Technium Vol. 2, pp. 8-11, (2020)
ISSN: 2668-778X
www.techniumscience.com

Performance of Silica Adsorbent Material for Removing Copper Ions from Produced Water

Karm Z [1], Sehud R[2], Dhahir A[3]

[1,3]University of Technology, Department of Production Engineering &Metallurgy, Iraq

[2] University of Technology, Department of Petroleum Technology, Iraq

Email:engm614@yahoo.com[1], ramze_eng@yahoo.com[2], 70071@uotechnology.edu.iq[3]

Abstract. In this study investigation , the utilization silica for removal of copper ions from produced water by the adsorption process. Examination was carried out by studying several parameters like pH solution, adsorbent dosage and contact time. Experiments of adsorption were done at 25 ˚C . Copper ions adsorption was very influenced by the pH of solution . The maximum removal efficiency reached (99.99) when the pH was 7. The optimum removal efficiency conditions for Cu^{2+} using silica are pH 7, contact time 60 min, and dose of silica adsorbent 0.4 mg.

1. Introduction

Heavy metals generally are distinguished by their relatively high densities (larger than 5 $g \cdot cm^{-3}$) and a range of atomic weights most often between 63.5 and 200.6 . Heavy metals are essential for lifecycle, large quantities over desired become harmful . Water pollution due to the existence of heavy metals is the main concern today of the world. Every year, large quantities of wastewater are created from various source [1].

Produced water (PW) is salty water trapped in underground structures, which are brought to the surface during oil and gas development and production. High amount of produced water, which contains a high concentration of metal ions that resulting a lot of environmental problems, so it should be treated this water before its discharging [2].

Recommends of World Health Organization (WHO), the highest amount concentration of Cu (II) approximately value of 1.5 mg. L^{-1} in drinking water. There's a lot of ways to remove copper ions from the wastewater, including ion exchange , membrane filtration, coagulation, chemical deposition. However, these methods have many disadvantages including incomplete metal removal, expensive equipment requirements and surveillance systems [3]. A number of materials have been used to remove heavy metals from wastewater such as activated carbon, charcoal, lignite, titanium dioxide, calcium carbon, silica and clay . Silica is a fine weight material similar in appearance to common salt and it is exhibits tremendous surface area because of highly porous and that resulting in superior adsorbent capabilities. It is more preferable than activated carbon especially for removing inorganic compounds [4].

In Iraq, oilfields generates huge amounts of produced water which contain high concentration of heavy metals. However, a large amount of produced water without suitable treatment, which creates huge environmental and disposal problems. Therefore, application of silica adsorbent material for removal copper ions from produced water offers highly effective method means in dealing with the heavy metals pollution of the aqua environment with the lowest investment requirement.

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2. Materials and Method

Table 1. shows the silica adsorbent was used in this experimental work.

Table 1. Properties of Silica adsorbent.

Properties of Silica	Value
Average diameter (µm)	1.5968
Surface area (m^2/g)	9
Average roughness (nm)	35

2.1. Point zero charge of adsorbent material

Adsorbents were added to 100 ml of solutions with changing pH from 3.0 to 11.0. For control of pH solution using 0.1 M NaOH and 0.1 M HNO_3. The mixture were stirred by magnetic stirrer for 24 h at room temperature (25 ˚C) . pH start (pH1) and pH final (pH2) were recorded . Point zero charge was recognized as the lowest change of pH (Δ pH) value was found estimated by means of the following equation(1) [1].

$$\mathbf{\Delta pH = pH1 - PH2} \quad (\mathbf{1})$$

2.2. adsorption process

For study of adsorption process, produced water was used provided from Petroleum Research and Development Center related to Middle Oil Company. Experiments were performed in series of flasks containing 1L of produced water which contain 139 ppm of copper ions was stirred at 50 rpm at 25±1˚C . The parameters of experiments used in this study were (30, 60, 90, 120, 150, and 180 min) using the adsorbent dose (0.2,and 0.4 mg) at different pH of (4,7,and 10) . Regulated a pH with NaOH or HCl .The mixtures were filtered using Whatman 42 filter paper . The primary concentration of copper ions (Ci) and final concentration (Cf) were determined by coupled plasma (ICP) mass spectrometry. The removal efficiency (R%) of Cu^{2+} was calculated by Equation (2)[5].

