HELIUM: Journal of Science and Applied Chemistry
https://journal.unpak.ac.id/index.php/helium
Volume 01, Number 01, Juni 2021, Page 11-18
e-ISSN: 2776-4508; p-ISSN: 2686-1038
Publisher : Universitas Pakuan

CHICKEN BONE BASED ADSORBENT FOR ADSORPTION OF Pb(II), Cd(II), AND Hg(II) METALS ION LIQUID WASTE

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***Article history:** received 06 April 2021; revised 20 Mei 2021; accepted 26 Juni 2021; published 31 Juni 2021*

Abstract

High productivity of chicken meat for supplying society also make some impact in high productivity of chicken bone and because it's unraveling properties makes this become waste. Pharmaceutical's Waste comes from production process, adstertion of production tools, laboratory activities and rejected product. Laboratory's routine analysis also producing residual waste analysis, one of the sources is come from heavy metals analysis of Pb, Cd, dan Hg. General process for waste treatment producing high quantity of sludge, mean while using third party service have impact in high costing of transportation and treatment process. An alternatif way for this case is using sorption treatment. Initial research starts from preparation of chicken bone-based adsorbent and its characterization using SEM and FTIR, followed by quality analysis of fresh waste (which is waste A and waste B) observed at pH, COD, TDS, TSS also Pb, Cd, dan Hg metals. Adsorption process was observed from adsorbent's graying temperature, adsorbent's particle size, contact time, pH of waste, and adsorbent's weight. Best result from adsorption process were applicated at fresh waste and simulation waste of Pb, Cd, and Hg metals also re-testing quality analysis of fresh waste and simulation waste for before-after result comparing purpose. The purpose of this research is for characterizing chicken bone-based adsorbent, observing adsorption process of Characterization of chicken bone ash-based adsorbent has been carried out in adsorbing Pb, Cd, and Hg metals in pharmaceutical laboratory waste. Functional group analysis with Fourier Transform Infrared Spectrophotometer (FTIR) showed that the chicken bone ash adsorbent contained the mineral compound apatite carbonate. Surface morphology with a Scanning Electron Microscope (SEM) shows that the adsorbent surface is porous and appears to be adsorbing metals. From the adsorption observations, it was found that the best adsorption conditions were at an ashing temperature of 800 ^oC, particle size of 80 mesh, contact time of 30 minutes, waste conditions at pH 6 and an adsorbent weight of 600 mg. Application chicken bone-based adsorbent against pharmaceutical waste shows its existence improve the quality of waste but still do not meet the quality standard requirements for Hg metal.

Keywords: pharmaceutical waste; heavy metals; adsorbent; chicken bone ash.

1. INTRODUCTION

Indonesia is a country that has a high population, so that it will affect the need for clothing and food. One of them is the consumption of chicken meat. The Directorate General of Animal Husbandry and Animal Health, Ministry of Agriculture of the Republic of Indonesia shows that the national production estimates for broiler chicken (broiler) in Indonesia are 1,498.87 tonnes (2013); 1,544.38 tons (2014); 1,628.31 tons (2015); 1,905.50 tons (2016), and 1,848.06 tons (2017). Increased production of broiler chicken meat appears as an impact of increasing consumption of Indonesian people, so that chicken bones as waste that are difficult to recycle will increase.

Bone contains both organic and inorganic components, where the main constituent of the bone inorganic phase is crystalline salt minerals in the form of calcium phosphate compounds which are often idealized as hydroxyapatite [1]. Hydroxyapatite mineral is a bioceramic material with a porous surface [1], so it has the ability to act as an adsorbent. One of the functions of this adsorbent is to adsorb metals in liquid waste.

One source of liquid waste comes from the pharmaceutical industry sector, which is generated from the production process, washing of production equipment, laboratory activities, and residual products that have been declared not of quality quality or originating from the failure of the production process (rejected product) [2]. One of the activities in the pharmaceutical industry is activities in laboratories that produce liquid waste from testing for heavy metal contaminants such as lead (Pb), cadmium (Cd), and mercury (Hg) which are referred to as "The big three" contributors to negative impacts. environment [3]. In the process of removing heavy metals from liquid waste, chemical substances such as chromate, nitrite, nitrate, phosphate and molybdate can be used. However, this has another impact in the form of the cost of using expensive materials and producing high quantity of sludge, which creates new problems [4]. Liquid waste treatment with the help of a third party can be carried out, but with the risk of processing and transporting waste high cost. One alternative way is using waste treatment sorption [5]. Adsorption using carbon is stated as a conventional treatment which has a high unit cost, especially in developing countries [6].

