The University of Tehran Press

Pollution

https://jpoll.ut.ac.ir/

Print ISSN: 2383-451X
Online ISSN: 2383-4501

Heavy Metals Leaching Characteristics Assessment of Medical Ash Wastes Through Cement Solidification / Stabilization Treatment Processes

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Article Info

Article type:
Research Article

Article history:
Received: 10 May 2024
Revised: 26 July 2024
Accepted: 26 August 2024

Keywords:
Medical waste
Local cement
Treatment Processes
Heavy Metals

ABSTRACT

In this study. Baghdad hospital waste ash was analyzed to determine the type of heavy and toxic concentrations in the waste and to study the potential effects of radioactive waste, health risks and the effectiveness of S/S hardening/stabilization processes based on local cement. Toxic medical waste was used in this work as bottom ash, which includes large amounts of pollutants such as As, Co, Cr, and Hg. Ash samples were taken from the medical waste incinerators of the main hospital in the city. The heavy metal sludge is stabilized and solidified using this bottom ash. The curing matrix was between 7% and 25% local cement in varying amounts. Before arriving at the physical and chemical properties of the solid, it underwent six different periods of treatment. Filtration experiments using solid-liquid partitioning as a function of pH, the filtration method was deployed to determine treatment efficiency. The compressive strength confined to the forms was also measured to ensure the solidity and durability of the molds. After disposal, the most effective solid material with good strength was found, which contains 25% of local cement. In addition, the results of the study showed that the efficiency of treating the filtration method for toxicological properties Ranging from 85% to 100%. The range of treatment efficiency in liquid/solid technology was 75%-100%. The S/S process can be a very good, effective and safe treatment process for handling and disposing of toxic medical waste ash or the possibility of reusing the formwork in bridges and roads.

Cite this article: Kadhem, N. Q., Hussain, B. A., & Hussein, I. F. (2024). Heavy Metals Leaching Characteristics Assessment of Medical Ash Wastes Through Cement Solidification / Stabilization Treatment Processes. *Pollution*, 10 (4), 1227-1244. https://doi.org/10.22059/poll.2024.376288.2367

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DOI: https://doi.org/10.22059/poll.2024.376288.2367

INTRODUCTION

The process of treating medical waste is very complex all over the world because it causes great harm to the environment and health (Rajor *et al.*, 2012). One of the most common methods of disposing of medical waste is the incineration of medical waste (Ghazali *et al.*, 2022; Gören, 2011). The combustion process produces a new type of pollutant, which is ash. There is still no way to dispose of medical waste ashes other than burying them in designated waste graves. Over time, this leads to devastating damage to the environment and health. Medical waste is one of the main problems that harms both the environment and people's health (Sawalem *et al.*, 2009; Lawi *et al.*, 2022). It can lessen the quantity of waste dumped in landfills and lessen its negative effects on the environment (Prajati *et al.*, 2017). There is an urgent need for processing and packaging techniques to prevent medical waste from ending up in landfills and harming people's health and the environment. Incineration is the principal technology used in communities for the treatment and final disposal of medical waste (Suryawan, 2014).

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One benefit of the incineration process, however, is the removal of medical waste's weight and volume. Medical waste is processed by incineration, which also produces fly ash, bottom ash, and gas residues. Medical waste can be put into a secure landfill once it has been burned (Komilis *et al*., 2011). Hazardous heavy metals are often present in some quantity in incinerator processing ash; nevertheless, excessive concentrations of heavy metals are considered micro pollutants because they can have detrimental impacts on both the environment and human health (Agamuthu *et al*., 2009; Xie *et al*., 2012; Lawi *et al*., 2023). In 2003, bottom ash was added to the list of hazardous waste materials, as per the Council of the European Union (Woolley *et al*., 2001). The ash is frequently disposed of without any particular treatment at any of the locations, either on the ground or in open landfill dumps. Because open-pit landfill leachate contains organic debris that can disintegrate, it is often difficult to treat for organic compounds and heavy metals. Many strategies are employed, such as improved oxidation processes, phytoremediation, adsorption, and others (Suryawan *et al*., 2018, Hu *et al*., 2016; Hassan *et al*., 2016; Suryawan, 2018). The recommended procedure for handling bottom and fly ash from healthcare facilities is solidification/stabilization (S/S). Through this procedure, the components are stabilized and rendered safe for use in products that are safe for the environment and human health (Suryawan *et al*., 2019; Ridha *et al*., 2018). The hazardous heavy metals are stabilized in cementitious matrices by physical and chemical means. This has to do with the limited permeability of the hardened product on a physical level and the high alkalinity pore solution of the cementitious matrix on a chemical level, which allows heavy metals to be transformed into insoluble compounds. Thus, the likelihood of leaking contaminants is reduced (Lombardi *et al*., 1998). It was discovered that solidifying bottom ash by combining it with cement material could reduce its toxicity in a straightforward and reasonably priced way (Rozumová *et al*., 2015). The aim of this study is to find a method for treating medical waste ash in a manner that is highly efficient, has a lower cost, is easy to dispose of, and reuses the prepared molds containing pollutants in building roads and bridges. This study also enables the use of land used for landfilling, and uses it in other activities. A variable percentage of local cement was used various treatment methods are used to reduce the bottom ash of medical waste that contains high concentrations of heavy metals. The treatment efficiency ranged from 74% to 100%. Also demonstrated the exceptional efficiency of local cement in encapsulating heavy metals within its structure and The effectiveness of cement-based solidification/stabilization processes for medical waste ash in preventing the release of elements and their adoption as a reliable means of handling and disposing of these toxic wastes and determine the best cement mix design (S/S) for medical waste ash.

MATERIAL AND METHODS

The incinerator unit of Baghdad Health Department Rusafa Hospital produced bottom ash. After grinding the sample manually, the ash was sieved through a silicon sieve with a diameter of ≤0.9 mm. Non-combustible components were removed from the ash, as shown in Fig. 1.

The untreated bottom ash was examined using an XRF machine. In light of the results, it showed the presence of higher than average amounts of heavy metals. Working with the hardening/setting treatment procedure, several cylinder-shaped molds were created using different amounts of cement and a specified amount of sand, in that order. Variable ratios were used for the filtration treatment where a mixing weight of ash of 100 and 300 was used Gram cement mixing ratio was 7% and 25%. The mold used is 5 cm in diameter and 10 cm high, and resembles a cylinder. Each shape underwent a 28-day wet curing process, in accordance with SNI 03-2834-2000. During the treatment period, each block was initially added to a can containing 2 L of distilled water at six different intervals (0.08, 1, 2, 7, 14, and 28 days). As shown in Fig.2.

Fig. 1. Medical waste ash before and after the grinding process

Fig. 2. Represents the processing mold and sample filtering method.

