Study of the health threatening mercury effective parameters for its removal from the aqueous solutions by using activated carbons

Maryam K. Hafshejani[1], Farzaneh Khandani[2], Ramin Heidarpour[3], Amin Sedighpour[4], Hamzeh Fuladvand[5], Roohollah Shokuhifard[6], Armin Arad*[7]

[1]Shahrekord University of Medical Sciences, Shahrekord, Iran
[2] Ahar Branch, Islamic Azad University, Ahar, Iran
[3]Department of applied chemistry & chemical engineering, Sofian branch, Islamic Azad University, Sofian, Iran
[4]Department of engineering, Bam branch, Islamic Azad University, Bam, Iran
[5]Department of science, Khorramabad branch, Islamic Azad University, Khorramabad, Iran
[6]Department of science, Andimeshk branch, Islamic Azad University, Andimeshk, Iran
[7]North Khorasan University of Medical Sciences, Bojnurd, Iran
Corresponding author email: aarad1384@yahoo.com

Abstract:A serious environmental threat from heavy metal ion pollution, especially mercury, has generated a great deal of attention in recent years. Mercury is one of the priority pollutant listed by USEPA as it can easily pass the blood-brain barrier and affect the fetal brain. High concentration of Hg (II) causes impairment of pulmonary function and kidney, chest pain and dyspnoea. Consequently, removal of mercury in water and wastewater assumes importance. In this review paper, we have evaluated the efforts which have been done for controlling the mercury emissions from aqueous solutions. According to the EPA agency, the tolerance limit for Hg (II) for discharge into inland surface water is 10µg/l and for drinking water is 1µg/l. Mercury (Hg) is one of the heavy metals of concern and has been found in the waste waters coming from manufacturing industry, and natural sources. Among several types of technology for removing of Hg in water (chemical precipitation, reverse osmosis, ion-exchange, etc.), adsorption is one of most frequently used. It is a complex process involving physical, chemical, and electrical interactions at sorbent surfaces. Therefore, in this study will investigate effective parameters such as pH, initial concentration and surface characteristic.

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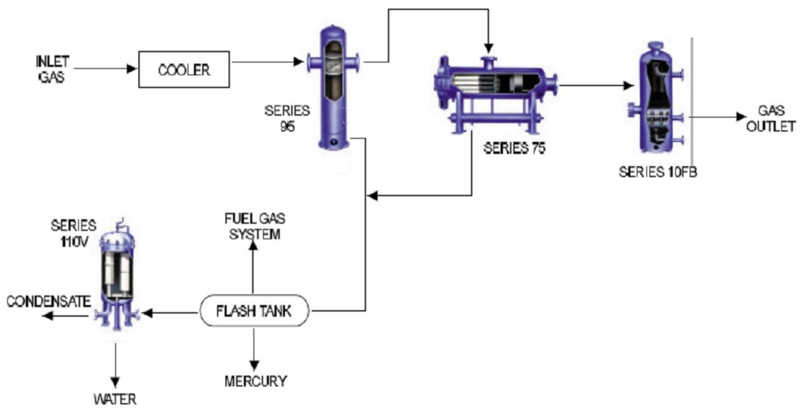
1. Introduction:

Heavy metals are known for their toxicity towards the aquatic environment. The discharge of effluents containing metals in the environment can constitute a threat to the aquatic life and have serious repercussions on the food chain. One of these metals is mercury [1-2]. Mercury exists in natural and process gases in elemental and metal salts forms. It is removed from the gases by reacting the mercury with a special impregnation on an activated carbon carrier. The mercury adsorbs to the reactant upon contact as the gas permeates the bed [1]. In past years, the presence of mercury received little attention in the environmental care. After the failure of several cold boxes, metallurgists determined that mercury corrosion was the source of the problem. Initially, it was believed that the mercury was present due to leaking instrumentation; however, further testing revealed mercury was present in the reservoir [2].

The adsorption of metallic ions from liquid has been studied for years, as well as the use of some so-called available absorbents. One of the low cost adsorbents is activated carbon. Activated carbon can be produced from a variety of carbonaceous raw materials, by either a physical or chemical activation methods. The adsorptive capacity of the final product depends on internal surface area, pore structure and surface chemistry that are defined by the nature of the starting material and production process [3].Among other reported techniques for the treatment of wastewater containing organic mercury, adsorption process shows good potential and can be cost efficient [4]. A carbon sorbent selected for mercury capture should have a suitable pore size distribution and large surface area, as a result of activation process. A carbon sorbent selected for mercury capture should have a suitable pore size distribution and large surface area, as a result of activation process. Activated carbons are widely used as adsorbents for removing different pollutants from drinking water usually, micropores posses the majority of the active sites for mercury adsorption, while mesopores act as transportation routes.



