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THE EFFECT OF USING ZOLITE AND WHEAT STRAW IN TREATING WASTEWATER CONTAMINATED WITH HEAVY METALS

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Abstract:

The experiment was carried out in the laboratories of the Department of Soil Sciences and Water Resources / University of Basra. The experiment aims to demonstrate the effect of using zeolite and wheat straw in reducing concentrations of heavy metals(Pb, Fe, Zn, Mn, Cu).Untreated wastewater was used from the wastewater collection station of the University of Basra in 2022. Chemical and physical analyses of the wastewater were conducted. The properties of zeolite and wheat straw were determined, as the results of the experiment showed that the size (less than 50 microns) was superior to zeolite and wheat straw. The weight (0.5 g) was superior to zeolite (1 g) for wheat straw, as well as the duration was superior (40 minutes) for zeolite and (20 minutes) for wheat straw, as it reduced all of them (sizes, weights, and periods) significantly reduce the concentrations of heavy metals (lead, iron, zinc, manganese, and copper) of wastewater.

Keywords:

INTRODUCTION

Water is an essential factor in sustaining life on earth. It is considered a major and important factor for the growth of living organisms, including plants. As a result of the continuous increase in population density, the expansion of cities, the misuse of water resources, and the focus on rapid agricultural and industrial development, this has exacerbated the problem of water shortage and pollution. The available and renewable water resources in Iraq are estimated at approximately 63.90 billion cubic meters per year. Agricultural use constitutes 47.85 billion cubic meters, and the rest is used in industrial and population operations (Unified Arab Economic Report 2003). Heavy metal pollution is a major environmental problem facing the modern era. Rapid industrialization leads to industrial expansion, which causes a continuous increase in metal concentrations and serious pollution problems due to improper dumping and disposal of industrial wastes directly into water bodies and land areas (Dixit et al., 2015). Several methods have been used to remove heavy metals from polluted water, including the adsorption method (Davarnejad, 2016). Therefore, adsorption is one of the best suitable methods because of its high efficiency and ease of using various adsorbents such as active carbon (Lee et al., 2015) and zeolite (Peturs and Warchol., 2005) (Wang et al., 2018). Adsorption is defined as the accumulation of matter on the surface separating the solid phase and the aqueous solution. Adsorption works in most natural environmental, biological and chemical systems. Adsorption is currently one of the best methods because it is inexpensive and has good effectiveness (Gottipati et al., 2012). Zeolites are a group of alumino-silicate minerals of highly crystalline ground minerals Na, K, Ca, and Mg. It follows the group of lattice silica tectosilicates, which consists of a three-dimensional network of tetrahedrons 4-Sio4, which are connected by their four corners. It contains channels filled with water and cations (Mumpton, 1999) and (Belova, 2019). The absorption capacity of zeolite increases with the increase in the concentration of heavy metal ions and is in the order and according to the increase in the adsorption capacity $Cu^{2+} > Fe^{2+} > Ni^{2+} > Co^{2+}$. And Dalahmeh et al. (2016) due to the unique properties of charcoal. There is increasing interest in its use as a filtration media to improve water quality and wastewater system sites. It purifies water and reduces the spread of contamination from hazardous chemicals in the treated flow streams.

MATERIALS USED IN THE STUDY

1: Wastewater

Water was collected from the wastewater collection station of the University of Basra/Karma Ali in 2022. Water samples were brought in clean plastic containers. It was stored in the refrigerator at a temperature of 4°C until the required analyses were carried out according to Standard Methods (2005). The total concentration of heavy metals and the physical and chemical properties of the wastewater were measured according to Table (1).

2: Zeolite: The mineral was brought from the General Company for Agricultural Equipment in Basra Governorate in the form of particles packed in plastic bags, each bag weighing 25 kg. The metal was washed with distilled water several times. Then, put it in the oven at a temperature of 105 degrees Celsius for 24 hours until the metal dries. After that, it was saved for use, as shown in Table (2).

3: Wheat straw: The wheat straw was prepared and washed several times with distilled water. Then, it was filtered and dried at 100 degrees Celsius for 24 hours. It was then ground and placed in a Mfful Furnace at a temperature of 500 °C for the purpose of obtaining vegetable charcoal according to the method followed (1995) by Pavia et al. Stored in sealed bags until use, as shown in Table (2).

Table 1 Characteristics of wastewater taken from a treatment plant affiliated with the University of Basra.

