WWJMRD 2020; 6(3): 45-49
www.wwjmrd.com
International Journal
Peer Reviewed Journal
Refereed Journal
Indexed Journal
Impact Factor MJIF: 4.25
E-ISSN: 2454-6615

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Study on the Zinc Absorbability of Ash from Domestic Waste Incinerator

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Abstract
Study on the Zinc absorbability of ash from domestic waste incinerator shows that: Ash from domestic waste incinerator is alkaline, Nitrogen – poor, Phosphorous – rich, low Zinc content which is equal to 2, 58 - 2, 69 mg/kg. The soil in Lead and Zinc mine in Hich village has average pH level, low electrical conductivity and high Zn content which is 4, 3 times higher than QCVN (Vietnamese Standards). The mobile Zn content is high, around 58, 61 mg/kg. Study on the zinc absorbability of ash from domestic waste incinerator shows that: modified ash can fix mobile Zinc better than normal ash. The mixing ratio is directly proportional to the effectiveness of mobile Zn fixation by ash from domestic waste incinerator. The highest effectiveness of mobile Zn fixation is achieved with the formula B20 which is 80, 99%. According to the research, the mobile Zn fixation is highest at 8 hours in experiment.

Keywords: ash slag, heavy metal, Hich village

1. Introduction
Vietnam has abundant and various mineral natural resources with more than 5000 mining points to produce 60 different types of natural minerals. Minerals with high reserves are normally exported in raw form to the countries in need like oil, coal. Mineral mining in Vietnam has been established and developed for more than 100 years, however, its contribution to the economy is assessed to be less than its potentials [7].
Thai Nguyen is among the province with various types of minerals including the high value ones like multi-metal tungsten, Iron, coal, Lead, Zinc, etc. The mineral exploitation is developed, contributing greatly to the local economic development. However, the environmental treatment is not conducted properly, resulting in the bad effects to the environment, especially the heavy metal pollution in soil.
Currently, there are different chemical – physical methods to treat heavy metals in soil that are available in the world like: soil treatment with ash, at-place fixation, electrodynamics treatment, heavy metal faunal absorbents, etc. However, as the soil pollution is happening in large scale now, the normal chemical-physical methods are not effective because of high cost. Currently, scientific researchers are paying more attention to use the available materials to absorb heavy metals with low treatment cost and environmentally-friendly techniques. Those methods could remove high toxic pollutants that the other methods are not able to remove. Moreover, these methods have the advantages in comparison with the other available methods, including: simple treatment processes, no requirement for complex facility and low treatment cost. The finding of new absorbents is among the great interests for scientific researchers [2].

2. Objects, Content and Methodology
2.1. Research object
+ Ash is taken from domestic waste incinerator in Phu Luong district, Thai Nguyen province.
+ Ash is modified by H_2SO_4 acid 0,05N.

2.2. Research content

- Research on the content, characteristics of ash from domestic waste incinerator and the one modified by H_2SO_4 acid 0,05N.
- Research on the Zn absorbability of ash from domestic waste incinerator and the one modified by H_2SO_4 acid 0,05N.

2.3. Methodology

2.3.1. Laboratory methodology

A large portion of soil (5 kg) at the depth of 20 cm is taken from the former disposal area in lead-zinc mine in Hich village and brought to the laboratory. After that, this soil is dried at laboratory temperature in a week to drain all water without changing the characteristics of soil. After being dried soil is ground and sifted through the mm sieve. This soil is then used for experiments with 9 formula, 3 repeating times with random process.

Table 2.1. Experiment formula

No.	Experiment Formula	Description
1	Benchmark	100% soil
2	B5	5% Ash is modified by H_2SO_4 acid 0,05N + 95% soil
3	B10	10% Ash is modified by H_2SO_4 acid 0,05N + 90% soil
4	B15	15% Ash is modified by H_2SO_4 acid 0,05N + 85% soil
5	B20	20% Ash is modified by H_2SO_4 acid 0,05N + 80% soil
6	T5	5% normal ash + 95% soil
7	T10	10% Normal ash + 90% soil
8	T15	15% Normal ash + 85% soil
9	T20	20% Normal ash + 80% soil

Step 1: Mixing the absorbent with soil; there are 2 absorbents (1 modified and 1 normal)

Weigh 40g Pb, Zn polluted soil and mix with 2 absorbents with the ratio of 0%, 5%, 10%, 15%, 20% (weigh the amount of: 0g, 2g, 4g, 6g, 8g on technical scale) with the repeating time is 3 for each ratio, put into the plastic bags with noted tags.

