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ASSESSMENT OF BTEX ORGANIC POLLUTION IN THE AIR AND RISKS TO HUMAN HEALTH IN THE AREA OF DOMESTIC WASTE INCINERATORS IN HAI LY COMMUNE, HAI HAU DISTRICT, NAM DINH PROVINCE, VIETNAM

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ABSTRACT

The trend for treatment of solid domestic waste by the domestic waste incinerator system is necessary to minimize the negative impacts of solid waste on the environment and human health. The survey and analysis results show that the organic waste composition ranges from 52.23% to 52.8%. Benzene concentration ranges from 0.55 to 23.19 µg/m^3. Toluene concentrations ranged from 16.29 µg/m^3 to 120.19 µg/m^3. Concentration (o,m,p)-Xylene ranges from 5.81 µg/m^3 to 14.73 µg/m^3. Ethyl Benzene concentrations ranged from 1.32 µg/m^3 to 8.63 µg/m^3. According to the risk assessment results, the exhaust gas from the incinerator has caused secondary environmental pollution, affecting the health of the workers operating the solid domestic waste incinerator. On that basis, the article recommends applying a number of management measures to minimize the negative impacts from the operation of the solid waste incinerator to the environment and the health of the workers operating the incinerator

KEY WORD : Organic pollution, BTEX, Health risks, Solid domestic waste.

INTRODUCTION

Currently, solid domestic waste in Nam Dinh in general and in Hai Hau district in particular is a worrying problem. Along with economic development, population growth and living habits, the solid domestic waste has an increasing number and an increasingly complex composition. This problem has threatened the local social – economic development.

To deal with this pollution, Nam Dinh province has chosen many treatment solutions, including investment in a small incinerators. Therefore, there is a situation that each district, each commune has invested in incinerators with small capacity to treat domestic waste generated in the area. However, according to the assessment of environmental experts, this solution, although achieving short-term benefits, will have many consequences in the long run. Since most types of solid waste incinerators have not been able to thoroughly treat the dust and emissions generated, especially organic compounds in the waste, this has led to secondary environmental pollution.

According to statistics of Nam Dinh Provincial People's Committee, currently, in Hai Hau district, there are 29 solid domestic waste incinerators, including 20 Losiho technology incinerators, with a capacity of 400kg/hour using burning fuel. natural gas. Hai Ly commune, Hai Hau district, Nam Dinh province is a purely agricultural commune, mainly engaged in agricultural production, salt production, animal husbandry and fishing. Along with the social-economic development, Hai Ly is also an attractive tourist destination for many people from all over the province as well as other provinces, so the amount of daily waste generated in the area is quite large. Currently, in the commune, two waste

collection teams have been organized with the frequency of collection every 3 days, then gathered and sent to the commune's waste landfill for treatment. In 2019, Hai Hai commune was equipped with 01 Losiho domestic waste incinerator with a capacity of 400 kg/hour to treat domestic waste generated in the commune. The conventional incineration process consists of 3 main steps: classification, incineration, and treatment of dust and ash. The dust removal process is shown in Figure 1.

Losiho's smoke and dust treatment method is the wet method. The smoke and dust treatment system of Losiho furnace includes 04 water tanks and 01 clear lime water tank. The gas flow in the combustion process is led from the top down and passes through the treatment system including 04 water tanks, after passing through 04 tanks, the exhaust gas continues to be led into the clear lime water tank before being released to the environment. Present, due to the fact that the operation and maintenance of the furnace exhaust gas treatment system has not been carried out regularly, leading to low treatment efficiency, this has caused some negative impacts on the health of workers. furnace operation

RESREACH METHODS

Methods of investigation and survey

In April and June 2021, the research team conducted a survey to determine the composition of solid domestic wastein Hai Ly commune, Hai Hau district, Nam Dinh province.

Methods of sampling and analysis

Sampling Solid domestic waste: Following TCVN 9466:2012 Standard guide for sampling waste piles.

Define component Solid domestic waste: Following TCVN 9461:2012 Standard test method for determination of the composition of unprocessed municipal solid waste

Waste gas samples: Carried out of guide of cicurlar number 40/2015/TT-BTNMT for the process of monitoring waste gas.

The surrounding BTEX norms were obtained using the SKC 224-PCXR8KD device.

Phase 1: April 8, 2021 to April 9, 2021 is typical for the rainy season, high temperature and humidity; The number of surrounding air samples is 04.

Phase 2: June 8, 2021 to June 9, 2021, characterized by dry season, low temperature and humidity; the number of ambient air samples is 04.