Properties	Measurement units	Value
PH	**------**	**6.70**
EC	**ds m^{-1}**	**4.55**
copper	**mg L^{-1}**	**1.71**
lead	**mg L^{-1}**	**3.94**
manganese	**mg L^{-1}**	**6.40**
zinc	**mg L^{-1}**	**5.73**
lead	**mg L^{-1}**	**1.54**
BOD	**mg L^{-1}**	**76**
COD	**mg L^{-1}**	**600**
TS	**mg L^{-1}**	**2543**
TDS	**mg L^{-1}**	**2662**
TSS	**mg L^{-1}**	**420**
Turbidity		**232**
Total Hardness		**273**
Dissolved Oxygen DO		**6.5**
(SAR)		**4.67**
Adj SAR		**10.64**
SSR		**46.08**

Table 2 Characteristics: Zeolite mineral and wheat straw

Properties	Measurement units	Value	Properties	Measurement units	Value
wheat straw			**Zeolite**		
Organic carbon	gm kg^{-1}	**240**	**CaO**	**%**	11.93
Total nitrogen	gm kg-1	**11.30**	**Fe_2O_3**	**%**	1.64
C /N Ratio	gm kg-1	**22.0:1**	**AL_2O_3**	**%**	12.33
P	gm kg-1	**0.26**	**SiO_2**	**%**	69.25
K	gm kg-1	**1.33**	**Na_2O**	**%**	0.87
Zn	mg kg^{-1}	**26**	**MgO**	**%**	0.99
Mn	mg kg-1	**120**	**P2O5**	**%**	1.84
Cu	mg kg-1	**36**	**CEC**	Milliequivalent/100g soil	112
Fe	mg kg-1	**90**			
Pb	mg kg-1	**0.003**			

Laboratory experiments

1: The effect of different sizes of materials used (zeolite and wheat straw ash) on the adsorption of heavy elements

Three sizes of sieves were used: (less than 50, 50-200, and 200-300 microns), where the weight of grams of different sizes was taken, and wastewater in a volume of 40 ml was added to it, placed in plastic bottles and shaken for two hours. After that, it was filtered through filter paper no. A42 and the heavy elements were determined using an atomic absorption device.

2: The effect of different weights used for materials (zeolite and wheat straw ash) on the adsorption of heavy elements.

Five weights were used in the experiment (0.25, 0.5, 1, 2, and 4 grams). These weights were placed in plastic bottles with 40 ml of wastewater. It was shaken for two hours, then filtered through filter paper no. A42 and the heavy metals were measured using an atomic absorption device.

3: The effect of different times used on the materials (zeolite and wheat straw ash) on the adsorption of heavy elements.

After determining the best two weights and the best two sizes for each (wheat straw ash and zeolite), which, through the previous two experiments, showed the best removal of heavy elements, the periods for saturation of materials with wastewater were used (20, 40, 80, 160, 320, 640 minutes). After that, it was filtered using A42 filter paper, and the heavy metals were measured using an atomic absorption device.

RESULTS AND DISCUSSION

1: Evaluation of the sizes of materials used (zeolite and wheat straw) in the adsorption of heavy metals in wastewater.

To study the effect of zeolite and wheat straw ash on the adsorption of heavy metals, three different sizes were chosen for wastewater treatment (less than 50 microns, 50-200 microns, and 200-300 microns). The results indicated that the best-adsorbed quantity of heavy elements (lead, iron, zinc, manganese, and copper) by the zeolite enhancer was at a size less than 50 microns, reaching sequentially (0.362, 0.908, 0.140, 0.012, 0.330 mg L^{-1}). At the same time, the smallest amount of heavy metals adsorbed by the zeolite enhancer was at the size (200-300 microns). Their values reached (0.848, 1.768, 0.244, 0.013, 0.144 mg L^{-1}). As for wheat straw improver, the best-adsorbed amount of heavy metals was less than 50 microns. They reached sequentially (0.320, 0.784, 0.139, 0.012, 0.3467 mg L^{-1}). The smallest adsorbed amount of heavy elements is at the size of 200-300 microns. The values reached (0.920, 1.586, 0.256, 0.013, 0.176 mg L^{-1}). As the size of the particles increases, the adsorption of heavy elements decreases. Babel and Kurniawan (2003) showed that the selective ability of the natural mineral zeolite for heavy metals increases selectively with an increase in the atomic number of the metals, according to the following sequence: ($Pb2+ > Cd2+ > Cu2+ > Co2+ > Cr2+ > Zn2+ > Mn2+ > Hg2+$). As for when using straw ash, Wheat in the adsorption of heavy metals (lead, iron, zinc, manganese and copper). The highest adsorption was at sizes (less than 50 microns and 50-200 microns). However, the highest adsorption was at sizes less than 50 microns. It was shown from the (FTIR) analysis of wheat straw that it contains a hydroxyl group that helps bind copper metal (Cu) and is responsible for its removal from the aqueous solution and when wheat straw adsorbs with heavy metals when following the Langmuir isotherm model before (Farooq et al, 2010). Also, previous studies showed the efficiency of biochar as a material Adsorbent and biofilm carrier for removing organics and surfactants (Ye et al., 2019). Figs (1،2،3،4،5) effect of zeolite and wheat straw minute sizes for adsorption of heavy elements (lead, iron, zinc, manganese, copper)