Take a sample of the sample after each period and send it for measurement. The second method was to break the mold and sift the ash particles to ensure they were smaller than 9.5 mm. Use 250 ml polypropylene containers. Each container has different pH levels, ranging from PH1 to PH9. It is produced by adding solutions (1N KOH and 2N HNO3) to reagent water to dilute it as shown in Figure 3. Table 1 show that the test begins by placing the sample in a 200 mL extraction solution with 20 grams of pre-ground weight. This mixture allows for a liquid to solid (L/S) ratio. This meets the requirements of EPA Method 1313, Test Process. Next, twelve containers – nine test and three ash-free – are arranged and stirred from start to finish over the course of eighteen hours. Finally, the liquid and solid are separated by sedimentation. Use 125mm F2042 filter papers. The sample was ready for examination. Liquid and solid materials were examined using an X-ray spectrometer (XRF) sample number NEX CG ll from Rigaku. The summary is shown in Fig. 4.

Then, based on the length of time it took the cement mixture to dry, we separated all of the mold samples into three groups and sent them out as follows:

Group WCM: Cement was mixed in proportions of 7% of the amount of sand with a weight of 100gm of medical waste ash.

Fig. 3. Solid-liquid separation with different pH readings.

Table 1. Acid and Base Titration Schedule for LSP pH function leaching test

Container No.	Targeted Extract PH	Sample Moister Volume (ml)	Volume of reagent Water added (ml)
Ph1	13.0	2	198
Ph2	12.0	2	198
Ph3	10.5	2	198
Ph4	9.0	2	198
Ph5	8.0	2	198
Ph6	Neutral	2	198
Ph7	5.5	2	198
Ph8	4.0	2	198
Ph9	2.0	2	198
Control 1	-	-	200
Control 2	2.0	2	198
Control 3	13.0	2	198

Group WCM: Cement was mixed in proportions of 25% of the amount of sand with a weight of 300gm of medical waste ash.

Group Control M: Cement was mixed in proportions of 7% and 25% of the amount of sand. As shown in Table 2 and Fig. 5. Different amounts of cement are used in the design of these molds. assessment of its impact on the ratio of blockage. The durations differ in order to ascertain the compression molds' resistance upon disposal. It was measured for engineering testing into concrete cylinders in the lab of the Engineering Consulting Group 7% cement

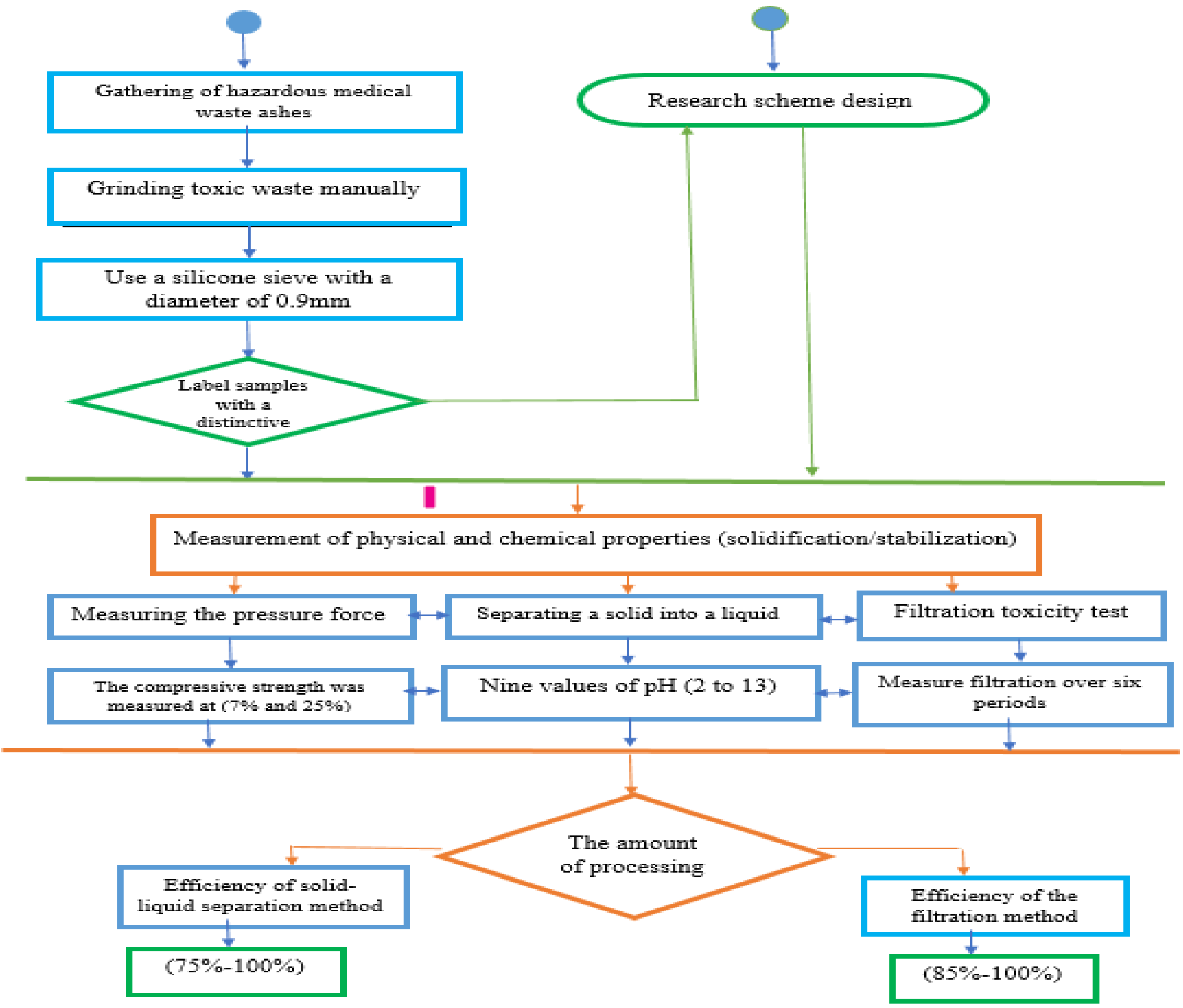

Fig. 4. Summary of the work and the method of analyzing samples

Table 2. Classification of molds in three groups.