Health risk assessment

To assess the risks of some organic substances to human health, the author used the method according to EPA-540-R-070-002,2009 [3] and selected the group of organic substances BTEX to evaluate. This is an organic compound that causes negative effects on human health when exposed.

The assessment process following with 4 steps:

Step 1: Hazard identification

Step 2: The chronic daily intake and Exposure Concentration

$CDI = (CA \times IR \times ET \times EF \times ED) / (BW \times AT_1)$ (Trinh Dinh Tran *et al.*, 2020)

$EC = (CA \times ET \times EF \times ED) / AT_2$ (Trinh Dinh Tran *et al.*, 2020)

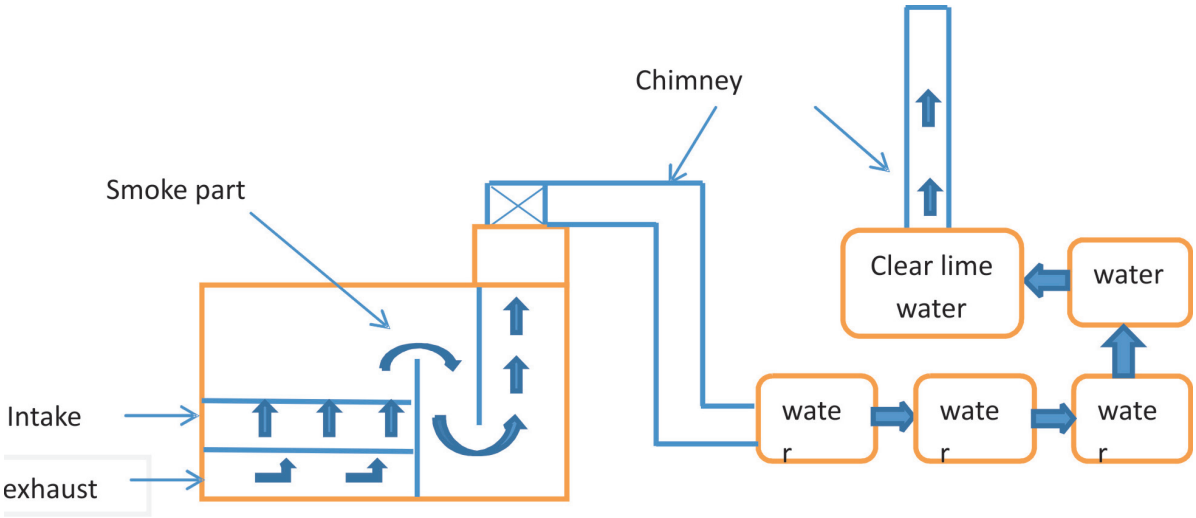

Fig. 1. Simulation of the Losiho's smoke and dust treatment process

+ CDI: The chronic daily intake (mg/kg.day).
+ EC: Exposure Concentration (µg/m^3)
+ CSF: The inhalation cancer slope factor: 0.029 (mg/kg.day) (V.Thi. Le. Ha *et al.*, 2020)
+ $RfC_{(Toluen):}$ The inhalation reference concentration: 5 (mg/m3) (V.Thi.Le. Ha *et al.*, 2020)
+ $RfC_{(Xylen)}$: The inhalation reference concentration: 1 (mg/m^3) (V.Thi.Le.Ha *et al.*, 2020)
+ CA: The contaminant concentration in air, (mg/m^3)
+ IR: The inhalation rate: 0,87 (m^3/day) (US EPA, 2009)
+ BW: Body Weight: 65 (kg) *(questionnaire)*
+ ET: The exposure time: 8 (h/day) (*questionnaire)*
+ EF: The exposure frequency: 300 (day/years) (*questionnaire)*
+ ED: The exposure duration: 10 (years) (*questionnaire)*
+ $AT_{(1)}$: The averaging time: 3.000 ngày (10 years x 300 day/years).
+ $AT_{(2)}$: The averaging time: 72.000 gio (10 years x 300 day/years x 24 hour).

Step 3: Risk calculation (Cancer and non-Cancer).

Assesment for each substance

IELCR = CDI × CSF (Trinh Dinh Tran *et al.*, 2020)
HQ = EC/RfC (Trinh Dinh Tran *et al.*, 2020)
IELCR: The Incremental Excess Lifetime Cancer Risk
HQ: Hazard Quotient

Risk assessment for total resources

$CTR = \Sigma_i IELCR_i$ (William F. Bleam, 2012)
$HI = \Sigma_i HQ_i$ (William F. Bleam, 2012)
CTR: Cumulative Target Risk
HI: Hazard Index

Step 4: *Risk assessment*

Non – Cancer: For the non-cancer risk, an HQ value higher than 1 means an adverse non-carcinogenic effect of concern, whereas at or less than 1 means an acceptable level (of no concern)

Cancer: A cancer risk value greater than 10^{-6} represents a carcinogenic risk of concern, while at or less than 10^{-6} is viewed as an acceptable level.

