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A System Dynamics Assessment on the Dispersion of Incinerator Pollutant Emission From Environmental Impact Assessment (EIA) Study: A Case of Medical Waste in Sidoarjo Regency

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Abstract: The present study aims to evaluate and to project the prediction of the incinerator pollutant emission from medical waste. The dispersion of pollutant emission cited from environmental impact assessment (EIA) study on medical waste in Sidoarjo Regency was assessed by using the Gauss equation and resulted in a range of disperse emissions standard quality in 2014. However, the assessment only reaches in the short temporal time. The present study aims to project the dispersion of pollutant emission in a relatively long projection of 5 years. Five parameters to include dust, SOx, NOx, CO and HC were assessed. A projection model was made and was simulated by system dynamic approach. The result revealed the disperse emissions were still in the range of standard quality within the 5 years projection.
Keywords: Incinerator Emission, Medical Waste, Emission Standard Quality, System Dynamics.

Introduction

The medical waste is categorized as a toxic hazardous material. It is frequently produced by hospital, community health centers, clinic, and doctor practice. It is produced in daily, which rarely treated and resulted in environmental impact. The medical waste was commonly treated by using incinerator, which it burns the medical waste in the temperature range of 1000-1200 degree Celsius. In the burning procedures, the gas emission was released from incinerator chimney. The incinerator emission is practically harm to the local citizens on the site location. This condition, however, requires the management to conduct an EIA study. Based on the applicable provision, the EIA study is assessed by the EIA commission in which located on central commission at Ministry of Environment Jakarta. Sidoarjo regency is one of the sites which will operate the incinerator for burning the medical waste. The EIA study was performed and feasibility permit was issued. However, ensuring the environmental safety is the main concern to maintain the impact according to the threshold. This study, hence, will assess the projection of emission range in the span of 5 years after the EIA study was concluded. A result of emission in the range of threshold is expected.

Materials and Methods

EIA regulation

According to Ministry of Environment of Indonesia No.5/2012[1], the incineration operation is counted as the activity that needs an EIA study. Furthermore, according to the Ministry of Environment of Indonesia No.8/2013[2], the incinerator activity is in the authority of the EIA commission center at the Ministry of Environment Jakarta.

Refer to Indonesian Act 32/2009[3] as well as Government Regulation 27/2012[4], the EIA study was conducted by the EIA team study. The EIA team consisted of one leader (Mursid, M.) and two members (Razif, M. and Boedisantosa, R.) in which they have the competency certificate as an EIA author as well as few others expert.

EIA result

In the EIA study regarding the burning process of medical waste by the incinerator in Sidoarjo Regency[5], an estimation was conducted from the incinerator emission by Gauss equation. The data were taken from the field and was used to simulate the incinerator dispersion as shown in Table 1.

Table. 1. Input Data of Dispersion Incinerator Model

» DATA:			**Dust**	**SOx**	**NOx**	**CO**	**HC**
Emission rate		Vs	m/s	0,8371	0,8371	0,8371	0,8371
Diameter stack	Ds	m	0,65	0,65	0,65	0,65	0,65
Wind velocity	U	m/s	4	4	4	4	4
Atmospheric pressure	P	mbar	1013	1013	1013	1013	1013
Emission gas temperature	Ts	K	343	343	343	343	343
Ambient temperature	T	K	303	303	303	303	303
Stack Height		Hs	m	20	20	20	20
The rate of emission levels	M	g/s	0,0139	0,0694	0,0833	0,0278	0,0097
Stabilities Pasquill	-	-	c	c	c	c	c
E		E	-	2,7183	2,7183	2,7183	2,7183
Phi		Π	-	3,1416	3,1416	3,1416	3,1416
Temperature difference	ΔT	K	40	40	40	40	40
High puff	Δh	m	0,27030	0,27030	0,27030	0,27030	0,27030
Effective height	He	m	20,27030	20,27030	20,27030	20,27030	20,27030
y farthest watch	y farthest	m	1000	1000	1000	1000	1000
		Δy	m	40	40	40	40
Distance x nearest	x nearest	km	0,01	0,01	0,01	0,01	0,01
The difference in distance x	Δx	km	0,01	0,01	0,01	0,01	0,01

Source : Mursid *et al*. [5]

After the data were used in Gauss equation, the result is shown in Table 2 and Figure 1.