Periods of Time	7% Cement	25% Cement
Group WCM (7 days)	WC_1M_1	WC_1M_2
	WC_2M_1	WC_2M_2
	Control M_1	Control M_2
Group B (14 days)	WC_1M_1	WC_2M_2
	WC_2M_1	WC_2M_2
	Control M_1	Control M_2
Group C (28 days)	WC_1M_1	WC_1M_2
	WC_2M_1	WC_2M_2
	Control M_1	Control M_2

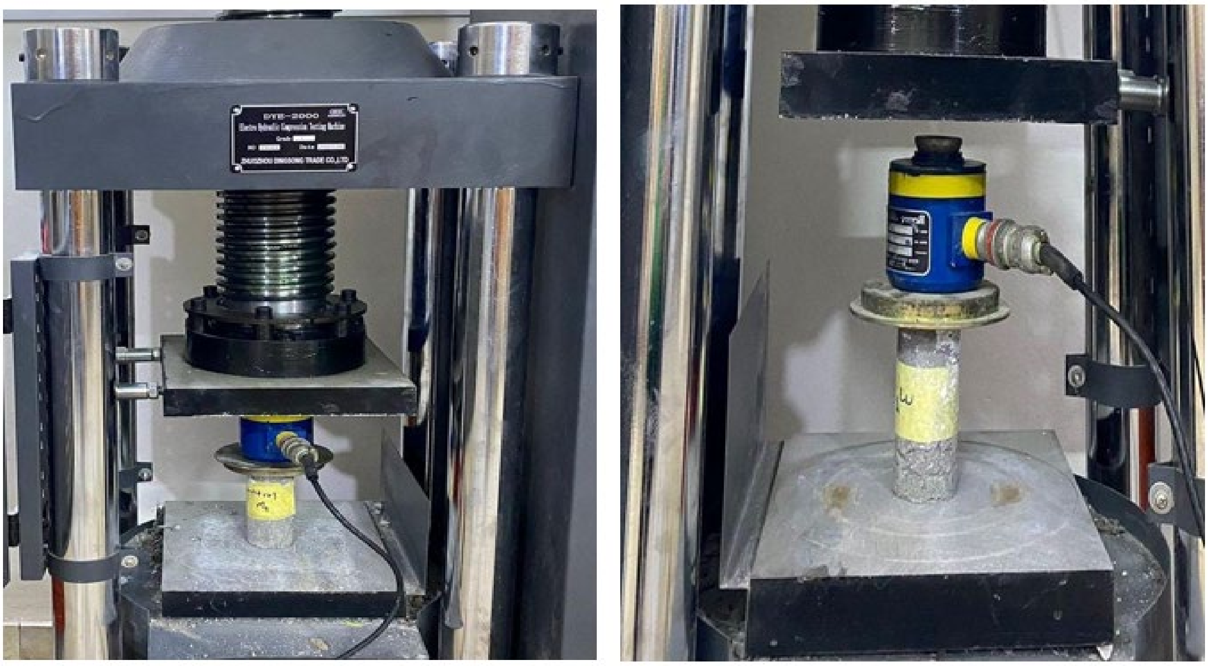

Fig. 5. Concrete pattern when using pistons to measure resistance.

cylinder = 75gm, 25% cement cylinder = 333gm. Where WC_1 represents the weight of ash (100 grams), M_1 = Mix (7%), while WC_2 = weight of ash (300 grams), M_2 = Mix (25%).

RESULTS AND DISCUSSION

The unconfined compressive strength was tested on samples consisting of cement, red sand, and the addition of a weight of toxic medical waste ash. After achieving the required rigidity, the samples were tested during three different periods (7, 14, and 28 days). Fig. (6) show the compressibility and resistance of molds made to prevent leakage of heavy metals as well as the harmful effects of hospital ash burns that affect hospital workers and the environment in general. The proportion of cement used to create the concrete mold determines the amount of cement required. A cement to sand ratio of 25% has been shown to work well enough to comply with the value set by the US Environmental Protection Agency. In addition, the use of 7% cement achieved the value specified by the US Environmental Protection Agency. It was observed that the compressive strength increased with an increase in the ash percentage. Using a mixture of 25% cement and a weight of toxic waste ash of 200gm is ideal for preserving the toxic waste ash mixture and the possibility of disposing of it in landfills or the possibility of reusing the mixture in roads and bridges. It has been shown that the results of this study are consistent with this studys (Abbas *et al*., 2021; Akyıldız *et al*., 2017; Vaičienė *et al*., 2022; Shih *et al*., 2003).

Leaching Tests

Several on-site solutions are used to treat contamination including treating heavy metals and hazardous waste by hardening/stabilization using cement as a binder, which is one of the most common methods used for bottom ash treatment. After the standard hardening process (28 days) to the samples. EPA toxicological filtration procedures have been implemented. The prepared samples were pre-filtered with different proportions and weights of the mixture and toxic ash. All samples were filtered over six periods. The absolute mineral content of the ash sample was determined from the filtration results. Bottom ash left untreated contains high levels of Zn

(1790 ppm), Ag (286 ppm), Bromine (130 ppm) and Manganese (148 ppm). Concerns were raised by the discovery of lead, copper, mercury, and arsenic, which were found in quantities of (187 ppm), (488 ppm), (41.7 ppm), and (7.57 ppm), respectively. Lead, zinc, iron, manganese and other heavy metals can be found in colors and additives used in plastics, radioisotope armor, sharps, and laboratory chemicals. Plastic found in medical waste that comes from packaging supplies and equipment. Ash contains mercury due to the decomposition of layers of mercury-containing materials, mercury thermometers, dental amalgams, and mercury-containing liquid pressure gauges. The results showed that all minerals Fe, Mn, Br, Co, and Cr were blocked by the leaching process of the WC_1M_1 samples. During all periods in which the treatment efficiency ratio ranged from 0.54 ppm to 3.44 ppm, the overall ratio decreased. Between 99% and 97%. Ag was the most concentrated element after treatment with a total percentage of 43.74 ppm and a treatment efficiency of 84%, while the total percentage of Cu was 14.28 ppm and a treatment efficiency of 97%. According to Table (3), and Fig. (7) showing the leachate concentrations of heavy metals during the six treatment periods, the treatment efficiency for the other elements, lead and mercury was 100%.

The overall percentage of Zn, Br, Mn, and Cr varied between 0.129 ppm and 7.017 ppm, according to the WC_1M_2 sample results, while the treatment effectiveness percentage varied between 99% and 92%. Cr (8.913ppm), the average percentage of all the elements, showed up, and the treatment's effectiveness was 92%. Cu (15.18 ppm), with a 96% processing efficiency. The Ag element had the highest filtering rate (45.37 ppm), and 84% of the sample was treated effectively. Pb, As, and Hg had 100% efficiency. According to Table (4), and Fig. (8) showing the leachate concentrations of heavy metals during the six treatment periods.