RESULTS AND DISCUSSION

Composition of Solid domestic waste in Hai Ly commune, Hai Hau district, Nam Dinh province

Samples of Solid domestic waste are classified to determine other organic and inorganic components to serve as a basis for recommending treatment methods.

Through the data in Table 1, it shows that the solid domestic waste in Hai Ly commune is mainly organic matter, accounting for the proportion from 52.29% to 52.80%. There is no significant difference in the composition of solid waste in the two surveys.

Contamination of BTEX around the incinerator area

To determine the concentration of BTEXs in the air around the incinerator area, the research team conducted 2 sampling and sample analysis sessions

Fig. 2. Incinerator of solid domestic waste in Hai Ly commune

Table 1. Composition of Solid domestic waste in Hai Ly commune, Hai Hau district, Nam Dinh province

Component	Percent (%)	
	Phase 1 (April 8, 2021 to April 9, 2021)	**Phase 2 (**June 8, 2021 to June 9, 2021)
Organic ingredients (leftovers, leaves, tea grounds, fruit peels, twigs, rags, etc.)	52.80	52.23
Waste paper, glass, metal	25.73	22.40
Plastic bags, plastic bottles of all kinds, imitation leather	2.90	3.70
Toxic substances (battery, paint, etc.)	0.01	0.02
Crockery, concrete, bricks, slag, seashells, snails, tires, ...	18.56	21.65

Fig. 3. Component of solid domestic waste in Hai Ly commune

on April 08-09, 2021 and June 08-09, 2021. , the analysis results are shown in Table 2.

QCVN 06:2013/BTNMT: National Technical regulation on hazardous substances in ambient air.

Based on the analysis results in Table 2.

The concentration of BTEX compound in June was 1,3 to 2,1 times higher than that in April. In which, the concentration of Benzene at K8 was 1,05 times higher than that of QCVN 06:2009/BTNMT.

Risk assessment of BTEX incinerators to operator's health

Since Vietnam has not had any official studies on environmental risks, the research team used standard parameters to compare and assess risks based on published research results of the environmental agency. United States EPA-540-R-070-002, 2009 (US EPA, 2009)

The results of the risk assessment of the BTEX compound of the two sampling periods are shown in Tables 3, 4 and 5.

——*Risk assessment for each substance*

The results of the risk calculation for each substance are shown in Tables 3 and 4

Comment: Through the results of risk assessment of BTEX compound to the health of workers operating the incinerator:

For substances with a risk of cancer including: Benzene and Etyl Benzene

Benzene: The cancer risk indices of 02 sampling sessions have corresponding values from 1,6 x 10^{-5} to 4,04 x 10^{-5} and from 2,12 x 10^{-5} to, respectively. 72 x 10^{-5}. According to EPA (US EPA, 2009), the cancer risk index of Benzene is greater than 10^{-6}, which shows that the concentration of Benzene in the air in the incinerator area is at an alarming level and poses a cancer risk to industrial plants. furnace operator.

Etyl Benzene: The cancer risk indices of 2 sampling sessions have corresponding values ranging from 4.,1 x 10^{-6} to 20 x 10^{-5} and from 8.,5 x 10^{-6}, respectively. to 2,7 x 10^{-5}. According to the EPA (US EPA, 2009), it is shown that the concentration of Etyl Benzene in the air in the incinerator area has been found to cause cancer for the workers operating the incinerator.

For substances that do not pose a carcinogenic risk, including: Toluene and (o, m, p) Xylene

The indicators that pose a risk to human health of

Table 2. Analysis results BTEX compound in the area around the incinerator

BTEX Compound	Unit	Concentrations								QCVN 06: 2009/BTNMT
		K1	K2	K3	K4	K5	K6	K7	K8	
Benzen	µg/m^3	5,55	7,32	10,57	13,01	6,82	12,96	19,77	23,19	22
Toluen	µg/m^3	16,29	29,32	43,98	65,05	34,92	101,27	83,81	120,19	500
(o,m,p)-Xylen	µg/m^3	5,81	7,55	8,72	10,39	7,45	10,43	9,68	14,73	1000
Etyl Benzen	µg/m^3	1,32	4,75	3,17	6,47	2,74	7,124	4,38	8,63	-

Note:

K1, K3 are samples taken from the bottom of the chimney 200m in the wind direction, respectively, on the morning of April 8, 2021 and April 9, 2021. Features shady weather, light wind.