Table2. Dispersion Polutan Incinerator

Distance (km)	Dust (µg/m3)	SOx(µg/m3)	NOx(µg/m3)	CO(µg/m3)	HC(µg/m3)
0,01	4,5E-107	2,3E-106	2,7E-106	9,1E-107	3,2E-107
0,05	2,44E-05	0,000122	0,000146	4,87E-05	1,71E-05
0,1	0,088498	0,442492	0,53099	0,176997	0,061949
0,15	0,293107	1,465534	1,75864	0,586213	0,205175
0,2	0,356142	1,780709	2,136851	0,712284	0,249299
0,25	0,335564	1,677818	2,013382	0,671127	0,234895
0,3	0,292471	1,462356	1,754827	0,584942	0,20473
0,35	0,249153	1,245763	1,494915	0,498305	0,174407
0,4	0,211616	1,058079	1,269695	0,423232	0,148131
0,45	0,180562	0,902811	1,083373	0,361124	0,126394
0,5	0,155209	0,776044	0,931253	0,310418	0,108646
0,55	0,134512	0,672562	0,807075	0,269025	0,094159
0,6	0,117527	0,587635	0,705162	0,235054	0,082269
0,65	0,103481	0,517404	0,620885	0,206962	0,072437
0,7	0,091767	0,458837	0,550604	0,183535	0,064237
0,75	0,081917	0,409583	0,4915	0,163833	0,057342
0,8	0,073564	0,367822	0,441387	0,147129	0,051495
0,85	0,066428	0,332139	0,398567	0,132856	0,0465
0,9	0,060286	0,301428	0,361714	0,120571	0,0422
0,95	0,054963	0,274817	0,32978	0,109927	0,038474
1	0,050323	0,251613	0,301936	0,100645	0,035226
Standard Quality*	260	262	92,5	22.600	160

*Ambient Air Quality Standards in accordance with the East Java Governor Regulation No. 10/2009 (Source : Mursid *et al.*[5])

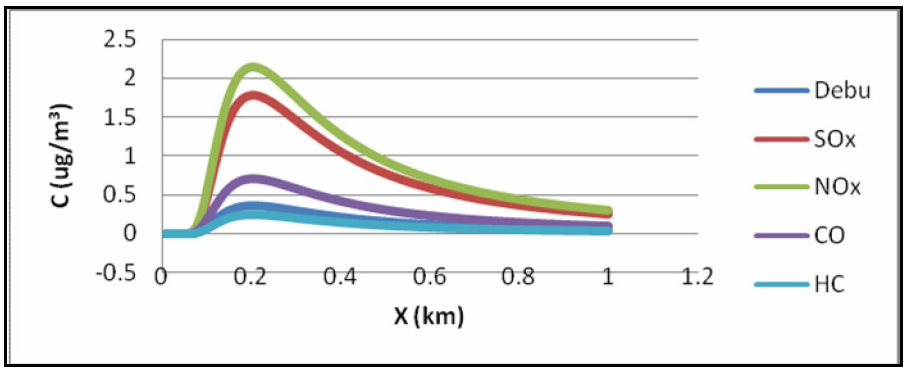

Figure 1. Dispersion of polutants, according to the distance (km) (Source : Mursid *et al.* [5])

System Dynamics

Razif *et al.*[6] were performed a fluctuation prediction in the Wastewater Treatment Plant by using the system dynamics approach for shopping center case in Surabaya city. In the Surabaya water quality research, the result became the basic reference of further study[7]. System dynamics by using the Stella software was also performed to a fluctuation of water quality in Surabaya river[8]. Based on the data collected from EIA study, a prediction for 5 years on the incinerator pollutant emission from medical waste will be performed by system dynamics approach. The measured parameters consist of dust, SOx, NOx, CO, HC. The constructed model can be seen in Figure 2. The predicted result will be compared to standard quality of ambient air based on East Java Governor Regulation No. 10/2009[9].