This research was conducted to utilize chicken bone waste as adsorbent to adsorb metals Pb, Cd, and Hg, which are applied to Pharmaceutical Laboratory wastewater.

2. METHODS

The materials used in this study included: chicken bones obtained from Catering Y Bogor, pharmaceutical laboratory waste from PT X Bogor, mains solution of Pb, Cd, and Hg, $KMnO_4$, $K_2S_2O_8$, $NH_2OH.HCl$, $SnCl_2$, H_2SO_4 (p), and HCl (p).

The tools used are: Spectroscopy Electron Microscope (SEM), Fourier Transform Infrared Spectrophotometer (FT-IR), Atomic Adsorption Spectrophotometer (AAS) with a Mercury Vapor Unit (MVU) device, shaker, mesh analyzer, pH meter, timer, polyethylene waste container, and glassware.

2.1. Making Chicken Bone Ash Adsorbent

First the chicken bones are boiled, then cleaned of organic matter such as marrow, and dried in an oven at 105 ^oC for 1 hour. The dried chicken bones are then put into the furnace for the ashing process in 600 ^oC; 700 ^oC; and 800 ^oC for 20 minutes. The results of the ashing of the chicken bones were then crushed with a mortar and mortar until they were smooth, then the powder was sieved using a mesh analyzer. Furthermore, the functional group characterization was carried out by FTIR and surface morphology by SEM.

2.2. Waste Quality Analysis

2.2.1. Analysis of Pb and Cd Metals

Analysis of Pb and Cd metals using an optimized Atomic Adsorption Spectrophotometer (AAS) according to the instructions (SNI 06-6989 8-2004; SNI 06-6989 16-2004).

2.2.2. Hg Metal Analysis

Analysis of Hg metal using an Atomic Adsorption Spectrophotometer (AAS) -MVU which has been optimized according to the instrument instructions (SNI 6989.78: 2011)

2.2.3. COD analysis

COD analysis was performed using the APHA 5200 B method.

2.2.4. TDS analysis

TDS analysis was carried out by the method according to SNI 06-6989 27-2005.

2.2.5. TSS analysis

TSS analysis was carried out according to the procedure in SNI 06-6989 3-2004.

2.2.4. pH Analysis in Waste

The pH value is measured using a calibrated pH meter (SNI 06-6989 11-2004).

2.3 Adsorption Process Observation

2.3.1. Ashes Temperature

A total of 10 grams of dried chicken bones are ignited in the furnace at a temperature variation of 600ºC; 700ºC; and 800ºC for 20 minutes. The ashing result was then crushed with mortar and mortar and sieved with mesh size no. 80. A total of 500 mg of powder is weighed into a 100 mL separating funnel, and 100 mL of waste is added. Then shaken with a shaker for 30 minutes. The supernatant was taken and then analyzed the content of Pb, Cd with SSA and Hg using SSA-MVU.

2.3.2. Particle Size

A total of 5.0 grams of powder produced from heating the optimum ashing temperature was weighed into a mesh sieve with a mesh size variation no. 60; 80; and 100. Sieved with a shieve analyzer with an amplitude of 100 for 10 minutes. The powder used is the powder that passes through the mesh. A total of 500 mg of the powder is put into a 100 mL separating funnel, and 100 mL of waste is added. Then shaken with a shaker for 30 minutes. The supernatant was taken and then analyzed the content of Pb, Cd with SSA and Hg using SSA-MVU.

2.3.3. Contact Time

A total of 500 mg of powder as a result of ashing and sieved with the optimum mesh size is weighed into a 100 mL separating funnel, and 100 mL of waste is added. Then shaken with a shaker for a variation of 20 minutes; 30 minutes; and 40 minutes. The supernatant was taken and then analyzed for Pb and Cd content using SSA and Hg using SSA-MVU.