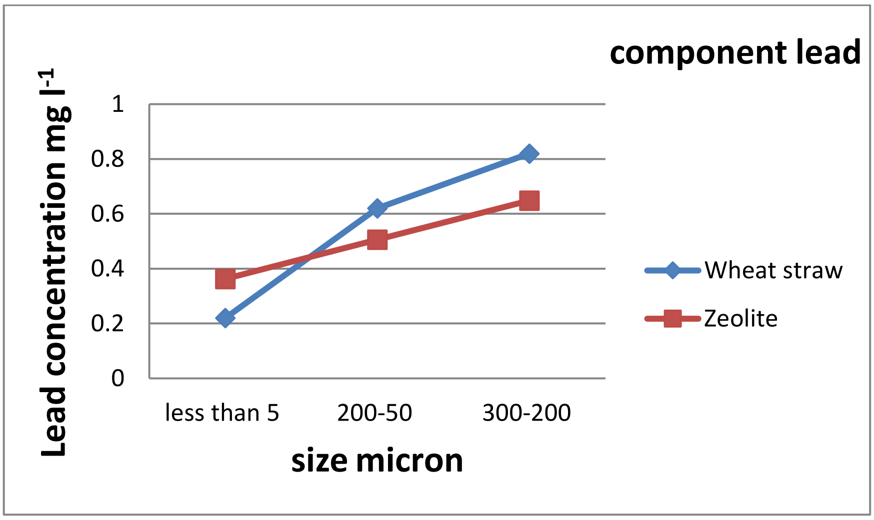


Fig .1.The effect of zeolite and wheat straw minute sizes on the adsorption of the lead element from wastewater.

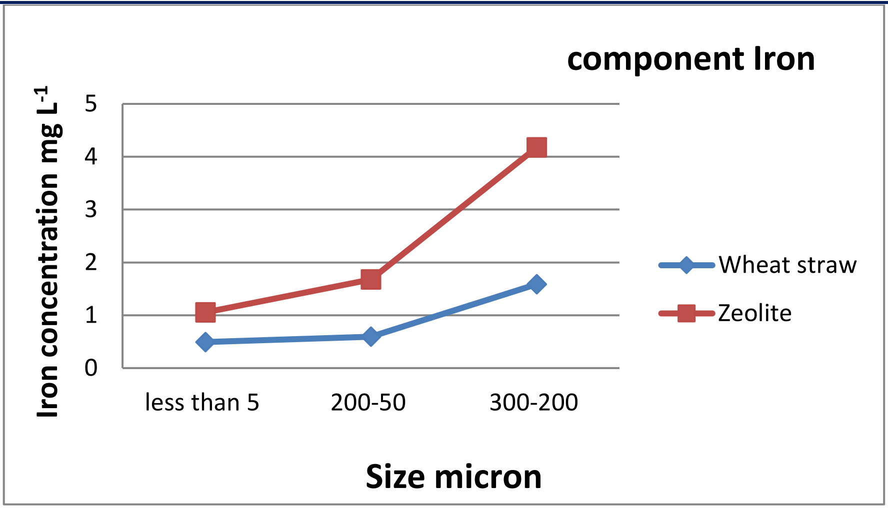


Fig. 2 The effect of zeolite and wheat straw minute sizes on the adsorption of the Iron element from wastewater

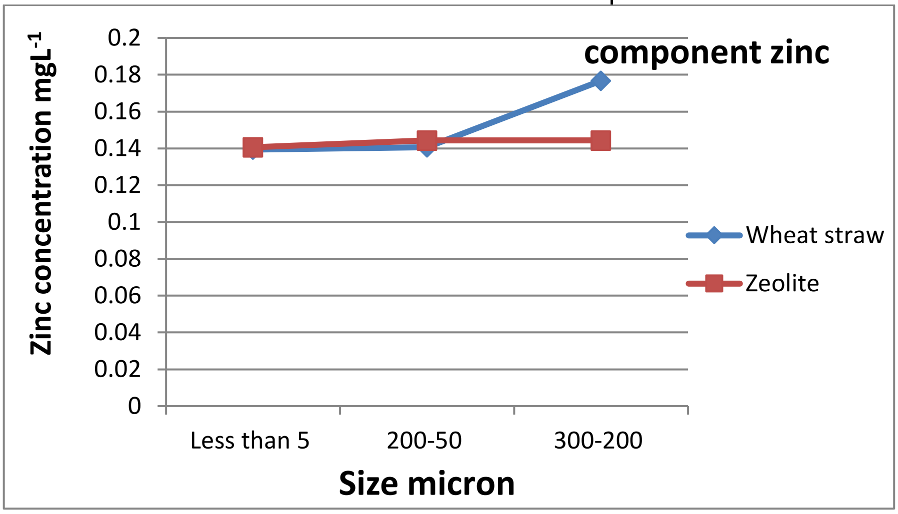


Fig.3. The effect of zeolite and wheat straw minute sizes on the adsorption of the zinc element from wastewater

