Removal of Food Carmoisine Dye E-112 From Waste Water Using Different Manufactured Media

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Abstract. The industrial and agricultural waste water contains many contaminants; one of them is the food carmoisine dye E112, which causes a series problems for the environment. Adsorption using porous media is one of the solutions to this problem. In the present work, activated silica sand (ASS), activated carbon (AC), porcelainite, silt and composite porous media, were prepared and used to remove the E112 from waste water using adsorption technique. It was predicted that the removal efficiency was affected by many factors such as time, pH, dose and ozonation of media. These factors were studied and analyzed to investigate the best media which is the activated carbon with the highest removal efficiency than the other porous medias. The results showed that:

• The best removal efficiency of carmoisine dye E-112 was by activated carbon (AC) that reaching to 76% under specific conditions (7 of pH, 20g of AC and 10 mg/l initial concentration of dye) which were selected after several attempts until reaching the best results of removal efficiency.
• Ozonation (ozon pumping to the porous media) was the effective reason of removal efficiency increasing.
• The best one of porous medias according to the removal efficiency was: AC> ASS> composite> porcelainite> silt.

Keywords: food carmoisine dye E112, adsorption, activated silica sand (ASS), activated carbon (AC) and ozonation.

1. Introduction

1.1 Adsorption technology
When the dissolved liquid or gas is stuck on the surface an Adsorption process is occurs, forming a molecular or atomic film (adsorption) [1]. Just Like adsorption, and surface tension, caused by the energy build up at surface. All surface atoms were not completely filled, therefore they pack up the adsorption [2]. In the point of view of force nature builds between the adsorbent and adsorbate, the adsorption process was classified into; chemisorption and physisorption [3].

Physical adsorption is result from the forces between molecules that react with adsorber and adsorbents. If the particles come too close together, the ferocious forces can move the particles away [4].

Chemical adsorption includes only coverage of monolayer, reaction of asite specific, occurs at specific functional group position [5].
The study's objective is: manufacturing and activation of adsorptive porous media used to remove food carmoisine dye E-112 from waste water.

1.2. Activated carbon
Activated carbon is found to be a functional absorbent, which various types of contaminants can remove such as metal ions [6].

Despite activated carbon performance, its use is sometimes decrease by its expensive cost. Therefore, investigators are looking for cheap capacitors to combat water infection, where expense plays a key role in this process. Accordingly, studies conducted until now were towards the development of alternative small -cost absorbent materials. Alternative Low-cost sorbents could manufactured from a number of different raw materials, which are sufficient and cheap, have low inorganic content, and high organic content (carbon) and can be activated easily [7].

Many advantages are shown by the manufacturing of cheap adsorbents that result from trash or waste materials, mostly from environmental and economic nature. A various range of good small -cost materials has manufactured from different waste using agricultural waste, also municipal and industrial waste. Even though many studies have most demonstrated the importance of cheap capacitors in the control of water pollution, most of them are generally either distinguishing adsorption (phenols, dyes, metals etc.) or distinguishing adsorbents [8, 9].

1.3. The Factors effecting Total Organic Carbon and heavy metal sorption:
There are several parameters which affect the sorption materials, like a temperature, hydrogen index, particle size, time of contacting …etc. [10].

1.3.1. Effect of agitation time
The agitation time was classified as one of the largest important factors that affecting the adsorption efficiency. Using the best values of metal concentration, pH, and media mass, the removal efficiency of the contaminants increases with the increasing of the time of agitation; [10].

1.3.2. pH
The influence of pH on heavy metal sorption from fluid solutions has been noted by many researchers. The researchers found that the removal of the ions of heavy metal is depending on pH for testing of varying pH ranges. Each result shows a characteristic variation of pH with the amount adsorbed which depending on the metal ion and/or initial concentration of metal, and adsorbent type; [11].

1.3.3. The dosage of Sorbent
The biomass dosage affects the amount of sorption. The amount of sorbent used for the treatment is a great limit, which determines the ability of sorbent to remove heavy metals at a given initial concentration. The sorption efficiency is highly dependent on the increasing in biomass dosage of the solution. An increasing in the biomass concentration generally increasing the amount of solute to be sorbed, due to the increasing of surface area of the sorbent, which as a result increases the number of binding sites; [12]. Sometimes, additional ricing in biomass dosage cause to lower the efficiency of sorption at primary concentration.

