Removal of Cu from Aqueous Solution Using Slag

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Abstract: This study intends to establish the usage of steel slag in absorption of Cu Within this study the two types of blast furnace and converter slag were examined in laboratory conditions and the effects of parameters of time, concentration, solutions' pH on the amount of absorption were studied. Studying the experiments showed convertor slag's absorption of Cu per gr was greater in a balance time of 15 minutes with high concentrations of metallic elements of 500 and 1000 ppm, but increase in pH did not alter the absorption. And the highest absorption of Cu was that of blast furnace slag with the same conditions. The only difference was that the more the pH increased the greater the absorption was, in a way that the greater amount of absorption occurred in a pH of 7. Considering the great volume of slag and its feature of absorbing Cu, usage of this absorbent can be taken into consideration as a method of quality treatment and complimentary filtration of effluent.

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INTRODUCTION and LITERATURE REVIEW

In order to design equipment for the handling, conveying, separation, drying, aeration, storing and processing of bean seeds, it is necessary to determine their physical properties. Recently scientists have made great efforts in evaluating basic physical properties of agricultural materials and have pointed out their practical utility in machine and structural design and in control engineering. Dimensions are important to design the cleaning, sizing and grading machines. Coefficient of friction is important in designing equipment for solid flow and storage structures. The coefficient of friction between seed and wall is an important parameter in the prediction of seed pressure on walls (Amin et al., 2004).

Heavy metals are among the components forming the earth's crust (Das et al., 2008). Their concentration in the environment has increased nowadays as the cities, and industries such as plating, mining, painting, intinction, electronics, rubber building have grown. In addition, due to their lack of quality experience there have been many environmental problems (Asiagwu et al., 2009). Heavy metals in industrial wastewater are highly hazardous for living creatures (Oboh et al.,2009). They get concentrated in the food chain and can result in health risks to human beings (Saravanan et al., 2009). There are many physical and chemical ways to extract heavy metals from water or effluent. To name a few: chemical deposit making, membrane processes, reverse Osmosis, evaporation, solvent extraction, ion exchange, and absorption (Kefala et al., 1999; Selatnia et al., 2004) . Absorption is an effective technique in purification and extraction, which has been used in industries especially in effluent filtration. In the past, because of its high capacity activated carbon was used to absorb heavy metals, but this usage has been limited due to the cost of providing the substance especially in developing countries (Souag et al., 2009). Today there seems to be a strong tendency towards using industrial and agricultural waste such as barks, sawdust, peanut skin, mountain pistachio, rice bran, corn woods, and volatile coal ash (Saikaew et al., 2009; Shama et al., 2010).Many factors including chemical form, temperature, pH, type of metal, type of absorbent, concentration of metal, amount of absorbent, and… are effective in the process of absorption and metal removing by the absorbent (Saikaew et al., 2009). Slag is one of the substances that can perhaps be used in the process of absorption of heavy metals.Slag is one of the non-metallic byproducts of metal melting industry that is produced during the formation process of iron, made of silica, alumina silica and calcium silica (Li,1999; Cha et al., 2006).A great amount of produced slag has been buried in the past without any proper utilization, but it has been of much use during recent decades (Durinck et al., 2008). However, due to the large amount of produced slag finding new methods for a better use is inevitable. Within this study the abilities of blast furnace slag and converter slag as absorbents and the effects of various parameters on absorption process by them were studied.

Table 1: some properties of Blast furnace slag and convertor slag

Salt's name	Chemical Formula	Molecular Weight (g)	Metal ion	Electrical load	Atomic weight (g)
Hydrated copper chloride	CuCl2,2H2O	170.5	Cu	+2	63.5

MATERIAL AND METHODES

The Types of Slag under study

After preparing the two types of slag both slag samples were passed through a two-millimeter sieve and the particles smaller than two millimeters were taken under study in absorption laboratories. All tests were carried out twice and their average was considered in calculations. Some of the physical and chemical properties of slag samples are shown in table 1.