2.3.4. Waste pH

A total of 500 mg of powder as a result of ashing and sieved with the optimum mesh size was weighed into a 100 mL separating funnel, and added 100 mL of waste with a variation of pH 5; 6; and 7. Then shaken with a shaker for the optimum time. The supernatant was taken and then analyzed with pH meter.

2.3.5. Adsorbent Weight

A number of powder as a result of ashing and sieved with the optimum mesh size is weighed with a weight variation of 400 mg; 500 mg; and 600 mg into a 100 mL separating funnel, and 100 mL of waste with optimum pH is added; then shaken with a shaker for the optimum time. The supernatant was taken and then analyzed for Pb and Cd content using SSA and Hg using SSA-MVU.

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e-ISSN: 2776-4508; p-ISSN: 2686-1038
Publisher : Universitas Pakuan

2.3.6. Adsorbent Sorption Characteristics

The powder as a result of ashing and sieving with the optimum mesh size is weighed as much as the optimum weight into a 100 mL separating funnel, and 100 mL of simulated waste Pb and Cd are added each with various concentrations of 20, 40, 60, 80, and 100 ppm; Hg simulation waste with variations of 10, 20, 30, 40, 50 ppm with optimum pH. Then shaken with a shaker for the optimum time. The supernatant was taken and then analyzed for Pb and Cd content using SSA and Hg using SSA-MVU. The adsorbent sorption was carried out on Pb, Cd, and Hg metals respectively tested by Langmuir and Freundlich equations.

2.3.7. Adsorbent Application in Simulation Waste

The powder resulting from ashes and sieved with the optimum mesh size is weighed as much as the optimum weight into a 100 mL separating funnel, and 100 mL of simulated waste Pb, Cd, and Hg are added each with various concentrations of 10, 15, and 20 ppm with the optimum pH. Then shaken with a shaker for the optimum time. The supernatant was taken and then analyzed for Pb and Cd content using SSA and Hg using SSA-MVU.

2.3.8. Adsorbent Application in Fresh Waste

The powder resulting from ashes and sieved with the optimum mesh size is weighed as much as the optimum weight into a 100 mL separating funnel, and 100 mL of waste with the optimum pH is added. Then shaken with a shaker for the optimum time. The supernatant was taken and then analyzed the pH, COD, TDS, TSS, as well as Pb and Cd metal content using AAS and Hg using SSA-MVU.

3. RESULTS AND DISCUSSION

The adsorption that occurs on heavy metals from the waste liquid with chicken bone-based adsorbent is a physical adsorption. Physical adsorption occurs due to an imbalance of the adsorbent surface which tends to be porous so that it tends to attract the adsorbate (heavy metal) to the adsorbent surface. Ash is defined as the residue of inorganic substances left over from combustion at temperatures above 575ºC [7]. In the ash making process, a material is heated and the mechanism consists of drying, devolatilization of volatile compounds, and burning charcoal. Moisture will be lost in the drying process, volatile compounds will evaporate and the results of burning charcoal will produce heat. In the charcoal burning process, there will be a reaction between carbon and oxygen to form CO gas, which then develops into CO_2 gas so that in the end there will be only material known as ash [8].

Figure 1. Visualization of Chicken Bone-based Adsorbent

3.1. Characteristics of Functional Groups of Chicken Bone Ash Adsorbent with FT-IR

In determining the functional groups contained in this chicken bone-based adsorbent, FT-IR analysis was carried out and the results were displayed in spectral form. The following is the FT-IR spectrum result of the adsorbent based on chicken bones.