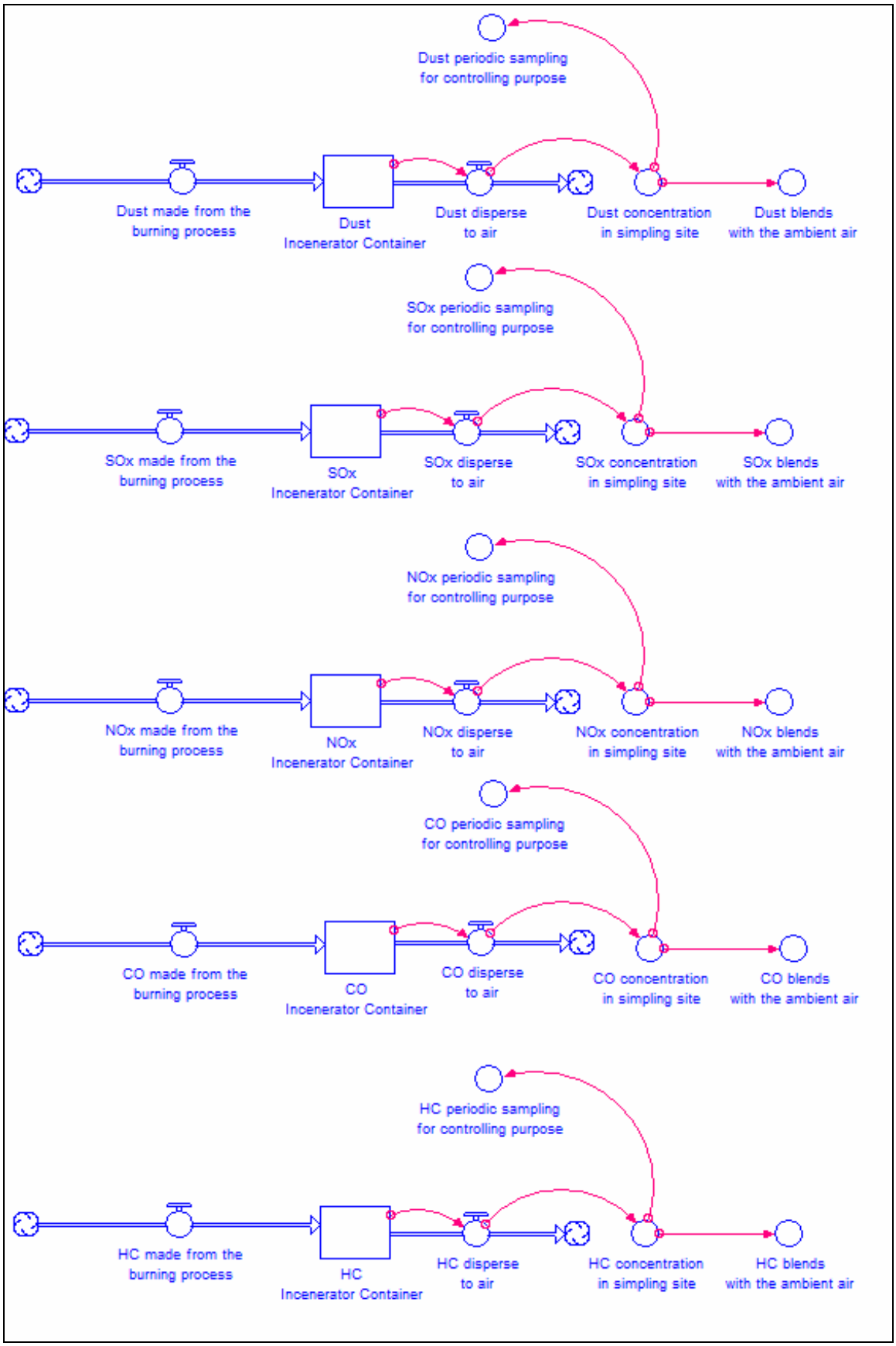

Figure 2. Projection model of dust, SOx, NOx, CO, and HC in the Sidoarjo regency medical waste incinerator

Result and Discussion

A descriptive statistical analysis is performed to analyze the 2014 sampling data and the outcome is presented in Table 2(a) and 2(b). The descriptive statistical analysis consists of mean, minimum value, quartile 1, median, quartile 3, maximum value, standard deviation, variance, coefficient of variance and the range of the data.