Step 2: Brewing absorbent with soil

Mix the weighed mixture with distilled water for 2 times to satirize the humidity of experiment mixture. The experiments are implemented in 1h, 2h, 4h, 8h.

Step 3: Extracting the solution

Weigh 2 g soil and put them into glass cup or jazz, then take accurately the amount of 50ml the solution 1M NH_4OAc which is mixed at pH = 7 and put them into the glass cup or jazz and leave for 2h at room temperature.

After 2h, the solution is filtered to scale the mobile Zn.

**** Parameters and monitoring methods:***

Monitoring the fixability of mobile Zn in soil of 2 absorbents.

2.3.2. Analysis methodology

Mobile Zn is analyzed by the Absorption Spectroscopy AAS

2.3.3 Data analysis

The results of experiments are analyzed by SAS software to check the difference among experiment formulas on mobile Zn in soil.

3. Research Results and Discussion

3.1. Contents and characteristics of ash from domestic waste incinerator

The results on contents and characteristics of ash from domestic waste incinerator in Table 3.1:

Table 3.1. Characteristics of ash from domestic waste incinerator

No.	Parameter	Unit	Results	
			Normal ash	Modified ash
1	pH_{KCl}	-	8,38	8,25
2	EC	mS/cm	128,80	19,84
3	N_{ts}	%	0,06	0,07
4	$P_2O_{5\ ts}$	%	0,49	0,56
5	Zn	mg/kg	2,69	2,58
6	Mobile Zn	mg/kg	-	-

Table 3.1 shows that: ash from domestic waste incinerator is alkaline and high pH.

Normal ash has pH = 8,38 và ash modified by H_2SO_4 has pH = 8,25. The electrical conductivity of ash is high (128,8 mS/cm), while that of modified ash is lower (19,84 mS/cm). Total nitrogen content is 0,06 - 0,07%. According to the nitrogen scale in soil, ash is poor in nitrogen. Total Phosphorous content is 0,49 - 0,56%. According to the Phosphorous scale in soil, ash is rich in Phosphorous. Zn content is very low, from 2,58 - 2,69 mg/kg. This amount of toxic Zn is very low according to the Vietnamese quality on heavy metal content in soil.

3.2. Current situation of soil in disposal area of Lead-Zinc mine in Hich village

The current situation of soil in the disposal area of Lead-Zinc mine in Hich village is shown in Table 3.2:

Table 3.2. Some parameters of soil in the disposal area of Lead-Zinc mine in Hich village

No	Parameter	Unit	Analysis result	QCVN 03:2015 (Agricultural Soil)
1	pH_{KCl}	-	7,04	-
2	EC	mS/cm	0,95	-
3	N_{ts}	%	0,01	-
4	$P_2O_{5\ ts}$	%	0,08	-
5	Zn	mg/kg	1061,60	200
6	Mobile Zn	mg/kg	58,61	-

The table 3.2 shows that: Soil in the disposal area of Lead-Zinc mine in Hich village has average pH, high electrical conductivity, and low nutrient (Nitrogen, Photsphorous).

Total Zn content is very high which is up to 1061 mg/kg. Zn content is 4.3 times higher than the permission in Vietnamese national standard on the limitation of heavy metal in soil (QCVN 03- MT: 2015/BTNMT). Mobile Zn content is also very high which is 58,61 mg/kg. Unless this mobile Zinc is fixed, it is easily to be transferred in the environment, from soil to ground water, surface water, accumulating in living things and people.

3.3. Research on mobile Zn absorbability of ash from domestic waste incinerator

The mobile Zn absorbability of ash from domestic waste incinerator is shown in Table 3.3.