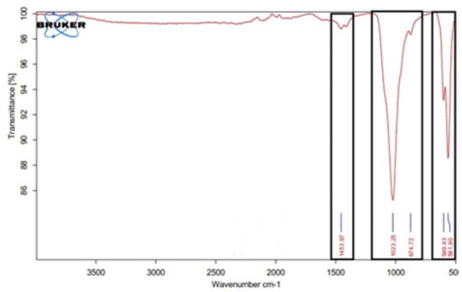
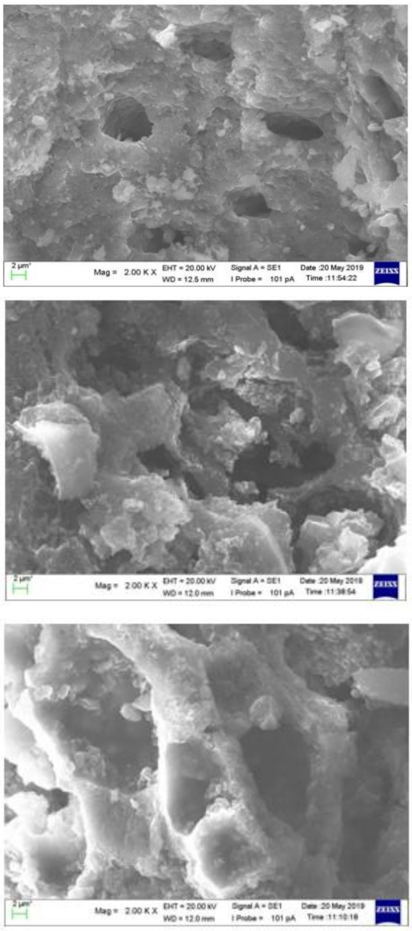


Figure 2. FT-IR Adsorbent Results

On Figure 2 shows that there is a sharp vibration of PO_4^{3-} groups at wave numbers 500 - 700 cm^{-1}; 900 - 1200 cm^{-1}; and the carbonate group (CO_3^{2-}) at wave number 1453 cm^{-1}. Research related to the results of FT-IR analysis of apatite minerals was stated by Alami [9] that the hydroxyapatite mineral in fish bones can be identified by the presence of PO_4^{3-} groups and OH^- groups. PO_4^{3-} groups that appear at wave numbers 900-1200 cm^{-1} can only appear in apatite minerals that undergo a sintering process (strong heating without destroying the substance being heated) above 500ºC [9]. However, in the research conducted there was no vibration which indicated the presence of an OH^- group; instead a carbonate group (CO_3^{2-}) appears. In the type of hydroxyapatite minerals as $Ca10(PO_4)_6(OH)_2$; Thus, it can be concluded that the apatite minerals contained are not derived from hydroxyapatite minerals; but can come from the mineral apatite carbonate type A or type B.

3.3. Surface Morphology of Chicken Bone Ash Adsorbent by SEM

Characterization was carried out on 2 types of adsorbents, namely before and after contact with waste, magnification of 2,000 times.



(a) (b) (c)

Figure 3 The surface morphology of the adsorbent before contact (a), after contact with waste A (b), after contact with waste B (c).

Based on Figure 3, it can be concluded that this adsorbent has a rough surface and is also porous (Figure (a)). In accordance with the research stated by Darmayanto [1], apatite mineral has a surface that tends to be rough and also porous. Thus, there is a relationship that the chicken bone ash adsorbent can be used as an adsorbent.

3.4. Results of Preliminary Measurement of Waste Quality

The analysis carried out in the initial determination of the quality of the waste used was checking the values of COD, TDS, TSS, pH, and the metal content of Pb, Cd, and Hg in fresh waste.

Table 1 Fresh Waste Quality before Adsorbent Contact

No	Parameter	Unit	Analysis Result Fresh Waste		Quality standard based on PermenLH No. 5 of 2014 (Gol. II)
			A	B	
1	COD	mg/L	220,08	263,45	150
2	TDS	mg/L	88	74	
3	TSS	mg/L	18	46	100
4	pH	mg/L	2,143	2,013	6-9
5	Metal				
	a. Pb	mg/L	8,05	-	1
	b. Cd	mg/L	9,58	-	0,1
	c. Hg	mg/L	-	7,17	0,005

Based on Table 1, it can be concluded that the condition of the waste is beyond the water quality standard based on PermenLH No. 5 of 2014 (Gol. II).

3.5 Results of the Adsorption Process Observation

3.5.1. Ashing Temperature Relationship in the Adsorption Process

The ashing temperature variation was carried out at a temperature of 600ºC; 700ºC; and 800ºC with the addition of adsorbent as much as 500 mg measuring 80 mesh, and contacted with waste for 30 minutes, at pH 6.