The total value of each of the following elements throughout six periods of Zn, Br, Mn, Co, and Cr was displayed in the WC_2M_1 sample results, and it ranged from (0.494ppm-4.753ppm) with a treatment efficiency of (95% to 99%). Cu content was 13.75 ppm, and 97% of the treatment was effective. With an 85% treatment efficiency, the Ag element had the greatest filtering rate

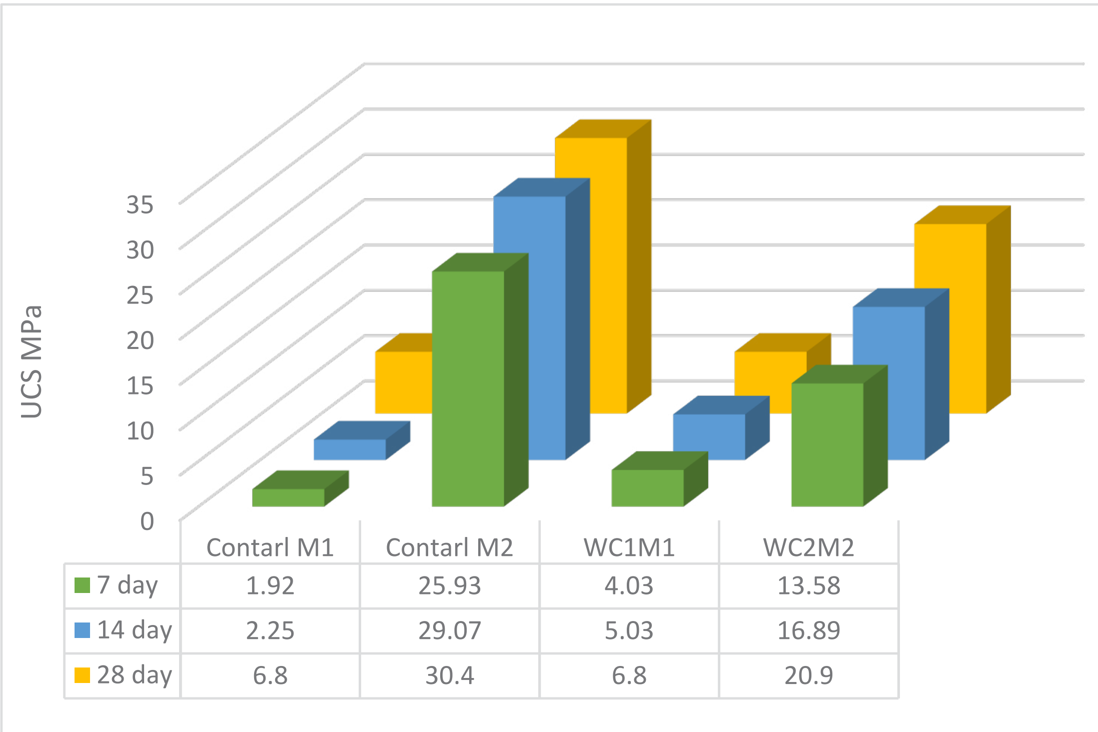

Fig. 6. Comparison between different percentages of cement with the curing age.

Table 3. Concentrations of heavy metals in sample WC_1M_1 before and after treatment.

Concentration before treatment (ppm)		**Concentration of element after treatment (ppm)**					
Heavy metals		**WC_1M_1 processing time**					
		2Huor	**1Day**	**2Day**	**7Day**	**14Day**	**28Day**
Zn	1790	1.34	ND	0.364	0.185	0.286	ND
Ag	286	8.20	6.95	6.80	6.61	8.08	7.11
Br	130	-	0.158	0.226	0.198	-	-
Cu	488	2.03	2.25	2.78	2.25	2.48	2.49
Pb	187	-	-	-	-	-	-
Mn	148	1.00	-	1.27	1.17	-	-
As	7.57	-	-	-	-	-	-
Co	20.4	-	-	0.540	-	-	-
Cr	112	-	-	1.36	1.05	-	0.694
Hg	41.7	-	-	-	-	-	-

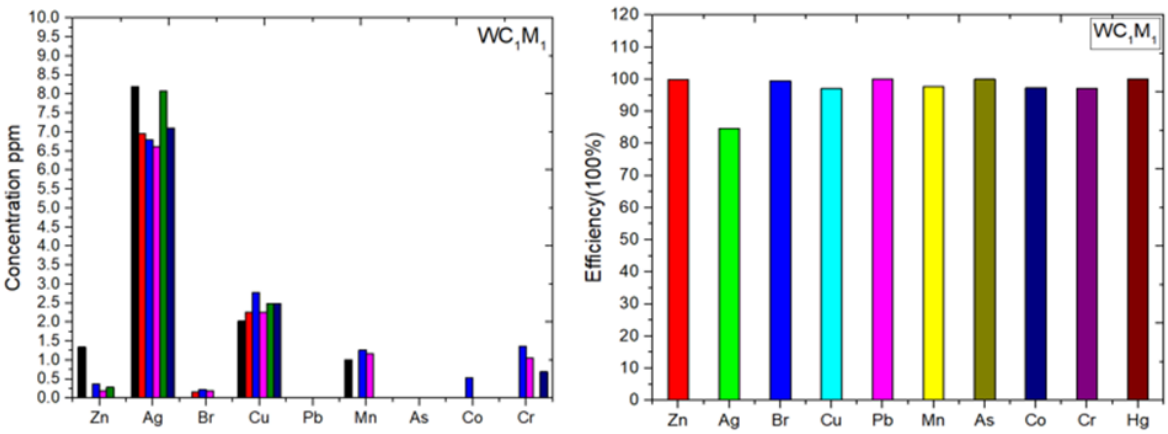

Fig. 7. Ratio of post-treatment concentrations and efficiency ratio for sample WC_1M_1

at 40.31 ppm. For Pb, As, and Hg, the treatment effectiveness was 100%. According to Table (5), and Fig. (9) showing the leachate concentrations of heavy metals during the six treatment periods.

The total value of each of the following elements throughout six periods of Zn, Br, Mn, Co, and Cr was displayed in the WC_2M_2 sample results, and it ranged from (0.494ppm-4.753ppm) with a treatment efficiency of (95% to 99%). Cu content was 13.75 ppm, and 97% of the treatment was effective. With an 85% treatment efficiency, the Ag element had the greatest filtering rate at 40.31 ppm. For Pb, As, and Hg, the treatment effectiveness was 100%. According to Table (6), and Fig. (10) showing the leachate concentrations of heavy metals during the six treatment periods. Study found that the treatment efficiency rate is lower than the current work efficiency

Table 4. Concentrations of heavy metals in sample WC_1M_2 before and after treatment.