Table 3.3. Mobile Zn absorbability ash from domestic waste incinerator

Experiment fomula	Input (mg/kg)	After 1h (mg/kg)	After 2 h (mg/kg)	After 4 h (mg/kg)	After 8 h (mg/kg)
Benchmark	58,61	44,704 ± 0,938^{a}	41,260 ± 1,597^{a}	35,992 ± 1,611^{a}	32,787 ± 0,460^{a}
B5		39,265 ± 1,721^{b}	38,641 ± 1,834^{a}	35,292 ± 3,625^{a}	31,904 ± 0,671^{ab}
B10		27,048 ± 0,878^{d}	25,970 ± 2,855^{c}	25,953 ± 1,598^{d}	25,611 ± 2,508^{c}
B15		24,080 ± 1,888^{e}	23,606 ± 3,485^{dc}	22,240 ± 0,820^{e}	22,200 ± 2,048^{d}
B20		14,717 ± 0,665^{g}	13,035 ± 0,845^{e}	13,975 ± 1,069^{f}	11,143 ± 1,473^{e}
T5		39,380 ± 2,371^{b}	39,471 ± 1,434^{a}	34,438 ± 0,512^{ab}	32,716 ± 0,866^{a}
T10		31,501 ± 1,913^{c}	32,412 ± 1,099^{b}	31,371 ± 0,692^{bc}	31,073 ± 1,676^{ab}
T15		30,700 ± 0,423^{c}	29,590 ± 1,486^{b}	29,501 ± 1,973^{c}	29,181 ± 2,380^{b}
T20		21,003 ± 1,408^{f}	21,679 ± 2,153^{d}	19,912 ± 2,190^{e}	19,575 ± 0,545^{d}
LSD_{05}		**2,5611**	**3,3903**	**3,1075**	**2,7326**

Note: The average value ± S.D, n = 3; the average value of the alphabetic characters show the noticeable differences in the same column, at the probability of 5%.

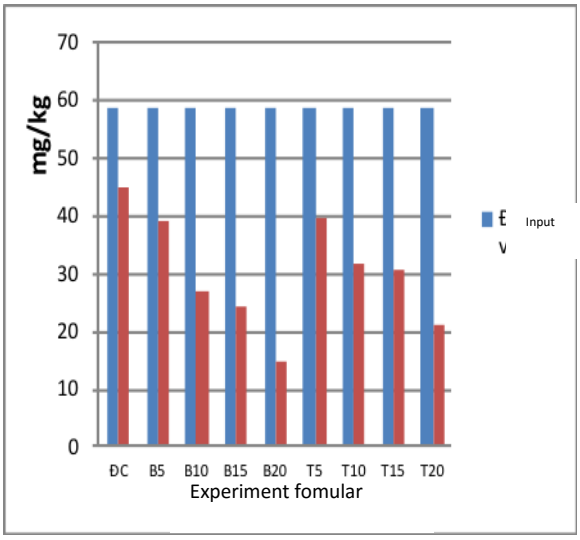

Fig. 3.1. Mobile Zn absorbability of ash from domestic waste incinerator after 1 hour

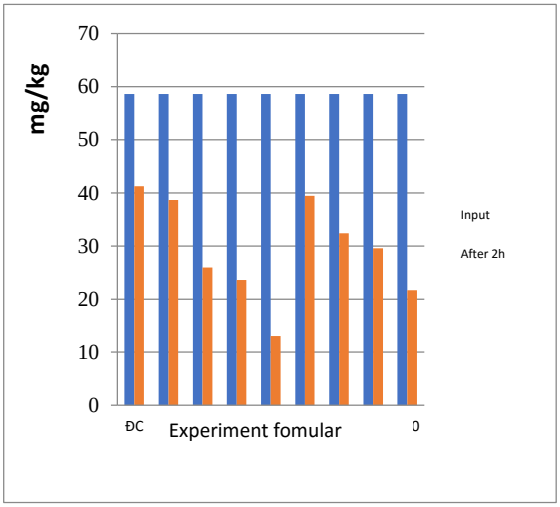

Fig. 3.1.b Mobile Zn absorbability of ash from domestic waste incinerator after 2 hour

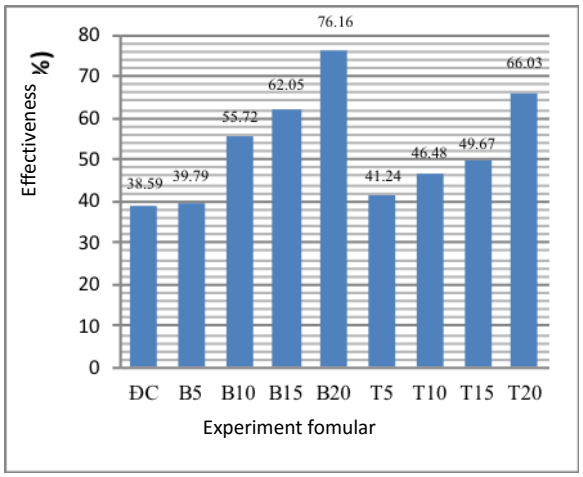

Fig. 3.1.c Mobile Zn absorbability of ash from domestic waste incinerator after 4 hour