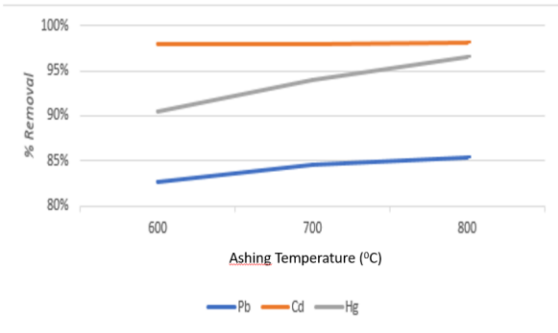


Figure 4. Graph of the relationship between ash temperature and% removal of Pb, Cd, and Hg metals

Based on Figure 4, it can be seen that an increase in ashing temperature can increase the% removal value. The results of this study are in accordance with research conducted by Idrus et al.,[10] regarding the effect of ashing temperature on the formation of activated carbon from coconut shells. In Figure 4, it is also seen that the increasing temperature, the adsorbent adsorption ability of Pb, Cd, and Hg metals increases, and reaches the optimum conditions at an ashing temperature of 800 ºC.

3.5.2. Particle Size Relationship in the Adsorption Process

The adsorbent that has been asphalted at the optimum temperature (800 ºC) is then sieved using a variation of the particle size of 60, 80, and 100 mesh. A total of 500 mg of adsorbent was contacted with the waste for 30 minutes at pH 6.

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e-ISSN: 2776-4508; p-ISSN: 2686-1038
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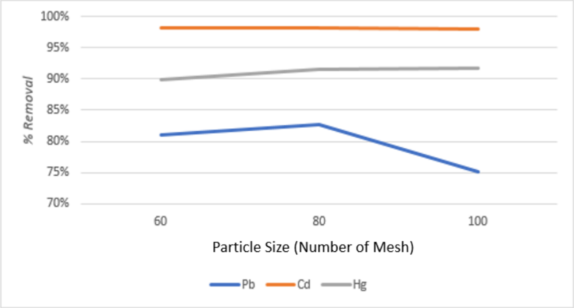

Figure 5. Graph of particle size relationship to% removal of Pb, Cd, and Hg metals

On Figure 5 can be seen that there is an increase in the% removal value along with the decrease in the size of the adsorbent particles. These results are consistent with the research conducted by Lia et al., [11] in determining the effect of the adsorbent particle size on continuous adsorption of waste.

Figure 5 shows also, for Pb metal with adsorbent measuring 100 mesh has decreased. This is possible because when the adsorbent manufacturing process is carried out in an open space, where there is free, humid air. The more the adsorbent particle size decreases, the adsorbent surface area will increase. From the increase in the surface area of the adsorbent, there is a possibility that the adsorbent will more easily adsorb moisture from free, humid air so that it covers the adsorbent surface and results in a decrease in the adsorption ability of the adsorbent [11]. In this study it can be concluded that the smaller the particle size, the larger the adsorbent surface area and the adsorption capacity will increase, and the achievement of % removal in the best conditions is by using an adsorbent that passes the mesh no.

3.5.3. Contact Time Relationship in the Adsorption Process

There were variations in contact time of 20, 30, and 40 minutes using the adsorbent that had been ignited at the optimum temperature (800 ºC) and the optimum particle size (80 mesh), as much as 500 mg of adsorbent against the waste that was conditioned at pH 6.

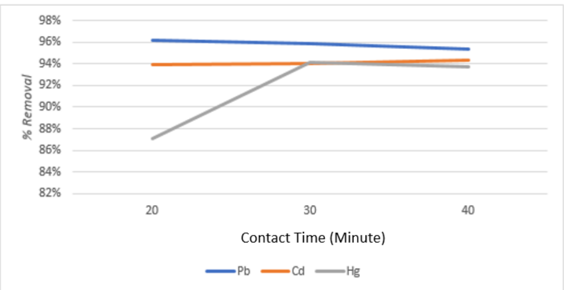

Figure 6. Graph of the Relationship between Contact Time and% Removal of Pb, Cd, and Hg

On Figure 6 shows that the % removal value of Pb and Cd decreased; while the % removal value of Hg increased. This can occur because in the waste condition A contains Pb and Cd metals which experience competition in the adsorption process carried out by the adsorbent. According to the research conducted by Anyakora et al. [12] where decreased levels of Pb (II), Cd (II), and Cu (II) with wheat adsorbent experienced differences in single simulation waste (each metal) and mixed simulations which indicated there was competition between metals contained in the waste. during the adsorption. In this study it can be concluded that the optimum % removal in terms of contact time for Pb, Cd, and Hg metals is 30 minutes.