$$R\ \% = \frac{Ci - Cf}{Ci} \times 100\ \% \quad (2)$$

3. Results and Discussion

3.1. point zero-charging point (PZC) of adsorbent material

Figure 1. shows the zero-charging point (PZC) of silica is 3. At pH lower than pH pzc ,the surface of silica becomes the positive carrier while at pH higher than pH pzc ,the surface of silica becomes the negative carrier charge. The surface charge has an important effect in the adsorption process [1]

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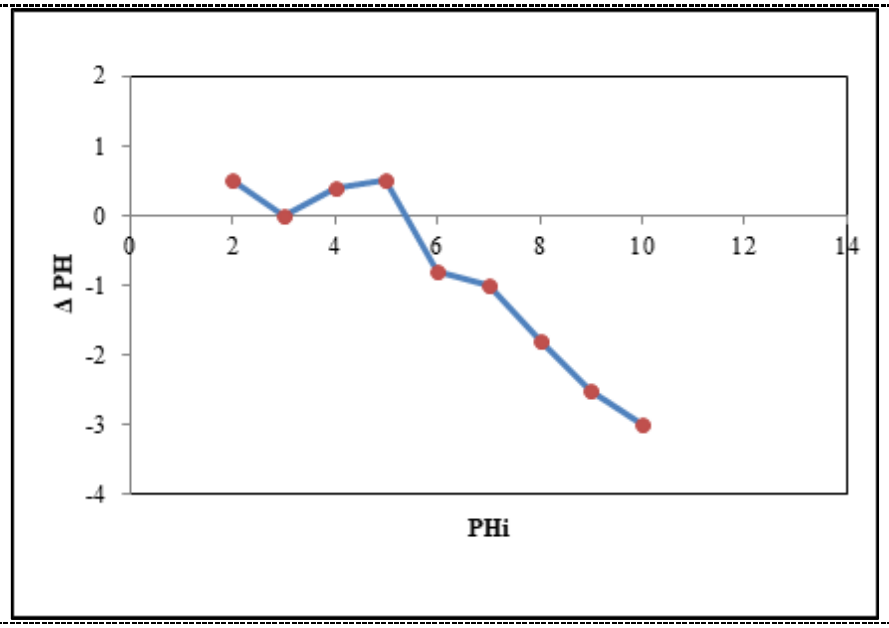

Figure 1. PH_{PZC} of silica.

3.2. Influence pH solution on copper (II) adsorption

pH of solutions are considered very important contributing and governing factor in the adsorption process [6]. The effect of pH on the copper adsorption onto silica was investigated in the 4,7,and 10 pH at 30 min (Figure 2). The maximum copper removal efficiency was found value (96.7% ,and 85.6%) at pH of 7 using 0.4 mg and 0.2 mg of silica respectively. The surface of adsorbent material becomes more negative charge with increasing pH making it more readily available for metal ion adsorption [5].

At pH of 4 competition between the Cu^{2+} ions and H^{+} ions for existing on the surface of silica , and other hand, as a result of positive charge of H^{+} ions surface associated with the silica will become positively surface charged therefore the removal efficiency rate of copper ion will be low value (78.9 % , 60.1 %) using 0.4 mg and 0.2 mg of silica respectively. The lower copper removal efficiency was found value (18.6% ,and 24.32%) at pH of 10 using 0.4 mg and 0.2 mg of silica respectively due to dissolve of silica in basal environments.