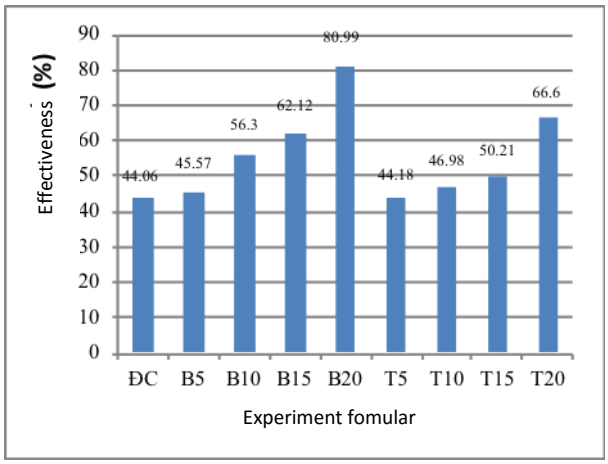

Fig. 3.1.d Mobile Zn absorbability of ash from domestic waste incinerator after 8 hour

Figure 3.1. Mobile Zn absorbability of ash from domestic waste incinerator

The table 3.3 and Figure 3.1 show that:

After 1h: Ash from domestic waste incinerator has high absorbability of mobile Zn in soil which is increased together with the mixing ratio of ash from domestic waste incinerator into soil. The highest mobile Zn absorbability is achieved with the mixing ratio of modified ash of 20%. The mobile Zinc content reduces from 58,61 mg/kg to 14,717 mg/kg. At the mixing ratio of normal ash into soil of 5%, 10%, 15%, 20%, after 1h, the mobile Zn absorbability is 32,81%, 46,25%, 47,62%, 64, 16% consecutively. The lowest mobile Zn absorbability is achieved with the mixing ratio of ash of 5%. The modified ash by H_2SO_4 has higher mobile Zn absorbability than that of normal ash. At the same time, the absorption effectiveness is increasing together with the mixing ratio of modified ash by H_2SO_4 into soil. When the mixing ratio increases from 5% to 20%, the effectiveness increases from 33,01% to 74,89%. So, the research on absorption after 1 hour shows that ash from domestic waste incinerator are able to fix the mobile Zn in after-mining soil; and the mixing ratio of ash from domestic waste incinerator and modified ash into soil affects greatly to that absorbability. The absorbability increases together with the mixing ratio of of ash from domestic waste incinerator and modified ash into soil. The highest effectiveness is achived when the mixing ratio is 20%.

After 2h: Mobile Zn fixability of modified ash is higher than that of normal ash. The effectiveness with modified ash is from 34,07 to 77,76%. Normal ash gets the fixation effectiveness of 32,65 - 63,01%. In term of mixing ratio, the noticeable difference could be seen with the mixing ratio above 10% with the reliability of 5% that means only when the mixing ratio of ash into soil is more than 10%, the ash has ability to fix mobile Zn in soil. The Zn fixation is highest with the formula of B20 (the content of mobile Zn reduces from 58,61 mg/kg to 13,975 mg/kg), after that is the formula of T20 (the content of mobile Zn reduces from 58,61 mg/kg to 19,912 mg/kg). The mobile Zn fixation is lowest with the formula of T5 (the content of mobile Zn reduces from 58,61 mg/kg to 34,438 mg/kg).

After 4h: Ash from domestic waste incinerator has good mobile Zn in after-mining soil and the mixing ratio of ash from domestic waste incinerator into soil after 4 hour affects greatly to the effectiveness. With the mixing ratio of normal ash into soil of 5%, 10%, 15%, 20%, after 4h, the mobile Zn absorbability increases with the mixing ratio: 41,24%, 46,48%, 49,67%, 66,03% accordingly. So, the highest effectiveness is achieved with the mixing ratio of 20% while the lowest one is achieved with the mixing ratio of 5%. In term of modified ash, the absorption effectiveness is 39,79%, 55,72%, 62,05%, and 76, 16% accordingly. The effectiveness of modified ash is always higher than that of normal ash. In particular, with the same mixing ratio of 20%, the absorption effectiveness of mobile Zn of modified ash is 76,16% while that of normal ash is only 66,03%. After 4h of experiment, the mixing ratio of ash into soil needs to be higher than 10% then the fixation of mobile Zn in soil is recorded.