3.5.4. The relationship between waste pH in the Adsorption Process

This research was carried out using variations in the pH of the waste namely at pH 5, 6, and 7. Total of 500 mg of adsorbent obtained from heating the optimum temperature (800 ºC), optimum particle size (80 ppm) and being contacted during the optimum contact time (30 minutes).

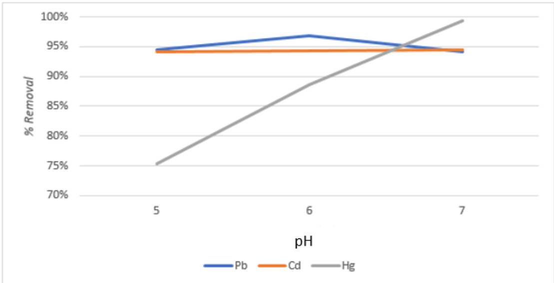

Figure 7. Graph of the Relationship between Waste pH and% Removal of Pb, Cd, and Hg

In Figure 7, it can be seen that there is an increase in the % removal value as the pH of the waste increases. The value of % Cd removal did not change significantly or was stable. Hg metal has an increase in the % removal value along with the increase in pH. The value of % Pb removal decreased at pH 7.

According to Cooney [13], if the pH of the adsorbate solvent is around the pH of the adsorbate ionization, there will be a repulsive interaction between the adsorbate and the adsorbent surface. Interactionwhich is formed is stronger than the Van Der Waals force so that it affects the adsorption equilibrium. In this study, it can be concluded that the optimum pH of the waste for the adsorption process is pH 6.

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e-ISSN: 2776-4508; p-ISSN: 2686-1038
Publisher : Universitas Pakuan

3.5.5. Adsorbent Weight Relationship in the Adsorption Process

In this study, the adsorbent weight variations were used, namely 400, 500, and 600 mg. The adsorbent powder obtained from heating the optimum temperature (800 ^oC), optimum particle size (80 mesh), was contacted during the optimum contact time (30 minutes) with the waste that had been conditioned to the optimum pH (pH 6).

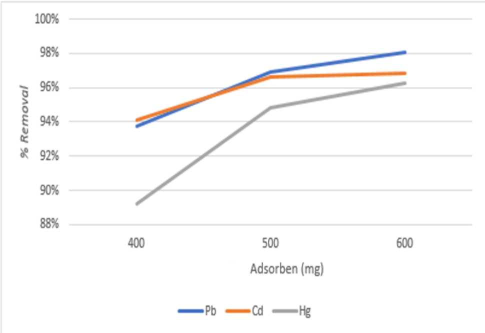

Figure 8. Graph of Adsorbent Weight Relation to% Removal of Pb, Cd, and Hg

Figure 8 shows an increase in% removal along with the increasing weight of the adsorbent used. These results are the same as research conducted by Pratiwi (2018) that the addition of adsorbent weight will also increase the % removal of adsorbed metals. In Figure 8, it can be seen that the adsorption process for Cd metal reaches a saturated state with the addition of 500 grams. The addition of too many adsorbents triggers a decrease in adsorption efficiency due to the narrowing of the contact surface area between the adsorbate and the adsorbent during the adsorption process [14]. In this study, it was concluded that the addition of the adsorbent weight could increase the adsorption capacity, where the optimum weight of the adsorbent was obtained using 600 mg.

3.5.6. Adsorbent Sorption Characteristics

The process of characterizing the adsorbent sorption in the adsorption of Pb, Cd, and Hg metals can be determined by comparing the results of the adsorption isotherm equation obtained. The adsorption isotherms used are Langmuir and Freundlich. The Langmuir isotherm interprets the adsorption that occurs during the adsorption process to form a single layer (monolayer) on the adsorbent surface, while the Freundlich isotherm states that adsorbate adsorption forms a multilayer layer on the adsorbent surface. This research was conducted using variations in the concentration of Pb and Cd metal simulation waste, namely 20, 40, 60, 80, and 100 ppm; while the variations in the concentration of Hg metal simulation waste are 10, 20, 30, 40, and 50 ppm.