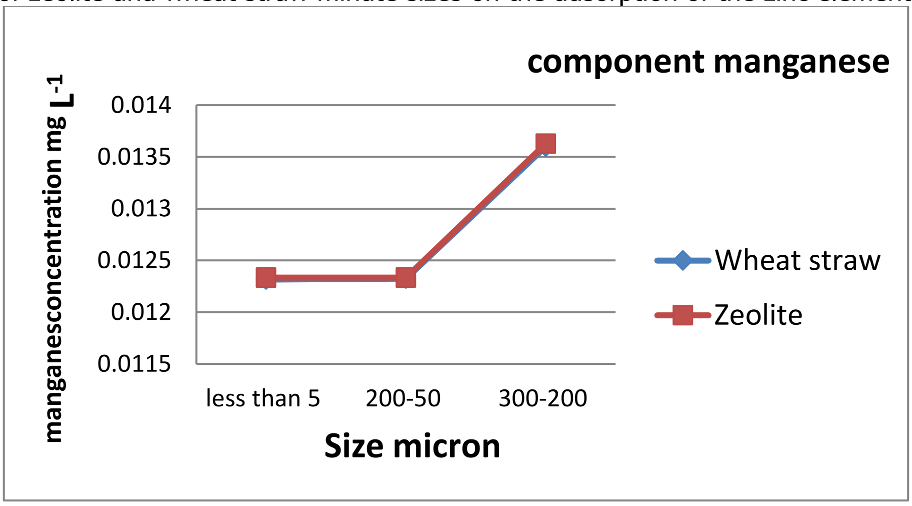


Fig .4. The effect of zeolite and wheat straw minute sizes on the adsorption of the Manganese element from wastewater

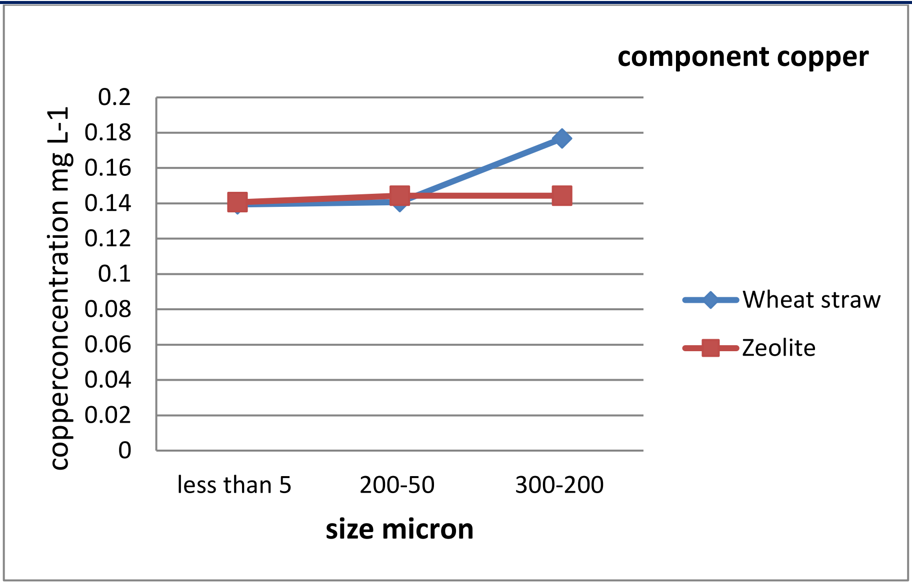


Fig.5. The effect of zeolite and wheat straw minute sizes on the adsorption of the copper element from wastewater

2: Evaluation of the weights of materials used (zeolite and wheat straw) for the adsorption of heavy metals in wastewater.

The results of the examination using the atomic absorption device showed that the highest adsorption was at the weight (0.5 g) in the zeolite enhancer. The highest amount of adsorption of heavy metals was recorded in wastewater treated with zeolite at weight (0.5 g). The values reached (0.0296, 0.213, 0.053, 0.0591, 0.386 mg L^{-1}), and the smallest amount adsorbed by weight (1 gram) reached (0.035, 0.228, 0.054, 0.0596, 0.452 mg L^{-1}). (Cabanilla et al., 2016) Explained that the mineral zeolite is of great importance in chemical reactions. This comes through its porous structure as well as a cycle in the ion exchange process.

The mineral zeolite has high adsorption properties, is often known to be hydrophilic, and is saturated with aluminium due to the large pore openings in its microstructure (Mccuster & Baerlocher, 2001). As for the results of wheat straw, untreated wastewater was passed according to the weights mentioned in the laboratory experiment. The highest rate of adsorption of heavy metals was measured, as it was shown that the best weight for the highest adsorption values of heavy metals in the wheat straw processor was at the weight (1 gm) and was as follows (0.0351, 0.0964, 0.0534, 0.0591, 0.401 mg L-1). The lowest adsorption occurred with wheat straw improver and at a weight of 4 g, where the values reached 0.0461, 0.125, 0.054, 0.0592, and 0.433 mg L^{-1}). It was shown that increasing the dose of adsorbents (the weights of the adsorbent) further enhanced its ability to adsorb heavy metals because wheat straw (wheat straw) contains pores (Amen et al., 2020), and wheat straw has a more excellent thermal decomposition behaviour. The reason for this is due to its weak (C-H) (C-C) bonds (Mohanty et al., 2013). Figs (6،7،8،9،10) The effect of the weights of the materials used (zeolite and wheat straw) to adsorb heavy elements (lead, iron, zinc, manganese, copper)