After 8h: In term of modified ash: the effectiveness increases with the mixing ratio: 45,57%, 56,3%, 62,12%, and 80,99% accordingly and is really noticeable at the mixing ratio of 10%, 15% and 20%. The comparison between the results of the mixing ratio of 5% with the benchmarking shows little noticeable difference. In term of normal ash: the effectiveness increases with the mixing ratio 44,18%, 46,98%, 50,21% and 66,6% accordingly. The effectiveness of absorbing mobile Zn with normal ash is only meaningful with the mixing ratio of 15% and 20%. The following chart shows the fact that Mobile Zn fixability of modified ash is higher than that of normal ash.

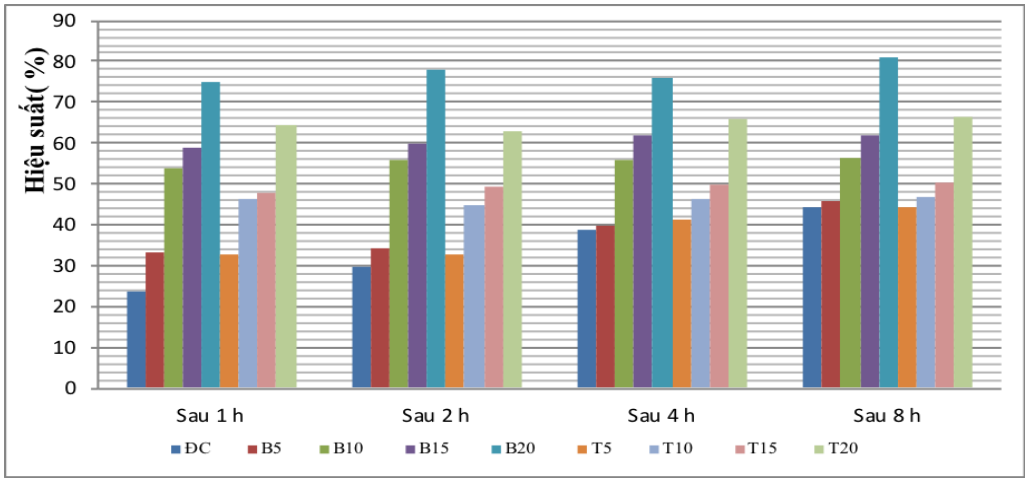

Fig.3.2. The fixation of mobile Zn in soil of ash from domestic waste incinerator

Table 3.3 and Figure 3.2 show that: The effectiveness of mobile Zn in soil absorption is in direct proportion to the mixing ratio of ash from domestic waste incinerator. The mobile Zn fixability is from 32,65% to 80,99% in which the highest effectiveness is achieved with the mixing ratio of 20%. In term of experiment time, the highest effectiveness of mobile Zn absorption is achieved after 8h and that also varies depending on the experiment time. However, it is still not clear whether it will increase or decrease with time. In particular, with the formula of B5, B10, B15, T15 and T20, the effectiveness of absorbing mobile Zn increases with treatment time and is highest at 8h. However, with the formula of B20, T5 and T10, the effectiveness is instantly increaes or decreases. It can be concluded that 8h is too short for the experiment to identify the best time for the absorption of mobile Zn of ash from domestic waste incinerator.

4. Conclusion

Ash from domestic waste incinerator is alkaline, nitrogen – poor, Phosphorous – rich, low Zinc content which is equal to 2,58 - 2,69 mg/kg. The soil in Lead - Zinc mine in Hich village has average pH level, low electrical conductivity and high Zn content which is 4,3 times higher than QCVN (Vietnamese standards). The mobile Zn content is high, around 58,61 mg/kg. Study on the zinc absorbability of ash from domestic waste incinerator shows that: modified ash can fix mobile Zinc better than normal ash. The mixing ratio is directly proportional to the effectiveness of mobile Zn fixation by ash from domestic waste incinerator. The highest effectiveness of mobile Zn fixation is achieved with the formula B20 which is 80,99%. According to the research, the mobile Zn fixation is highest at 8 hours in experiment.

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