Concentration before treatment (ppm)		Concentration of element after treatment (ppm)					
Heavy metals		**WC_1M_2 processing time**					
		2Huor	**1Day**	**2Day**	**7Day**	**14Day**	**28Day**
Zn	1790	0.423	-	0.223	0.455	0.341	-
Ag	286	6.87	8.44	7.28	7.36	7.12	8.30
Br	130	-	-	-	-	0.129	-
Cu	488	3.03	2.28	2.37	2.41	2.70	2.39
Pb	187	-	-	-	-	-	-
Mn	148	1.60	1.76	-	0.957	2.70	-
As	7.57	-	-	-	-	-	-
Co	20.4	0.539	0.460	-	-	0.629	-
Cr	112	3.86	1.05	0.877	1.06	1.51	0.556
Hg	41.7	-	-	-	-	-	-

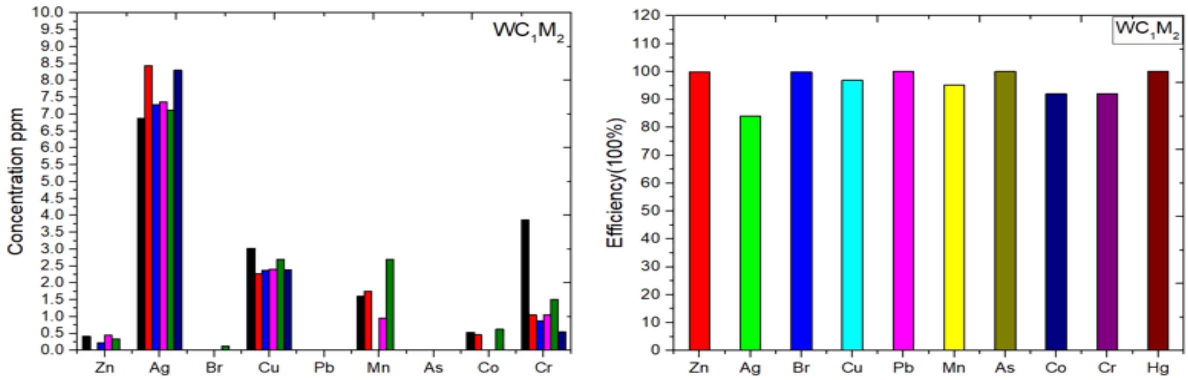

Fig. 8. Ratio of post-treatment concentrations and efficiency ratio for sample WC_1M_2

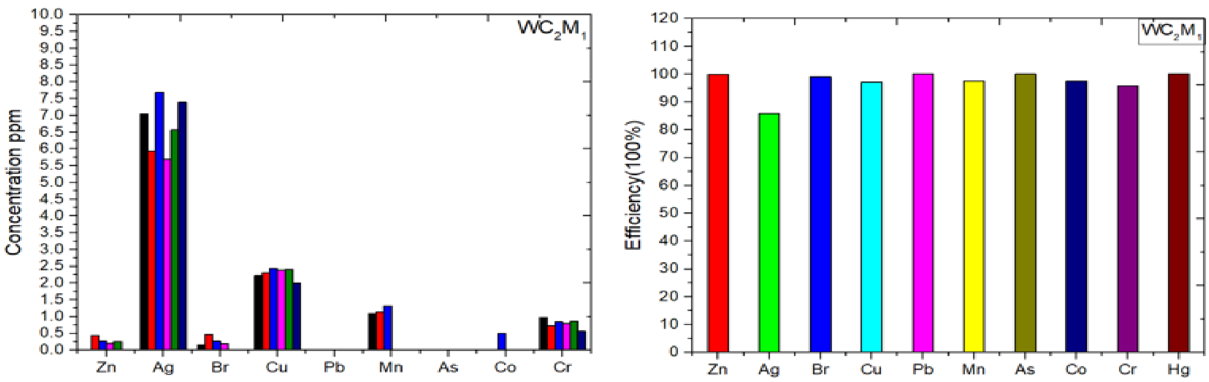

Fig. 9. Ratio of post-treatment concentrations and efficiency ratio for sample WC_2M_1

Table 5. Concentrations of heavy metals in sample WC_2M_1 before and after treatment.

Concentration before treatment (ppm)		Concentration of element after treatment (ppm)					
Heavy metals		WC_2M_1 processing time					
		2Huor	1Day	2Day	7Day	14Day	28Day
Zn	1790	-	0.432	0.265	0.202	0.263	-
Ag	286	7.04	5.94	7.69	5.69	6.56	7.39
Br	130	0.156	0.460	0.270	0.193	-	-
Cu	488	2.22	2.31	2.43	2.38	2.41	2.00
Pb	187	-	-	-	-	-	-
Mn	148	1.08	1.14	1.32	-	-	-
As	7.57	-	-	-	-	-	-
Co	20.4	-	-	0.494	-	-	-
Cr	112	0.977	0.724	0.838	0.786	0.865	0.563
Hg	41.7	-	-	-	-	-	-

Table 6. Concentrations of heavy metals in sample WC_2M_2 before and after treatment.

Concentration before treatment (ppm)		Concentration of element after treatment (ppm)					
Heavy metals		WC_2M_2 processing time					
		2Hour	1Day	2Day	7Day	14Day	28Day
Zn	1790	-	0.268	0.249	0.538	-	-
Ag	286	7.82	7.15	7.40	7.62	7.70	7.45
Br	130	-	0.332	0.302	0.956	-	-
Cu	488	2.13	2.46	2.20	2.97	2.16	2.23
Pb	187	-	-	-	-	-	-
Mn	148	-	-	1.42	1.93	2.01	-
As	7.57	-	-	-	-	-	-
Co	20.4	0.610	-	-	0.638	-	-
Cr	112	0.858	1.04	0.864	4.47	0.793	0.904
Hg	41.7	-	-	-	-	-	-

rate. The reason for this difference is due to working conditions, the difference in the type of waste from one hospital to another, and the efficiency of the materials used. All of these factors have a major role in the rate of treatment efficiency (Al-Kindi ,2019; Anastasiadou *et al.*, 2012; Al-Akhras *et al.*, 2011; Bakkali *et al.*, 2013).

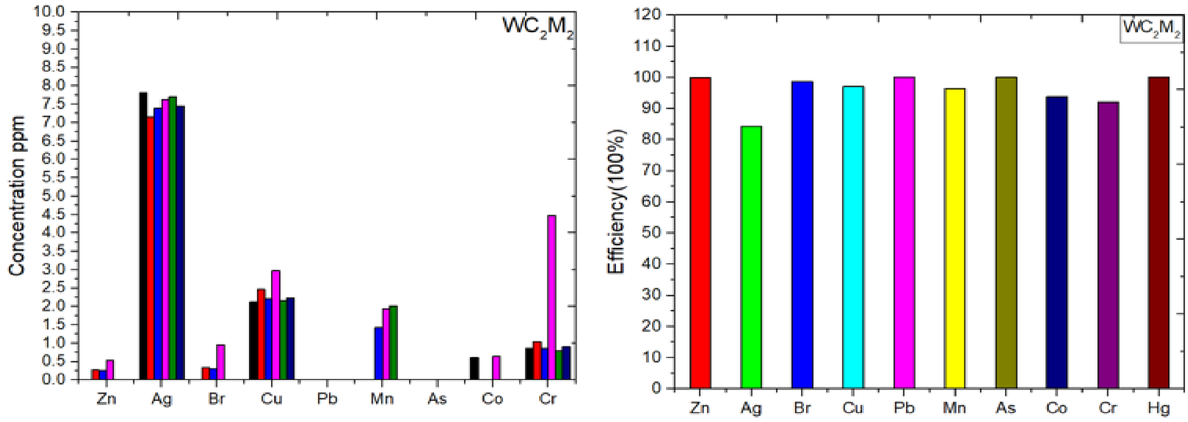

Fig. 10. Ratio of post-treatment concentrations and efficiency ratio for sample WC_2M_2