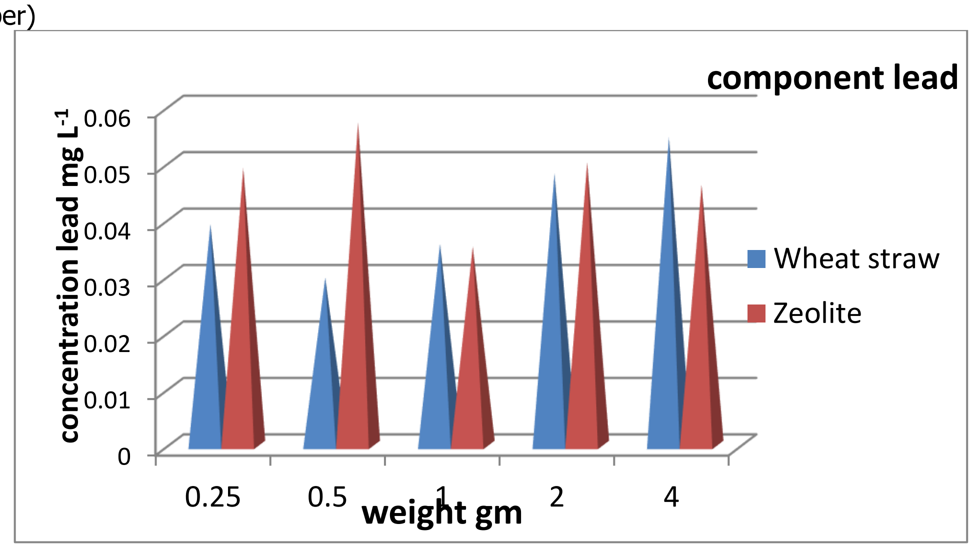


Fig.6.The effect of zeolite and wheat straw minute weight on the adsorption of the lead element from wastewater.

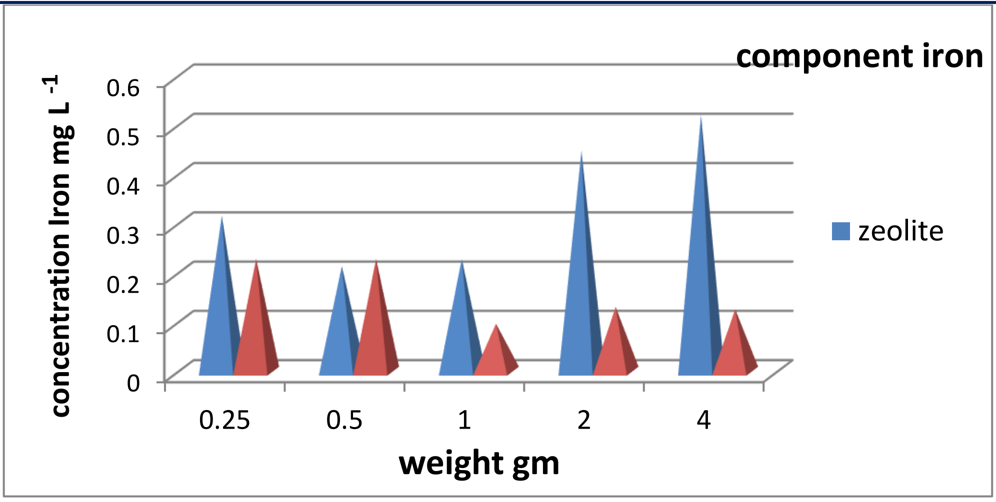


Fig.7. The effect of zeolite and wheat straw minute weight on the adsorption of the Iron element from wastewater

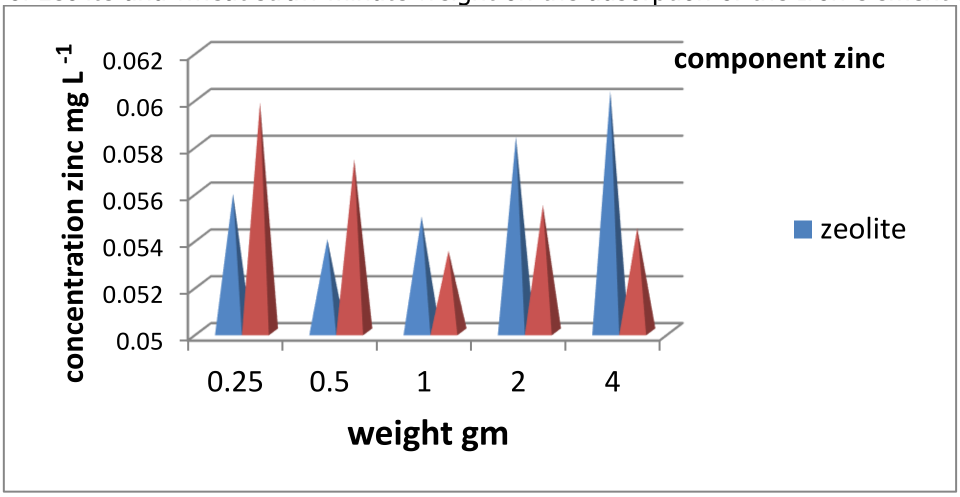


Fig.8. The effect of zeolite and wheat straw minute weight on the adsorption of the zinc element from wastewater