K2, K4: Samples were taken 200m from the chimney foot in the wind direction, respectively, on the afternoon of April 8, 2021 and April 9, 2021. Characteristics of hot weather, light wind.

K5, K7 The samples were taken 200m from the chimney foot in the wind direction, in the morning of June 8, 2021 and June 9, 2021, respectively. Features shady weather, light wind.

K6, K8 The samples were taken at a distance of 200m from the chimney foot in the wind direction, on the afternoon of June 8, 2021 and June 9, 2021, respectively. Characteristics of cool weather, light wind.

Table 3. Risk Assessment Results of Benzene and Etyl Benzene

	Ci (mg/m^3)	CDI	IELCR
Phase 1$_{Benzen}$	0,0056 - 0,0131	5,7 x 10^{-4} - 1,39 x 10^{-3}	1,6 x 10^{-5} - 4,04 x 10^{-5}
Phase 2$_{Benzen}$	0,0068 - 0,0232	7,3 x 10^{-4} - 2,5 x 10^{-3}	2,12 x 10^{-5} - 7,2 x 10^{-5}
Phase 1$_{Etyl\ Benzen}$	0,0013 - 0,0065	1,4 x 10^{-4} - 6,9 x 10^{-4}	4,1 x 10^{-6} - 2,0 x 10^{-5}
Phase 2$_{Etyl\ Benzen}$	0,0027 - 0,0086	2,9 x 10^{-4} - 9,2 x 10^{-4}	8,5 x 10^{-6} - 2,7 x 10^{-5}

Table 4. Risk Assessment Results of Toluene and (o,m,p)-Xylene

	Ci (mg/m^3)	EC	HQ
Phase 1$_{Toluen}$	0,016 - 0,065	0,005 - 0,022	0,001 - 0,004
Phase 2$_{Toluen}$	0,034 - 0,120	0,011 - 0,040	0,002- 0,008
Phase 1$_{(o,m,p)\text{-}Xylen}$	0,006 - 0,010	0,002- 0,003	0,002- 0,003
Phase 2$_{(o,m,p)\text{-}Xylen}$	0,007 - 0,015	0,002 - 0,005	0,003 - 0,005

Toluene and (o,m,p) Xylene in the ambient air of the two sampling periods ranged from 0.001 to 0.008 and from 0.002 to 0.005, respectively. According to US EPA, 2009, the index of health effects of these two substances are ≤ 1, which shows that the impact of these substances on the health of workers operating the area around the incinerator is at a low level.

Risk assessment for total resources

The results of risk calculation by total source are shown in Table 5

Comment: Through the results of risk assessment according to the total source in Table 5.

For the group of substances with a risk of causing cancer, including: Benzene and EthyBenzene

Total sources of potentially carcinogenic substances ranged from 2,05 x 10^{-5} to 6,04 x 10^{-5} and from 2,97 x 10^{-5} to 9,9 x 10^{-5}. According to William F. Bleam, 2012, the calculated index of total carcinogenicity in the range $10^{-6} < CR < 10^{-4}$ is an acceptable threshold, which shows the impact of carcinogenic sources. in the air at the incinerator area is at an average level. For the group of substances with no risk of causing cancer, including: Toluene and (o, m, p) Xylene.

The total source of non-carcinogenic substances in the air around the domestic waste incinerators ranged from 0,003 to 0,007 and from 0,005 to 0013.

Table 5. Risk assessment results of total carcinogenic and non-carcinogenic sources

	IELCR	HI
Phase 1	2,05 x 10^{-5} – 6,04 x 10^{-5}	0,003 – 0,007
Phase 2	2,97 x 10^{-5} – 9,9 x 10^{-5}	0,005 – 0,013

According to William F. Bleam, 2012, the health impact index of total non-carcinogenic sources ≤ 1 is an acceptable level, which indicates the impact of these total substances on the health of transport workers. The operating area around the furnace is at a low level.

CONCLUSION

The measurement and analysis results show that the air around the incinerator area has been affected by the burning of domestic waste, in which the Benzene indicator exceeds the QCVN 06:2013/BTNMT standard by 1.05 times. The results of the risk calculation show that, for Toluene and (o,m,p) Xylene, the level of impact on the health of workers operating the incinerator is at a low level. For Benzene and Etyl Benzene, there have been negative impacts on the health of operators and timely handling measures are required.

In order to minimize the impact of BTEX on the health of the workers operating the incinerator, the article proposes to apply some management measures such as wearing protective equipment for the workers operating the incinerator, regularly and periodically. Maintaining the incinerator system, and at the same time improving and installing more gas treatment systems for the incinerator, etc. to ensure the requirements of exhaust gas treatment before being discharged into the environment.

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