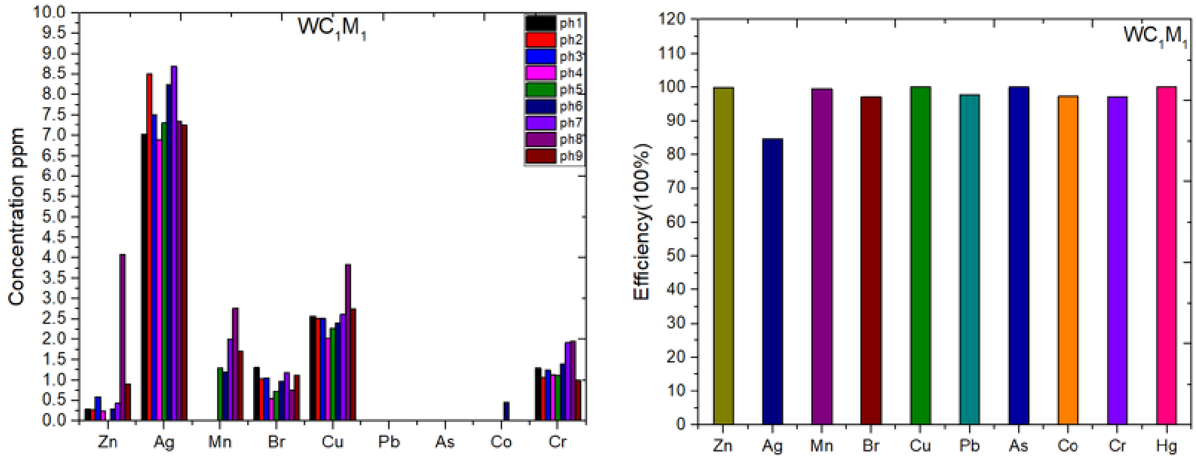

Fig. 11. Post-treatment elements concentrations and treatment efficiency percentage in sample WC_1M_1

Partitioning Liquid-Solid as a pH Function Leaching Process

Solidification/stabilization to bottom ash was also studied, and the effect of the mixture composition ratio on leaching of heavy metals was evaluated, which is affected by pH, stirring, and filtration time. The sample was manually crushed to a size of 0.9 mm. This method was studied knowing the influences of pH and the influence of the external environment when disposing of the samples and calculating the work efficiency. The liquid/solid technology filters samples at different pH levels. The concentrations of zinc, magnesium, bromide, and cobalt are presented in the WC_1M_1 sample results. Their concentrations ranged from 0.45 ppm to 8.94 ppm after the treatment process at different pH levels. Compared with the control sample WC_1M_1, the percentage of elements was less than (3 ppm). It ranges between (93% to 99%) in terms of therapeutic efficiency. Chromium was present in the control element at a concentration of less than 3 ppm, while the total percentage was 12.12 ppm with process 89% of data efficiently. There was less than 3 ppm copper (23.52 ppm) in the control group. As much as 95% processing efficiency; with an element concentration of less than 25 ppm and a treatment efficiency of 75%, Ag had the highest filtration rate (68.77 ppm). Lead, mercury, and mercury had a therapeutic efficiency of 100%, and the proportion of these elements in the control group was nil. As can be seen from the figures: post-treatment element concentrations and treatment efficiency ratio in Fig. (11) and Table (7).

Zn, Br, and Co elements were all found in modest amounts in the WC_1M_2 sample results. Their results fell below 6 ppm as compared to the control % in the WC_1M_2 sample, which ranged from 1.291 ppm to 5.548 ppm. Achieving a 93% to 99% treatment efficiency. The proportion of Cr in the control group was less than 2ppm, and the concentration was 16.61ppm. has an 85% therapeutic effectiveness. The control has less than 2 ppm of the Mn element (17.79 ppm). has an 87% therapeutic effectiveness. Less than 6 ppm of the element Cu (23.51 ppm) is present in the control. with a 95% therapeutic effectiveness. Ag was the largest leaching element in all pH readings (65.6 ppm), whereas it was less than 23 ppm in the control. has a 77% therapeutic effectiveness. The treatment effectiveness for Pb, As, and Hg was 100% across all variable Ph values. In accordance with Table (8) and Fig.(12) show concentrations of post-treatment elements, treatment efficiency ratio

Zn, Mn, As, Co, and Cr had low concentrations following treatment, according to the WC_2M_1 sample results. These values ranged from 0.123ppm to 9.296ppm, and the percentages of these elements in the control group were less than 19ppm. The range of treatment efficiency was 91% to 99%. Less than 2ppm of Br (21.6ppm) was present in the control group. has an 83% treatment success rate. Less than 9ppm separates the Cu element (24.23ppm) from its control value. has a 95% treatment success rate. The Ag element had the maximum filtering value (65.67 ppm), whereas the control had the lowest filtering value (less than 23 ppm). has a 77% treatment success rate. In every pH reading that was varied, Pb and Hg had 100% treatment efficiency. as demonstrated by Fig. (13) and Table (9).show concentrations of post-treatment elements and treatment efficiency ratio.

In the WC_2M_2 sample, Co had the lowest concentration (0.5 ppm) across all variable pH readings, and the control had a concentration of less than 1 ppm with a processing efficiency

Table 7. Concentrations of elements before and after treatment with variable pH readings in sample WC_1M_1

Heavy metals	Concentration before treatment (ppm)	Concentration of element after treatment (ppm)											
		Percentage of PH WC_1M_1											
		Ph_1	Ph_2	Ph_3	Ph_4	Ph_5	Ph_6	Ph_7	Ph_8	Ph_9	$Contral_1$	$Contral_2$	$Contral_3$
Zn	1790	0.28	0.272	0.582	0.239	-	0.283	0.433	4.08	0.907	0.295	-	0.243
Ag	286	7.02	8.50	7.51	6.89	7.31	8.24	8.70	7.35	7.25	7.46	7.33	7.35
Mn	148	-	-	-	-	1.29	1.20	1.99	2.76	1.70	1.14	1.20	1.08
Br	130	1.31	1.04	1.06	0.552	0.735	0.978	1.18	0.754	1.12	-	-	1.98
Cu	488	2.57	2.52	2.52	2.03	2.28	2.41	2.61	3.83	2.75	2.21	2.40	3.25
Pb	187	-	-	-	-	-	-	-	-	-	-	-	-
As	7.57	-	-	-	-	-	-	-	-	-	-	-	-
Co	20.4	-	-	-	-	-	0.450	-	-	-	-	0.468	-
Cr	112	1.30	1.07	1.25	1.13	1.12	1.40	1.91	1.94	1.00	0.832	0.902	1.46
Hg	41.7	-	-	-	-	-	-	-	-	-	-	-	-