Table 2: chemical properties of salts used in laboratories of heavy metal absorption

	CEC(Meq/100g)	pH	Specific surface(m^2/g)	Bulk density(g/cm^3)
Blast furnace slag	1.9	8.0	0.51	1.1
Convertor slag	2.5	11.2	2.2	1.7

Laboratory solutions containing heavy metals

Throughout this project absorption of element copper in laboratory solutions by the two types of slag were studied. Chemical formula and properties of the salt are shown in table 2. Stoke solutions with concentration of 1000 milligrams were provided for each of the aforementioned element. Solutions containing 100 milligrams of the elements per liter were prepared by diluting the stoke solutions for the tests regarding absorption of Cu by slag. One-gram slag was added to 100 milliliter of the solution with a certain concentration of cu, and the solution was stirred using a sweep shaker at 150rpm. Then these suspensions were passed through Whatman filter papers grade 42, and the concentration of Cu in the filtered solution was measured using atomic absorption spectroscopy.

Absorption tests

Determining the balance time

In order to determine the balance time the slag types using laboratory solutions that contain pollutants, absorption tests were conducted using the suspension method, by adding one gr of slag to 100 milliliter of the solution and stirring in 5, 15, 30, 60, and 120 minutes.

The effect of pH

To study the effect of the first solution's pH on the amount of absorption of Cu: copper solutions with pH's of 3, 4, 5, 6, and 7 were prepared. With pH's more than 7 the solubility of Cu' ions decreased and they settled in the form of hydraksyd compounds. Therefore, the absorption tests were not conducted in alkaline pH's. pH was adjusted by adding chloridric acid, or 0.1 chlorid to the the solution on a magnetic mixer having a pH-meter electrode, Jenway, model no. 3310.

The effect of concentration

Solutions with various concentrations of 0, 10, 25, 50, 100, 250, 500, and 1000 milligrams per liter of defined Cu and pH's were prepared to study the effects of primary concentration on the amount of absorption. Absorption tests were carried out using the suspension method by adding one gr of slag to 100 milliliter of solution.

RESULTS and DISCUSSION

Absorption of Cu by slag

Within this study the inexpensive material, slag, was used to absorb Cu in laboratory filtration solutions considering the four factors of time, pH, and concentration.

Determining the balance time

According to the figure 1, the absorption process for copper was completed in 15 minutes and then the amount of absorption by both elements remained constant. But for convenience, a time was picked for other elements' absorption and studying the effects of different parameters on the amount of absorption. The slag samples at hand were much different considering the amount of absorption of copper. The amount of absorption of Cu by the convertor slag reached almost 100 percent; while the amount of absorption of copper by the furnace slag was orderly 30 and 10 percent. The main reason to the higher amount of absorption of these elements by convertor slag can be associated with its being more alkaline, so much that the final pH of the solutions containing convertor slag was more than 10. In addition, the convertor slag has a bigger CEC (cation exchange capacity) and specific surface area compared to the furnace slag, which helps the absorption sites be more on its surfaces (table1).

The effects of pH on absorption of heavy metals

According to the figure 2 and table 3 and 4, there is no significant difference between the amount of absorption by the convertor slag in different levels of pH, and the amount of absorption for Cu went beyond 95%. In fact, the strong alkaline characteristic of of convertor slag in increasing the final pH of all solutions to more than 10 and settling of dissolved the solution did. This increase was not the same for all the elements under study. For copper, the percentage of absorption slightly rose from a pH of 3 to 6 and when pH=7 it reached to its maximum of 98%. Overall, the solution's primary pH is one of the effective parameters in absorption process of heavy metals by absorbents.