1.3.4. Particle size
Wang, Silbaugh, Pfeffer, and Lin [13] used different ranges of size of hydrophobic silica aerogel to get rid of oil from water in inverse fluidized bed reactors. These sizes were (0.5-0.85; 0.7-1.2, and 1.7-2.35) mm. The results represented that the main factor which influences the removal efficiency of oil and capacity is the bed particles size.

1.3.5. Initial metals concentration
Amarasinghe and Williams [15] recorded that Pb²⁺ and Cu²⁺ ions removal efficiency increases when the initial concentration of ion decreases. At low ion concentrations the ratio of surface active sites to the total metal ions in the solution is high and hence all metal ions may interact with the adsorbent and
may remove from the solution. However, the quantity of metal adsorbed per unit weight of adsorbent is higher at high concentrations.

1.3.6. Surface area, pore structure, and pore size distribution
Surface area is one of the basic characteristics that affect the adsorptive capacity of the adsorbent, because the process of adsorption results in a concentration of solutes at the surface. Pore structure and chemistry of activated carbon made from agricultural by-products are strongly depending on pyrolysis temperature, composition, and structure of the fresh material.

2. Materials and Methodology

2.1 The selected Materials
Five groups of porous media are tested in this investigation:

- Activated silica sand (ASS)
  This form of silica sand, or so-called silica sand, was obtained from light bulbs factory in Altaji, which was clean by distilled water to eliminate a chemical impurity. The clean with water sand was then dried at 110 °C for 72 hours. After drying process, crashed coal added to a silica sand by ratio of volume four to six respectively and then blended distilled water with one to one ratio and exposed to heat at various values of temperatures. The mixture had been exposed to ozone for 1 hr. media Physical characterize were obtained in the Engineering College /University of Al-Mustansiriya/ Laboratory Soil, according to No.45/1984 Iraqi specification as illustrative in Table 1.

![Activated silica Sand Media Porous](image)

**Figure 1.** Activated silica Sand Media Porous

| Characterize                          | Results from the Test |
|---------------------------------------|-----------------------|
| Apparent S.G                          | 2.33                  |
| ASTM Particle Size Distribution       |                       |
| Effective \(d_{10}\)milimeter size    | 0.43                  |
| Bulk Density (kg/m\(^3\))             | 1978                  |
| Porosity                              | 0.53                  |

- Silt
  This Iraqi soil was used as a porous media in the present study after washing by distilled water and drying at 110 °C for 24 hours as shown in Figure 2. Also, Table 2 presents the soil properties.
Figure 2. Silt

Table 2. Silt Physical Properties.

| Properties                              | Test Results |
|-----------------------------------------|--------------|
| Porosity                               | 0.38         |
| ASTM Distribution of Particle Size     | 0.16         |
| Effective 10μmeter size                |              |

- Porcilinaite
These media were supplied in this work by fragmentation process and sieving and washed by water and then placed in heating oven at 110°C in duration of 6 hr, as illustrative in Figure 3.

Figure 3. (Porcilinaite) Porous Media

Table 3. Porcilinaite Physicochemical properties.

| Constituent           | (%) |
|-----------------------|-----|
| Average diameter (mm) | 12  |
| Porosity (n)          | 0.45|

- (AC) Activated Carbon
This material is consisting of carbon treat to have pores with low-volume and small size which is rise the surface area as illustrative in Figure 4. Kaolin, crashed coal and Porcilinaite in ratio of volume six to four to four respectively were prepared with water by ratio one to one and exposed to heat at various temperatures. Table 4 shows the physical properties of Activated carbon.
4 nature media porous (Gravel, sand, Porcilinaite and clay) were prepared by gather them together. Figure 5 shows the particle size distribution of this media. Physical properties of Composite porous media are illustrative in the below Table 5.

| Characteristic | Test Results |
|---------------|--------------|
| Average diameter | 0.2 |
| Porosity | 0.6 |

**Composite media porous**

2.2. **Adsorption Process**

Adsorption solution of 75 ml was prepared, a suitable quantity of adsorbent with definite particle size, was added, then filtrate and analyze the final product for carmoisene dye concentration. The analysis was achieved by the spectrophotometer. The process repeated to ensure the results.

2.3. **Sieve Size Distribution**

The sieve for five media in this study (Activated silica sand, silt, porcilinaite, composite porous media and AC) was conducted in the Engineering College/ Laboratory of Soil.
Particle – the curves of size distribution for the two groups of media porous (silt, porcilonite) were graphed in Figure 6. Figures (7,8) show the particle-size distribution analysis for the activated carbon and activated silica sand respectively.