Table 8. Concentrations of elements before and after treatment with variable pH readings in sample WC_1M_2

Concentration before treatment (ppm)		Concentration of element after treatment (ppm)											
Heavy metals		Percentage of PH WC_1M_2											
		Ph_1	Ph_2	Ph_3	Ph_4	Ph_5	Ph_6	Ph_7	Ph_8	Ph_9	$Contral_1$	$Contral_2$	$Contral_3$
Zn	1790	1.42	0.277	-	0.700	0.244	-	0.747	-	0.229	4.39	-	-
Ag	286	8.43	7.13	7.24	7.61	7.11	7.20	4.67	7.50	8.71	6.87	7.66	7.66
Mn	148	10.8	1.43	1.63	-	-	-	2.39	-	1.54	0.979	-	1.02
Br	130	0.830	0.463	0.713	-	0.512	0.741	1.25	0.283	0.756	-	-	-
Cu	488	3.10	2.33	2.66	2.13	2.38	2.17	4.16	2.00	2.58	1.49	2.73	2.50
Pb	187	-	-	-	-	-	-	-	-	-	-	-	-
As	7.57	-	-	-	-	-	-	-	-	-	-	-	-
Co	20.4	-	-	-	-	0.526	-	0.765	-	-	0.296	-	0.457
Cr	112	4.76	1.18	1.33	1.07	1.51	1.02	3.10	1.20	1.44	0.601	0.807	0.987
Hg	41.7	-	-	-	-	-	-	-	-	-	-	-	-

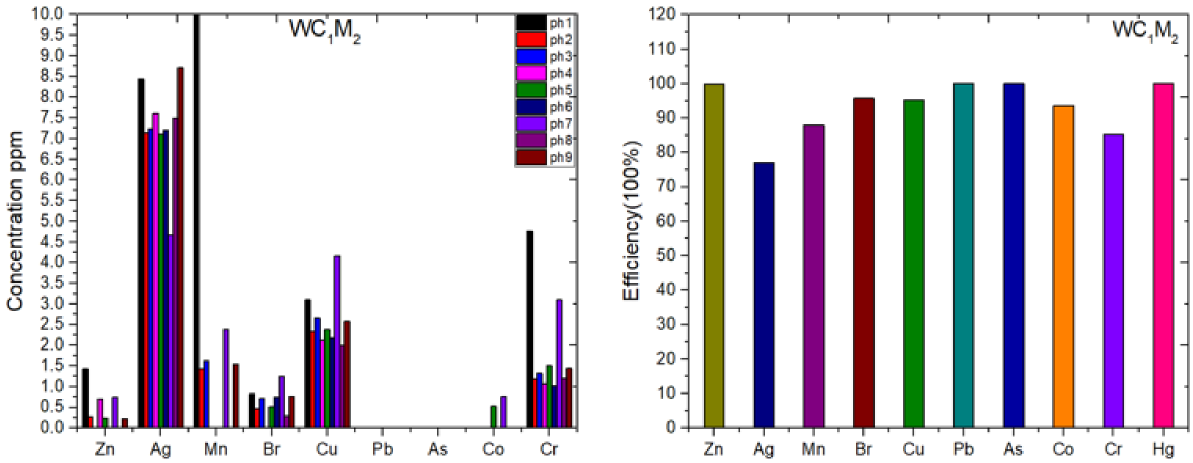

Fig. 12. Post-treatment elements concentrations and treatment efficiency percentage in sample WC_1M_2

of 97%. Both the Zn (6.294 ppm) and control filtrate concentrations were below 5 ppm with a processing efficiency of 99%. Less than 2 ppm of the Mn element (8.42 ppm) was present in the control group has a 94% treatment success rate. In the lower control, the element Br (14.99ppm) was completely absent. has an 88% treatment success rate. The Cr element was less than 3 ppm in the control and 14.77 ppm in the sample has an 86% treatment success rate. Cu is present in the control at less than 5 ppm and at 23.79 ppm. has a 95% treatment success rate. There was a maximum filtration rate in the Pb and Hg 100% treatment efficiency as demonstrated by Figure Concentrations of post-treatment elements and treatment efficiency ratio (14), and Table (10).

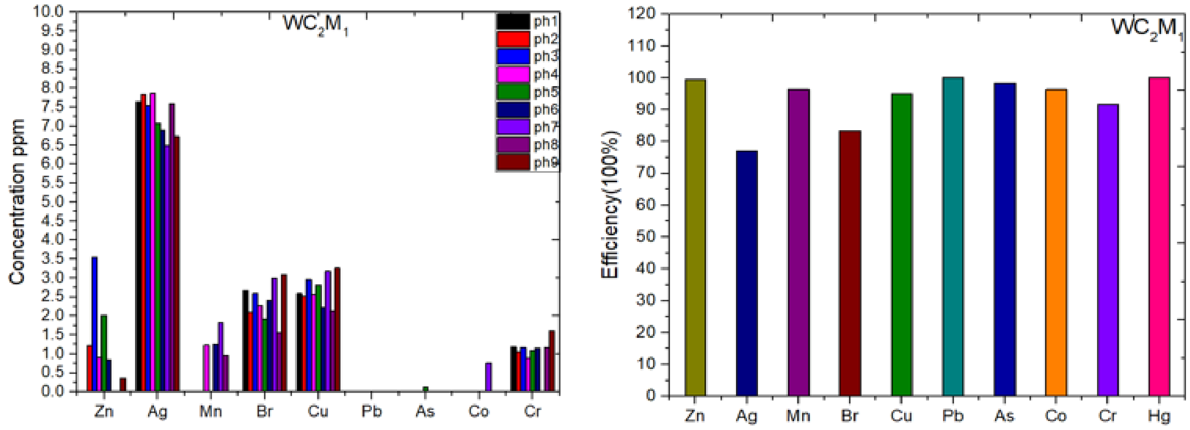

Fig. 13. Post-treatment elements concentrations and treatment efficiency percentage in sample WC_2M_1

Table 9. Concentrations of elements before and after treatment with variable pH readings in sample WC_2M_1