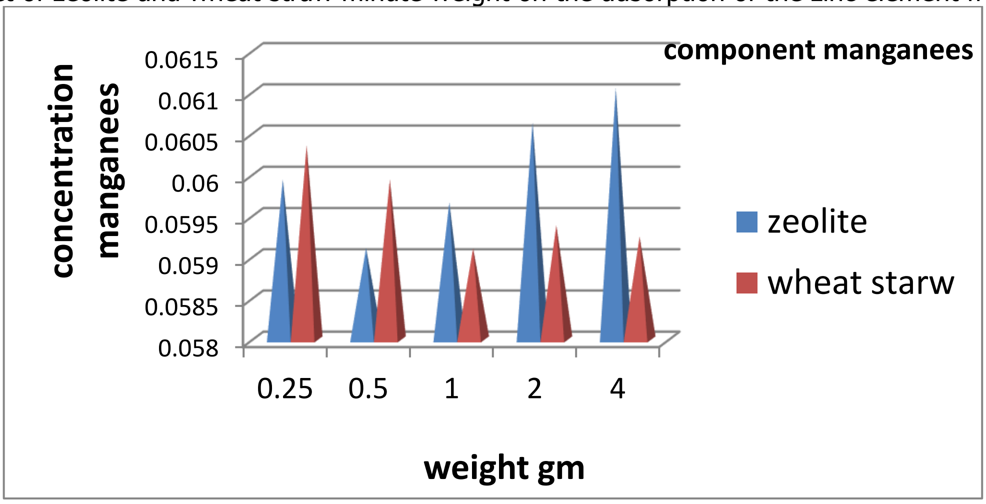
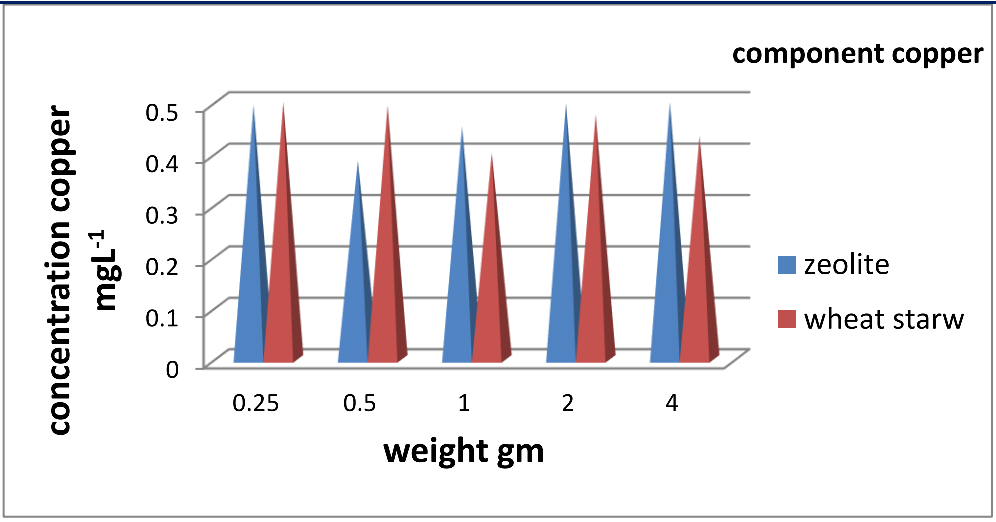


Fig.9. The effect of zeolite and wheat straw minute weight on the adsorption of the manganees element from wastewater



. Fig.10.The effect of zeolite and wheat straw minute weight on the adsorption of the copper element from wastewater

3. Evaluation of the contact time of the materials used (wheat straw and zeolite) in the adsorption of heavy metals from wastewater.

To study the effect of contact time on the adsorption of heavy elements, 6 different periods were used (20, 40, 80, 160, 230, and 460 minutes) to find out which period had the most significant effect on the adsorption of heavy elements when using wheat straw and zeolite, and the best removal of zeolite was at period 40 for all the elements studied. The element values reached (0.386, 0.018, 0.304, 0.477 mg L^{-1}). As for lead, the adsorption periods were similar and reached (0.275 mg L-1). The elements were arranged as follows according to the best removal: Zn>Pb>Mn>Fe>Cu, and this was agreed with (Sharma et al., 2008). Abdel Salam et al 2011 also noted that the rate of natural zeolite adsorption was rapid in the first 30 minutes, where the copper adsorption rate was 60%, and the zinc rate was 62%. The adsorption of heavy metals occurs particularly at low (first) contact times continuously. Natural zeolite is considered a mineral that is characterized by very low exchange mobility during long (last) contact times (Malihe et al., 2020).