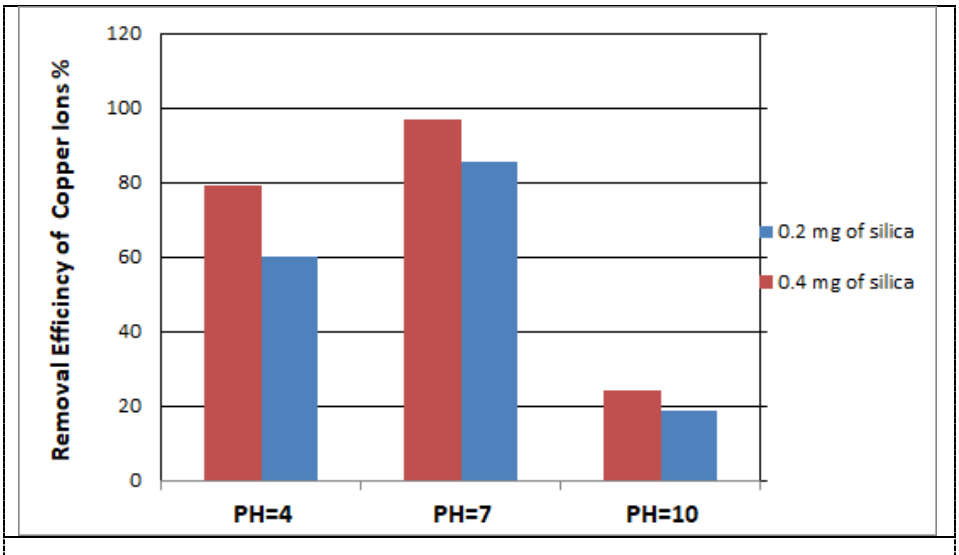

Figure 2. Effect of pH on removal efficiency of copper ions at 30min

3.3. Effect of contact time

As shown in Figure 3,the removal efficiency of copper ions using silica adsorbent was found to be relatively very rapid during the first 30 min because significant number of vacant active binding sites on surface of silica and as a result large amount of copper ions were bound rapidly onto adsorbent surface material [5] . The removal efficiency of copper ion on silica was reached maximum value (99.99 and 99.98 %) at 90 min using 0.4 mg and 0.2 of silica respectively ,after 90 min did not enhance due to non-availability of sorption sites.

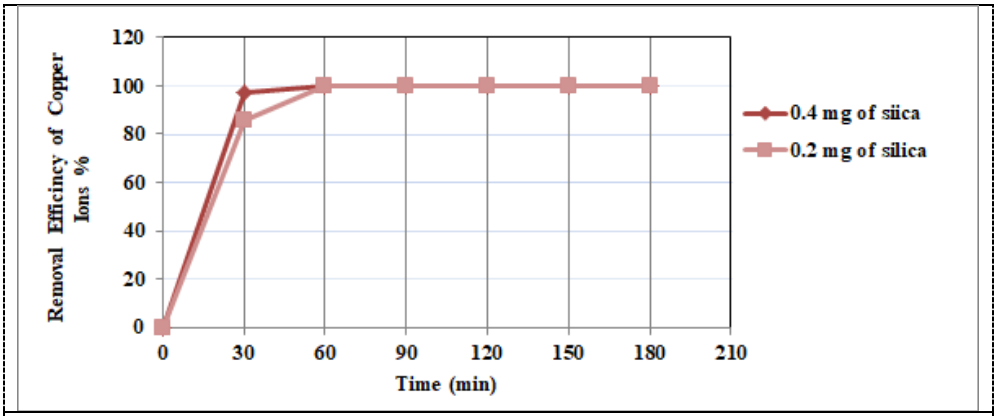

Figure 3. Effect of time on removal efficiency of copper ions

4. Conclusions

The results acquired from experimental study, it has been shown that the silica adsorbent material can be used for the removal of Cu2+ from produced water . The effect of several parameters such as pH of solution ,time of contact, and adsorbent dose has been studied. This study also showed that silica powder had the large adsorption performance of Cu2+ with a high removal efficiency rate reached to of 99.99at 90 min and 7 pH .

5. References

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