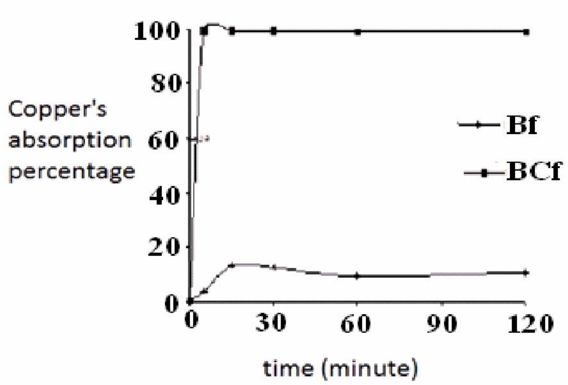

Fig 1: the effect of time of the amount of absorption of copper by slag

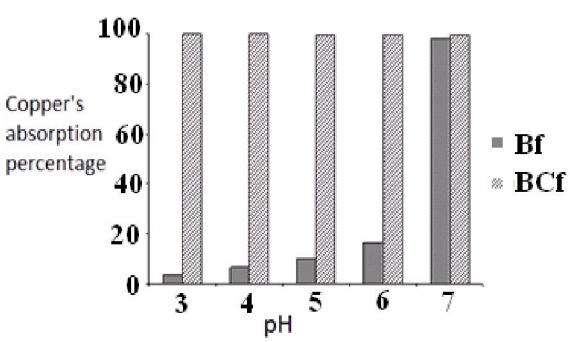

Fig 2: the effect of pH on the amount of absorption of copper by slag

Table3: the amount of absorption of Cu in different PH by Furnace slag

pH	3	4	5	6	7	8	9
Absorption(mg/g)	3.6	6.6	10	16.6	97.3	97.9	97.72

Table4: the amount of absorption of Cu in different PH by Convertor slag

pH	3	4	5	6	7	8	9
Absorption(mg/g)	99.85	99.84	99.6	99.69	99.67	99.74	99.66

Effects of concentration on absorption of Cu

The effects of primary concentration of Cu in solutions when pH=5 are shown on figure 3 and table 5 and 6. The more the concentration of metal ion increased, the higher the amount of absorption (milligram/gram) of slag samples grew. However, due to the stability of the relationship between absorbent and solution (1 gr for each various concentration) while the concentration increases, the absorption percentage, especially for furnace slag, decreases. The amount of absorption of copper was calculated orderly 77 percent.

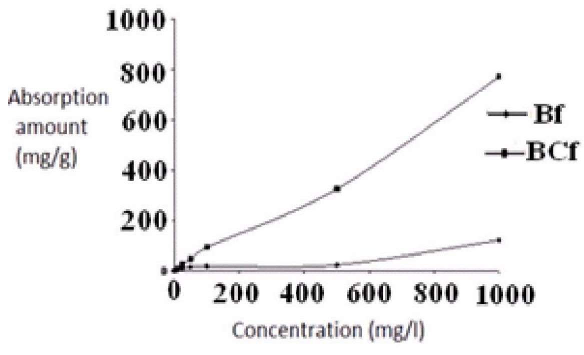

Fig 3: the effect of concentration on the amount of absorption of copper by slag

Table 5: the amount of absorption of Cu in different concentration by Furnace slag

Concentration(ppm)	10	25	50	100	500	1000
Absorption(mg/g)	5.4	11.4	15.6	19.2	23	122

Concentration(ppm)	10	25	50	100	500	1000
Absorption(mg/g)	9.83	24.53	47.2	93.96	325.5	770.1

CONCLUSIONS

According to the results, it seems that steel slag can be an appropriate absorbent for removing Cu from aqueous solutions. However, it should be heeded that due to its alkaline characteristic the amount of these elements is more when using the convertor slag compared to furnace slag; the convertor slag has played a much better role as an absorbent. As it was observed during the tests, the balance time for both types of slag was 15 minutes and it is after this time that the absorption amount remains constant. In different levels of pH for furnace slag, the more the level was, the more the amount of absorption became, while the best level of absorption happened when pH=7. But the convertor slag had a large amount of absorption at all levels of pH due to its alkaline characteristic. The amount of absorption for both types of slag increased with an increase in the concentration per gr of slag. The highest amount of absorption for both types of slag belongs to absorption in concentration of 1000ppm.As it was observed, the samples were prepared in laboratory conditions. We can take a new step into the recovery of quality and complimentary filtration effluent by using steel slag, which is an inexpensive product, as an absorbent of heavy metals in effluent filtration processes. This however requires more devotion of time to tests.

Table 6: the amount of absorption of Cu in different concentration by Convertor slag

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