The results showed that the amount of heavy elements adsorbed when using wheat straw, the highest adsorption was at the 20 minutes compared to the other times used in the experiment, where the values of the elements reached sequentially (0.554, 0.049, 0.972, 0.498 mg L^{-1}). As for lead, the values were similar and amounted to (0.275 $mg.L^{-1}$). The elements were arranged according to the most adsorption as follows: Zn>Pb>Cu>Fe>Mn. A study showed that using ground straw to remove the less toxic metal chromium ions, the process was very fast, and equilibrium was reached in less than 20 minutes (Farooq et al., 2007).

Charcoal is characterized by its large surface area and high ability to absorb heavy metals and organic pollutants. There are well-known mechanisms for charcoal to adsorb heavy elements, including surface adsorption, complication, and ion exchange. Hence (Rehman et al., 2019). Figs (11،12،13،14،15) The effect of the contact time of the materials used (zeolite and wheat straw) for adsorption of heavy elements in wastewater

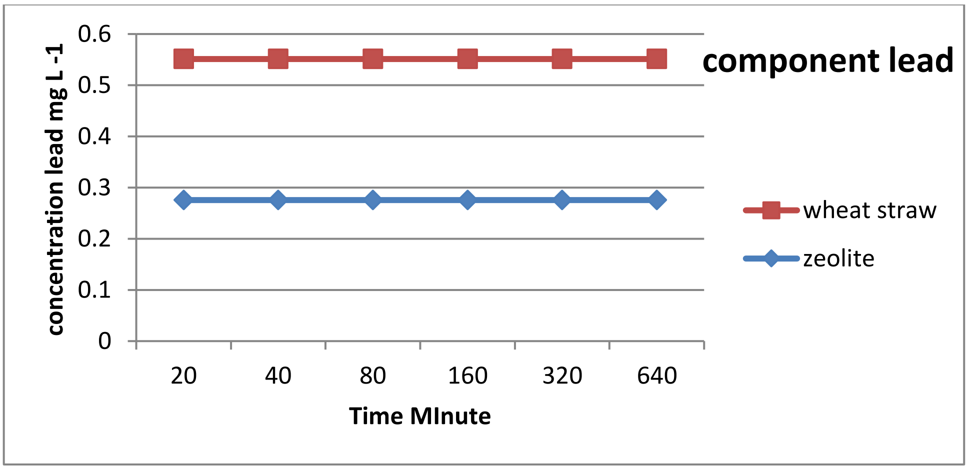


Fig. 11. The effect of the contact time of the materials used (zeolite and wheat straw) in the adsorption of the lead element.

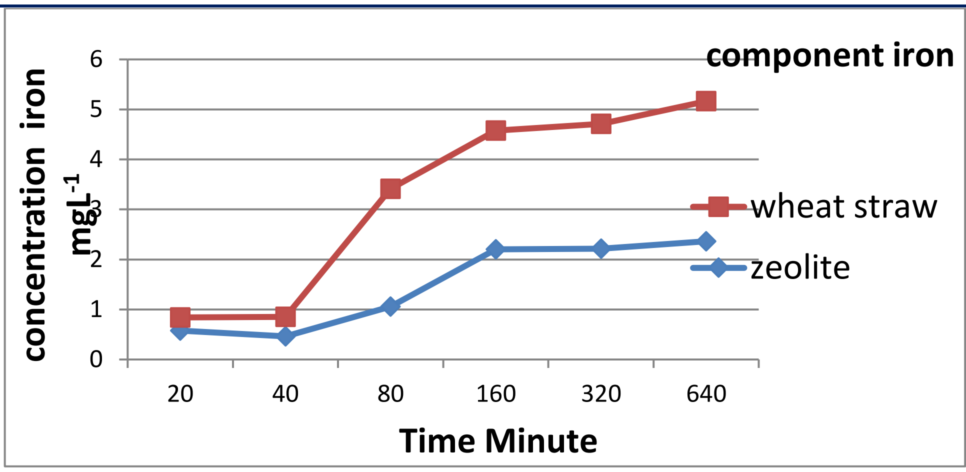


Fig.12. The effect of the contact time of the materials used (zeolite and wheat straw) on the adsorption of the Iron element.

