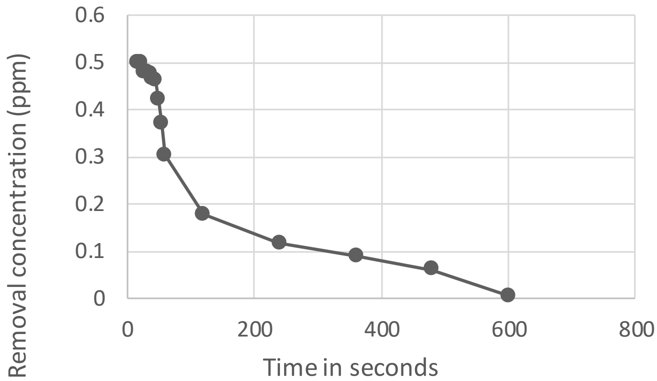
b. Cr removal rate for (0.2) ppm concentration



c. Cr removal rate for (0.3) ppm concentration



d.Cr removal rate for (0.4) ppm concentration



e. Cr removal rate for (0.5) ppm concentration.

Figure 2. Chromium removal rates behavior with time periods for different concentrations

Conclusion

The present work gives a clear scope on the use of cold plasma for heavy elements removal. Chromium may be the most element that contaminates the environment in Iraq industries and some other countries and its removal in high percentage take important interest. The removal of Cr ions from water using cold plasma was effective in the removal process and spend very little time about 10 min, with no need for more treatment. The removal rates curves behave in the same manner with a slow then fast rate. This gives an indication to the speed of the removal process. For 0.5 ppm of Chromium, the process was slower than other concentrations because of the high concentration of Cr (III) in the sample. Increasing concentration leads to increasing the accelerated activated species. Also, the usage of this method is simple and does not need to large area to work or expensive equipment. Industries can make little tanks with discharge system to treat polluted water simply.

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