Heavy metals	Concentration before treatment (ppm)	Concentration of element after treatment (ppm)											
		Percentage of PH WC_2M_1											
		Ph_1	Ph_2	Ph_3	Ph_4	Ph_5	Ph_6	Ph_7	Ph_8	Ph_9	$Contral_1$	$Contral_2$	$Contral_3$
Zn	1790	-	01.21	3.54	0.912	2.02	0.836	-	-	0.358	0.295	-	0.243
Ag	286	7.64	7.83	7.55	7.87	7.08	6.90	6.48	7.59	6.73	7.46	7.33	7.35
Mn	148	-	-	-	1.23	-	1.25	1.82	0.957	-	1.14	1.20	1.08
Br	130	2.67	2.10	2.60	2.28	1.92	2.41	2.98	1.55	3.09	-	-	1.98
Cu	488	2.59	2.52	2.96	2.56	2.81	2.23	3.18	2.12	3.26	2.21	2.40	3.25
Pb	187	-	-	-	-	-	-	-	-	-	-	-	-
As	7.57	-	-	-	-	0.123	-	-	-	-	-	-	-
Co	20.4	-	-	-	-	-	-	0.757	-	-	-	0.468	-
Cr	112	1.18	1.05	1.17	0.886	1.09	1.15	-	1.16	1.61	0.832	0.902	1.46
Hg	41.7	-	-	-	-	-	-	-	-	-	-	-	-

It was noted from these results that pH has a significant effect on the leaching of heavy metals, and in this study the effect of pH on heavy metals was confirmed (Prodani, 2014; Sobiecka *et al*., 2014; Yakubu *et al*., 2018). It was found that the efficiency ratio of solid to liquid is less than the efficiency of filtration. The reason is that heavy elements do not dissolve in water, but when using different acid and base readings it helps in analyzing the elements. It was also proven that the efficiency ratio of solidification and stabilization was from good to excellent in stabilizing many elements and getting rid of them. Finally, when comparing the results of the concentrations after the treatment process in the two methods, at all times, the percentage of concentrations was much lower than the concentrations before treatment.

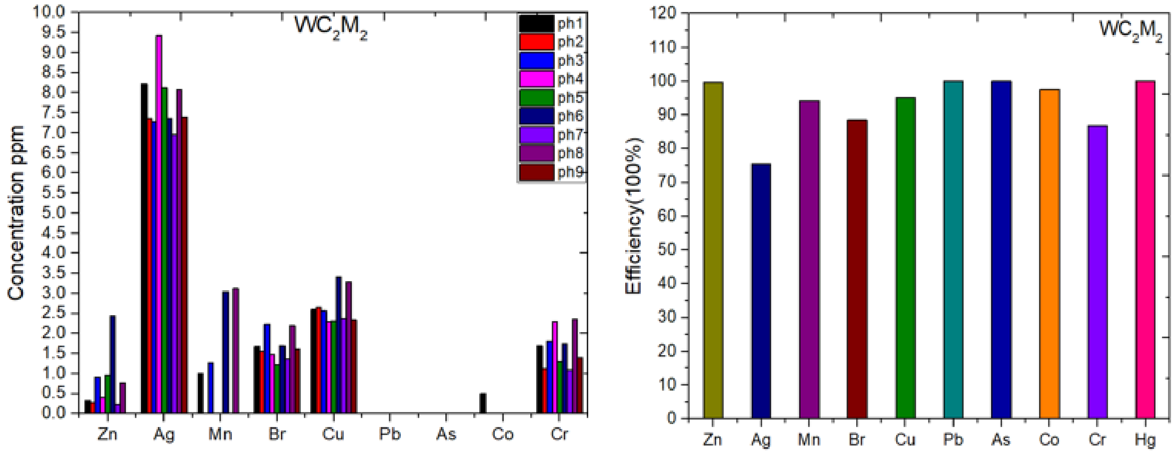

Fig. 14. Post-treatment elements concentrations and treatment efficiency percentage in sample WC_2M_2

Table 10. Concentrations of elements before and after treatment with variable pH readings in sample WC_2M_2

Heavy metals	Concentration before treatment (ppm)	Concentration of element after treatment (ppm)											
		Percentage of PH WC_2M_2											
		Ph_1	Ph_2	Ph_3	Ph_4	Ph_5	Ph_6	Ph_7	Ph_8	Ph_9	$Contral_1$	$Contral_2$	$Contral_3$
Zn	1790	0.329	0.277	0.907	0.397	0.960	2.44	0.219	0.765	-	4.39	-	-
Ag	286	8.22	7.36	7.28	9.43	8.13	7.36	6.95	8.08	7.40	6.87	7.66	7.66
Mn	148	1.01	-	1.26	-	-	3.04	-	3.11	-	0.979	-	1.02
Br	130	1.67	1.56	2.23	1.47	1.21	1.69	1.36	2.19	1.61	-	-	-
Cu	488	2.59	2.64	2.56	2.29	2.31	3.41	2.37	3.29	2.33	1.49	2.73	2.50
Pb	187	-	-	-	-	-	-	-	-	-	-	-	-
As	7.57	-	-	-	-	-	-	-	-	-	-	-	-
Co	20.4	0.500	-	-	-	-	-	-	-	-	0.296	-	0.457
Cr	112	1.69	1.12	1.80	2.29	1.30	1.74	1.08	2.35	1.40	0.601	0.807	0.987
Hg	41.7	-	-	-	-	-	-	-	-	-	-	-	-

CONCLUSIONS

The following conclusions were drawn from the tests and experiments conducted for this study:

• The study's conclusions showed that the 7% and 25% mixtures satisfied the advised compression standards and that adding 300 and 100 grams of ash to the 7% mixture increased its compressive strength.

• When 100 grams of ash are added to a 25% mixture, its compressive strength rises, and when 300 grams of ash are added, it slightly decreases. Whereas, the best combination is 25% and 200 grams of ash, and using 25% Cement is the best mixture for the filtration process. It has been shown to be useful in freezing heavy elements and preventing their leaking outdoors.

• During the solidification process, nearly all of the extremely dangerous elements—such as Pb, As, and Hg—were successfully handled. The success of other heavy metal treatments at range 99%

• The results of the study showed that, in the 25% combination, treatment efficiency under different pH leaching conditions varied from 99% to 75% in all variable pH readings. It also worked well for freezing three exceedingly dangerous elements: Pb, As, and Hg. The mold had a 100% success rate in preventing element leaks. The results showed that the Ag element had the highest filtration rate in both methods and with combining 7% and 25%.

• Finally, cement is quite good at stabilizing heavy elements, according to study results. When applied in different ways and for different amounts of time, the freezing/stabilization process is very effective at eliminating medical waste with the least level of harm to people. It has also been demonstrated to be advantageous when considering the external factors related to the disposal of ash, such as the general environment, worker safety, and health. Another factor to take into account when deciding whether to utilize these molds in the construction of sidewalks and bridges is their durability.

ACKNOWLEDGMENTS

The authors are grateful for their help from Mustansiriyah University in Baghdad-Iraq and The Ministry of Health and Hospital Administration for their cooperation in providing medical waste samples.

GRANT SUPPORT DETAILS

The present research did not receive any financial support.

CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

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