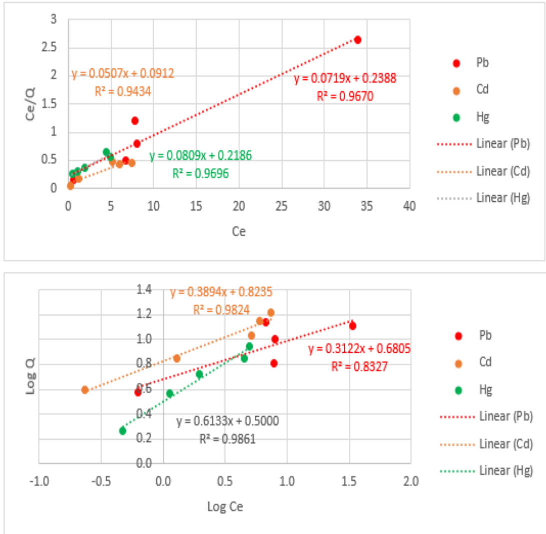

Figure 9.Graph of Langmuir (top) and Freundlich (bottom) Adsorption Isotherm Equation

From the two graphs above, the correlation value (r^2) to determine the adsorption modeling that occurs on Pb, Cd, and Hg metals by chicken bone ash adsorbent. The following table compares the correlation values of the two equations:

Table 2. Value of Qm, b in Langmuir Isotherm; values of k, n and r^2 in the Freundlich Isotherm

Metal	Langmuir			Freundlich		
	Q_m (mg/g)	b (l/mg)	r^2	k	n	r^2
Pb	13.91	0.30	0.9670	1.97	3.20	0.8327
Cd	17.54	0.63	0.9434	2.28	2.57	0.9824
Hg	12.36	0.37	0.9699	1.65	1.63	0.9861

From Table 2. It can be concluded that the adsorption modeling for Pb metal using chicken bone ash adsorbent follows the Langmuir Adsorption Isotherm model, where the adsorbate (Pb metal) forms a monolayer layer on the surface of the chicken bone ash adsorbent. These results are consistent with research conducted by Lurtwitayapont et al. [15] used pork bone as an adsorbent for Pb metal and Jihoon et al. [16] used bovine bone as Pb adsorbent where both results concluded that the modeling of Pb adsorption by bone adsorbent followed the Langmuir Adsorption Isotherm model. Meanwhile, Cd and Hg adsorption modeling using chicken bone ash adsorbent followed the Freundlich Adsorption Isotherm model. This modeling is also in accordance with the research conducted by Setyono et al [18] using activated Na_2CO_3 beef bone as a Cd metal adsorbent; and Dawlet et al. [19] used goat bone as an Hg metal adsorbent which stated that the adsorption process by bone adsorbent followed the Freundlich Adsorption Isotherm model for Cd and Hg metals.

HELIUM: Journal of Science and Applied Chemistry
https://journal.unpak.ac.id/index.php/helium
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e-ISSN: 2776-4508; p-ISSN: 2686-1038
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3.6. Adsorption Application for Simulation Waste and Fresh Lime at optimum conditions

In this study, simulated waste of Pb, Cd, and Hg metals concentrated 10, 15, and 20 ppm respectively; and fresh waste. This application is carried out to determine whether or not there is a difference in the value of % removal of Pb, Cd, and Hg in simulated waste and fresh waste. The following are the results of the application of the best conditions for adsorption on simulated waste.