Fgure 1 : Schematic diagram of Hg removal using activated carbon [1]

Adsorption of Hg by activated carbons at ambient temperatures (e.g. 238C) has been suggested to be a combination of chemisorption and physisorption, whereas chemisorption is prevalent at higher temperatures; e.g. 1400C [5]. Many factors have been found to influence the efficiency of mercury removal, including carbon characteristics, flue gas composition, and the presence of active components [6]. The aim of the present work was to study the review of mercury (II) removal in aqueous solution by activated carbon. At first, the adsorption of mercury present in aqueous solutions onto fly ashes was studied in static reactor. Then a leaching test was also carried out to estimate the capacity of solids to retain durably the mercuric ions. Finally, the surface of spent ash samples after the adsorption experiments were investigated to understand mechanisms involved by mercury adsorption. In this paper activated carbon design has been studied. Therefore, some parameters such as temperature, initial concentration, and pH and isotherm models have been investigated as effective parameters.

2. Methods and materials:

The method of preparation of activated carbon involves two steps: the carbonization of the raw carbonaceous material in an inert atmosphere and the activation of the carbonized product. Various types of activated carbons with different pore size distributions can be obtained by using different raw materials and activation methods. The activation methods can be classified into physical and chemical activation. The former involves heating the carbonaceous materials at a high temperature with a reactant such as CO2 and H2O. The chemical activation involves heating the carbonaceous material at relatively low temperatures with the addition of activating agents such as H3PO4, ZnCl2, K2CO3, and KOH [7–8].

The adsorption capacity of designed activated carbon towards Hg(II) ion is investigated using an aqueous solution of the metal. The adsorbate stock solution of the test metal is prepared by dissolving the necessary amount of $HgCl_2$ in distilled water. This stock solution is diluted to obtain standard solutions containing fixed Hg(II) concentration. Batch adsorption studies are carried out with fixed amount of adsorbent and fixed volume of Hg solution with the desired concentration at one defined by conical flasks. Stoppered flasks containing the adsorbent and the adsorbate are agitated for predetermined time intervals at room temperature on the mechanical shaker. At the end of agitation the suspensions are filtered through microporous filter paper. The amount of the Hg(II) in the final volume is determined by atomic adsorption device.

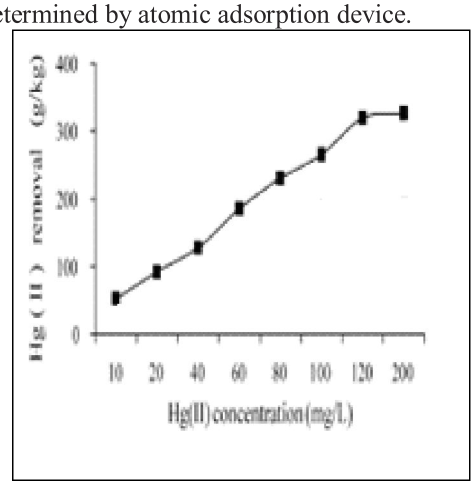


Figure 2. The effect of initial Hg (II) Concentrations on its removal by sewage sludge carbon [9].

3. Results

3.1 Initial concentrations effect:

Mercury adsorption with some activated carbons showed that the Hg removal increased almost linearly with the enhancement of Hg (II) concentration (Figure 2).

It is clear that the sorption amount of ions increases with increasing the initial ion concentration. Also, the amount of metal ion absorbed sharply increases with time in the initial stage (usually 0–20 min range), and then gradually increases to reach an equilibrium value. A further increase in contact time had a negligible effect on the amount of ion sorption. The equilibrium time was found to be independent of the initial concentration [11-13].

3.2 Adsorbent dose influence:

Mercury (II) adsorption increased with increase in the dosage of adsorbents. This increasing trend is ascribed to the introduction of more binding sites for adsorption on increasing the carbon dose.

The results of this experiment were used to develop a mathematical relationship between percentage removal and adsorbent dose by non-linear or linear optimization method.

Usually this equation can be used to predict the percentage Hg (II)removal for any activated carbons dose within the experimental conditionsstudied. One of the most important factors iscorrelation coefficient, r^2, obtained between theexperimental and calculated percentage removal values must be near 1[11]. Another effective factor is the surface area of adsorbent. By increasing in surface area the capacity of activated carbon will be increased so it can be removed a lot of mercury ions. By increasing the micro pores in activated carbons, the surface area will be increased. But interaction between ions maybe shows that the best pore size is meso pore.

4. Conclusions:

The results of several investigations on the adsorption of mercury ion by activated carbons from aqueous solutions reveal that the best absorbent is activated carbon with agricultural solid waste base. Employing activated carbons, adsorption will be increased by increasing initial Hg (II) concentration, pH of the solution, contact time and surface area of the absorbent. With physical activation, carbonization temperature in the adsorbent preparation step, and with chemical activation, types of chemicals used in the impregnation step are the most influencing parameters on the adsorption of mercury. Another important factor is the structure of porosity. The best size of pore is meso size.

Corresponding Author:
Dr. Armin Arad
North Khorasan University of Medical Sciences
Bojnurd, Iran
E-mail: aarad1384@yahoo.com

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