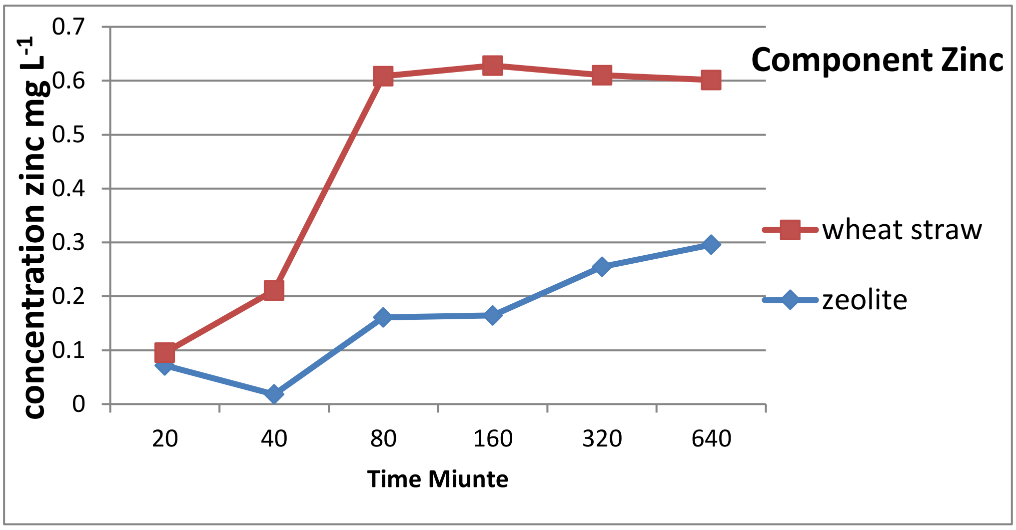


Fig.13. The effect of the contact time of the materials used (zeolite and wheat straw) on the adsorption of the zinc element.

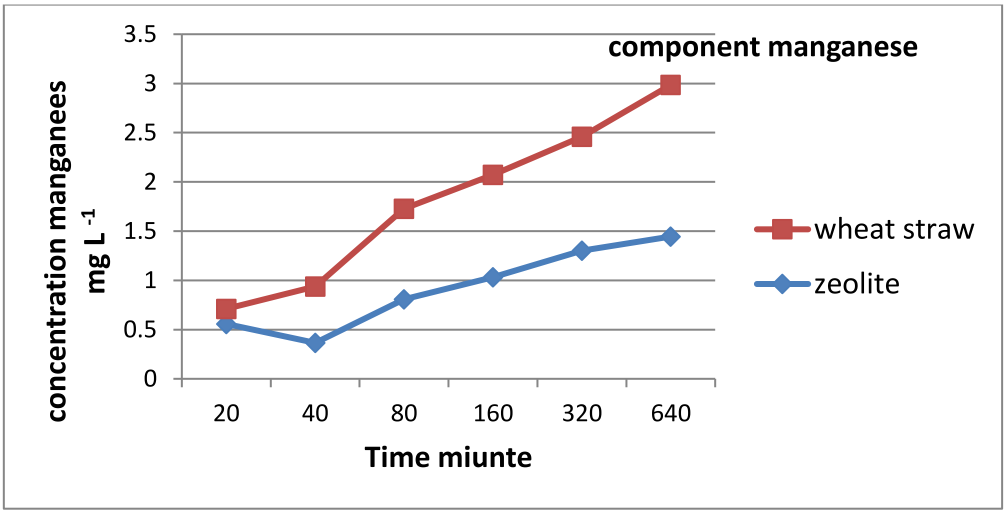


Fig.14. The effect of the contact time of the materials used (zeolite and wheat straw) on the adsorption of the manganese element.

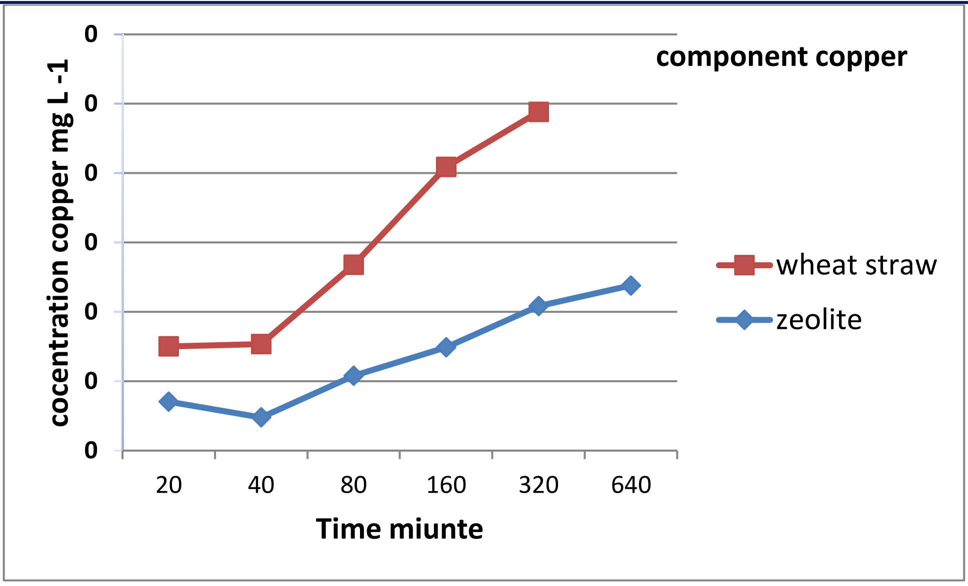


Fig .15. . The effect of the contact time of the materials used (zeolite and wheat straw) on the adsorption of the copper element.

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