Table 1 (a). Descriptive statistical analysis result

Variable	N	Mean	Minimum	Q1	Median	Q3	Maximum
Dust (µg/m3)	21	0.357	0.000	0.070	0.118	0.271	4.500
SOx (µg/m3)	21	0.823	0.000	0.350	0.588	1.354	2.300
NOx (µg/m3)	21	0.985	0.000	0.420	0.705	1.625	2.700
CO (µg/m3)	21	0.719	0.000	0.140	0.235	0.542	9.100
HC (µg/m3)	21	0.252	0.000	0.049	0.082	0.190	3.200

Table 2 (b). Descriptive statistical analysis result 2

Variable	St Dev	Variance	Coe Var	Range
Dust (µg/m3)	0.955	0.912	267.44	4.500
SOx (µg/m3)	0.614	0.377	74.58	2.300
NOx (µg/m3)	0.730	0.532	74.07	2.700
CO (µg/m3)	1.931	3.730	268.69	9.100
HC (µg/m3)	0.679	0.461	269.22	3.200

The application of System Dynamics was similarly conducted in prior research regarding wastewater treatment plant for Mall case[6] as well as river quality in Surabaya rivers[8]. In the present study, a prediction is conducted on the incinerator pollutant emission from medical waste. The projection results of System Dynamic with STELLA software are shown in Figure 3-7 as well as Table 3 and Table 4.