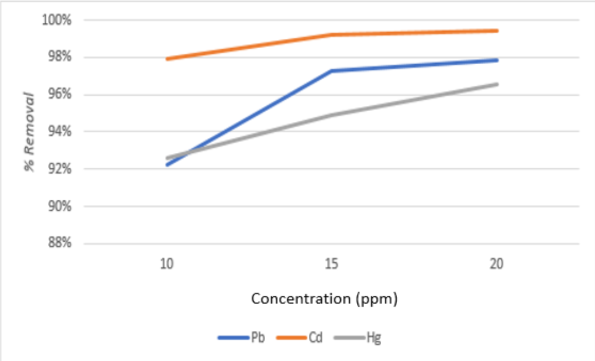

Figure 10. Application Results in Simulation Waste

From Figure 10 shows that the adsorption conditions reached a saturation point at a waste concentration of 20 ppm. This result is in accordance with the research conducted by Nugraheni et al., (2016) which also states that the increasing concentration of metal will increase the efficiency of metal adsorption due to the saturation of the adsorbent by the metals that have been successfully adsorbed on the adsorbent surface. From Figure 10 it can be concluded that the higher the metal concentration, the higher the metal adsorption by the adsorbent.

Then the best condition for the adsorption adsorption by the chicken bone ash adsorbent was re-applied to the fresh waste. The following is a comparison of the results of the adsorbent application in fresh waste and simulated waste.

Table 3 Adsorbent Application in Fresh Waste and Simulation Waste

Parameter	Unit	*Removal* (%)		
		Simulation Waste	Fresh Waste	
			Waste A	Waste B
Pb	mg/L	97,83	95,09	Not Tested
Cd	mg/L	99,43	98,96	Not Tested
Hg	mg/L	96,56	Not Tested	90,41

From Table 3 it can be concluded that the adsorption of Pb and Cd metals in simulation waste has decreased compared to fresh waste, where in the simulation waste there is only one metal; whereas in fresh waste, both metals (Pb and Cd) are in the same solution. It can be concluded that there is competition for the adsorption of Pb and Cd metals in the same solution by the chicken bone ash adsorbent.

3.7. Waste Quality Results after adding the Adsorbent

The fresh waste after being contacted with the chicken bone ash adsorbent is then analyzed again for the quality of the waste.

Table 4. Final Waste Analysis Results

No.	Parameter	Unit	Analysis Result					
			Before Contact		After Contact		Removal	
			Waste A	Waste B	Waste A	Waste B	Waste A	Waste B
1.	COD	mg/L	220,08	263,45	56,22	86,75	74,45%	67,07%
2.	TDS	mg/L	88	74	32	36	63,64%	51,35%
3.	TSS	mg/L	18	46	6	14	66,67%	46,15%
4.	pH		2,143	2,013	5,318	5,089		
5.	Metal							
a.	Pb	mg/L	8,05	-	0,40	-	95,09%	-
b.	Cd	mg/L	9,58	-	0,10	-	98,96%	-
c.	Hg	mg/L		7,17	-	0,69	-	90,41%

Note: (-) Not tested

Based on Table 4, it can be seen that the addition of chicken bone-based adsorbent can reduce the COD value in waste A by 74.45%; and for waste B 67.07%. The TDS value of waste A and B decreased by 63.64% and 51.35%, respectively. Likewise, the TSS value in waste A and B decreased by 66.67% and 46.15%, respectively. The pH of the waste has increased in waste A from 2,143 to 5,318; meanwhile, the pH of waste B increased from 2.013 to 5.089 The Pb and Cd metals in waste A experienced a decrease of 95.09% and 98.96%, respectively; while the Hg metal in waste B decreased by 90.41%.

When compared with the Decree of the Republic of Indonesia PermenLH No.5 of 2014 concerning BI Wastewater Quality for Pharmaceutical Industry Businesses and / or Activities and Wastewater Quality Standards for Businesses and / or Activities that Do not Have Unspecified Wastewater Quality Standards (Category II), it can be concluded that the addition of chicken bone ash adsorbent can improve the quality of waste. but still not meeting the quality standard requirements for Hg metal which are still above the quality standard requirements.

CONCLUSIONS

The adsorbent from chicken bone ash characteristically contains apatite carbonate compound minerals and rough and porous surface morphology. Increasing the ashing temperature, contact time, particle size, and weight of the adsorbent used will increase the adsorption performance. pH that is close to neutral pH increases the physical adsorption process that occurs. Chicken bone ash adsorbent can reduce levels of Pb, Cd and Hg metals and improve the quality of waste.

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e-ISSN: 2776-4508; p-ISSN: 2686-1038
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