Figure 6. Sieve Size Distribution Curve of Silt and Porcilinaite.

Figure 7. Activated Carbon Grain Size Distribution on Porous Media.

Figure 8. Sieve Size Distribution Curve of Activated silica sand.
3. Results and Discussion

3.1. Factor affecting on the removal efficiency of porous media

3.1.1. Contact Time

The study of Contact time was carried out to accomplish the equilibrium time for maximum amount of the dye. Experiments were carried out for varying contact time with a constant adsorbent dose of 20g. Figure 9 shows the effect of contact time on carmoisene E-112 colour removal using 20 g of activated carbon, composite, porcilinaite, silt and activated silica sand added to 75 ml of 10mg/l colour solution for batch tests at 24ºC. Figure 9 explain and study the contact time for the dye to reach equilibrium. The slower sorption may be as a result of aggregation of dye molecules that surrounding the adsorbent particles. The kinetic data show that 55%, 45%, 28%, 25% and 20% colour was removed by activated carbon, activated silica sand, composite, porcilonite and silt respectively in 100 minutes.

![Figure 9](image9.png)

**Figure 9.** The efficiency of carmoisene removal on porous media

3.1.2. Solution pH

Hydrogen dye index play a key role in the adsorption operation. The operating condition must be fixed during each test, and verificate the initial concentration at 10 mg/l for the dye. The test was accomplished using sodium hydroxide and sulfuric acid. Figure 10 shows the removal efficiency of the carmoisene dye on the porous media at different pH values. The ionization happened by the dye molecules, and the capture ability of the adsorbant were strongly affect the value of the removal efficiency.

![Figure 10](image10.png)

**Figure 10.** Removal efficiency of carmoisene on porous media at several values of pH.
3.1.3. Adsorbent dose
The approval of carmoisene sorption on adsorption dosage has been studied by changing the amount of porous media (10 to 30)g which was placed to 75 ml of contaminated sample for batch system at 24°C, pH=8, and contact time 100 minute. The removal efficiencies of contaminat increases with increasing sorbent dosage as illustrated in Figure 11.

![Figure 11](image1)

**Figure 11** Effect of dose of porous media on carmoisene removal efficiencies.

3.1.4. Effect of ozone on removal efficiency
In this test, the ozone was pumped through the activated carbon, Activated silica sand (ASS), Composite, porcilonite and silt in batches at equal intervals under the same conditions, 20g of porous media which has PH=8 was added to 75 ml of contaminated solution for batch tests at 24°C.

In figures below, the removal efficiencies of color increase with increasing of ozone pumping time until it reached to the point at which the removal efficiencies gradually decreased.

![Figure 12](image2)

**Figure 12.** Effect of ozone on ASS
Figure 13. Effect of ozone on AC.

Figure 14. Effect of ozone on composite.

Figure 15. Effect of ozone on porcilonite
3.2. Environmental parameters

3.2.1. Total dissolved solids
They are solids in water that can pass through a filter. It is a measure of the quantity of material dissolved in water.

Figure 17 shows the variations of TDS concentrations in the solution during the period of 100 minutes with initial values of 780 mg/l on activated carbon, activated silica sand, composite, porcilinaite and silt respectively.

3.2.2. Turbidity removal
The clarity of a liquid is the measure as Turbidity of. It defines as ocular properties of water and it is a term of the amount of light that is dispread by material in the water while a light is brightens through the specimen of water. Figure 18 shows the turbidity variation in the solution during the period of 100 minutes with initial values of 180 NTU on activated carbon, activated silica sand, composite, porcilinaite, silt respectively.
4. Conclusions

- The Removal efficiency of carmoicine E-112 increasing with the increasing of contact time.
- Removal efficiency of carmoicine E-112 by activated carbon, composite, porcilinaite, silty sand and silty clay increasing with increasing the dosage of sorbent, at the same initial concentration and PH , and when the weight of porous media was 20 g the higher removal efficiency of E112 dye- was recorded.
- The best removal efficiency of E-112 dye was found in the activated carbon.
- It was conclude that with the rising of its initial concentration, The Removal efficiency of carmoicine E112 is rise also.
- At pH=8 higher removal efficiency of E-112 dye was recorded.
- Ozone pumping was found to be a good activated factor for adsorption process.
- The best media was activated carbon.

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