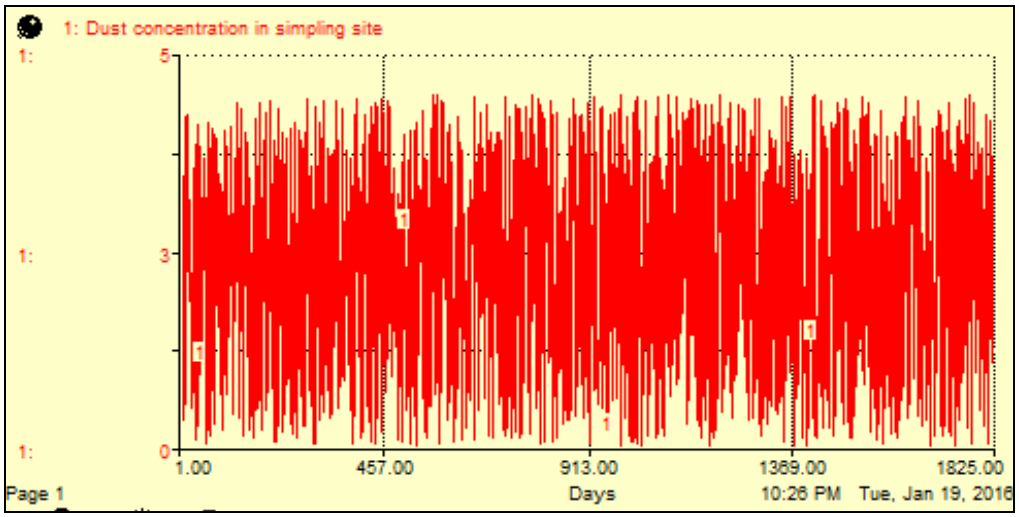

Figure 3. Five year projection of Dust concentration in sampling site

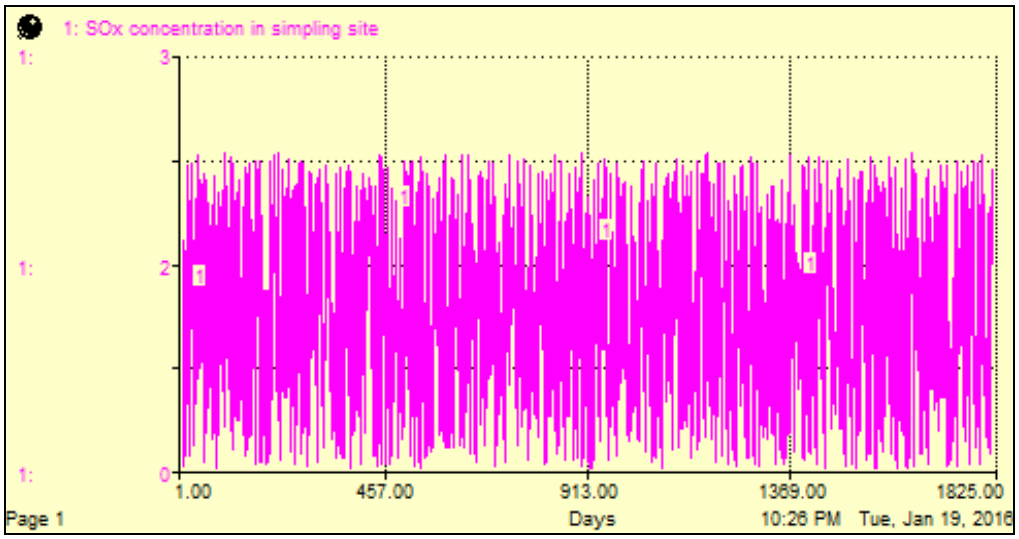

Figure 4. Five year projection of SOx concentration in sampling site

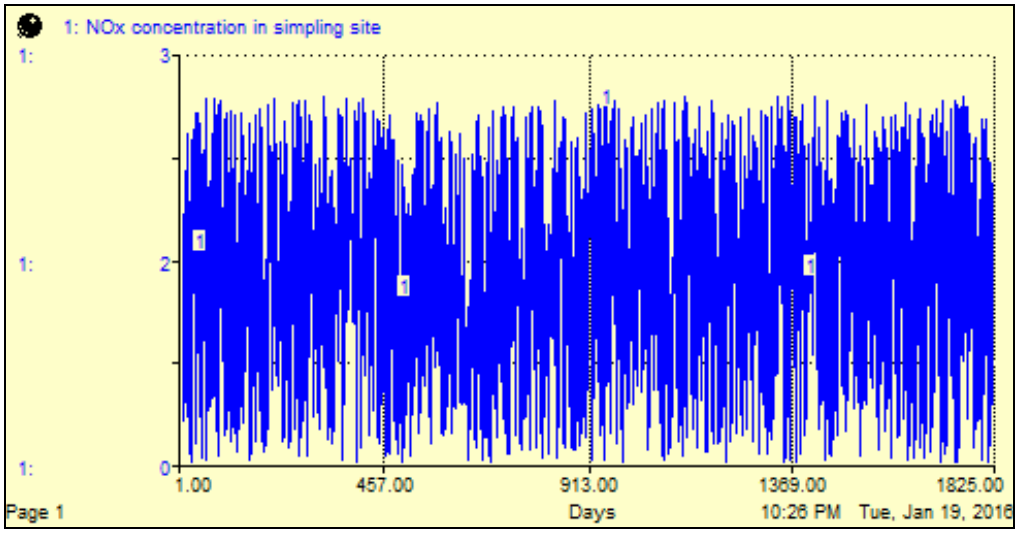

Figure 5. Five year projection of NOx concentration in sampling site

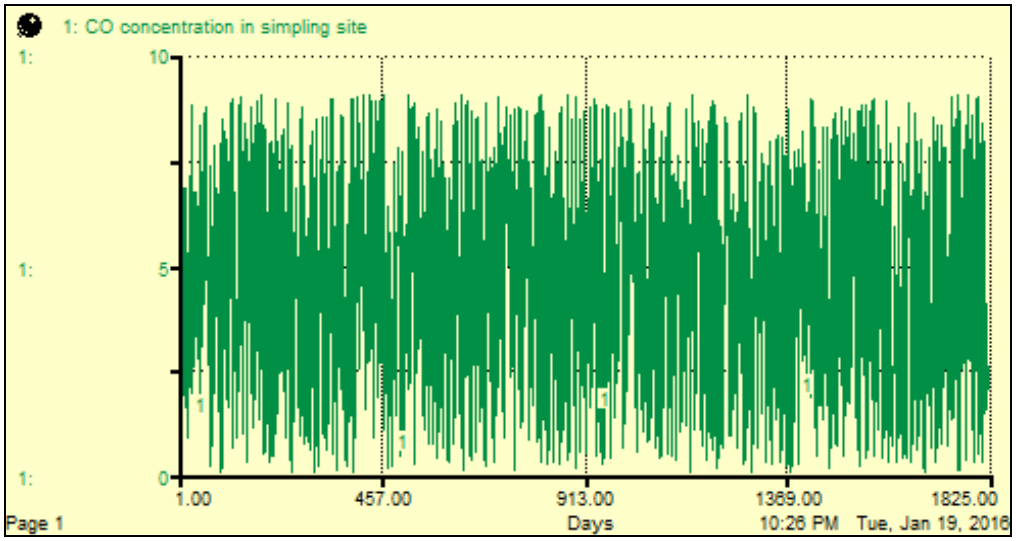

Figure 6. Five year projection of CO concentration in sampling site

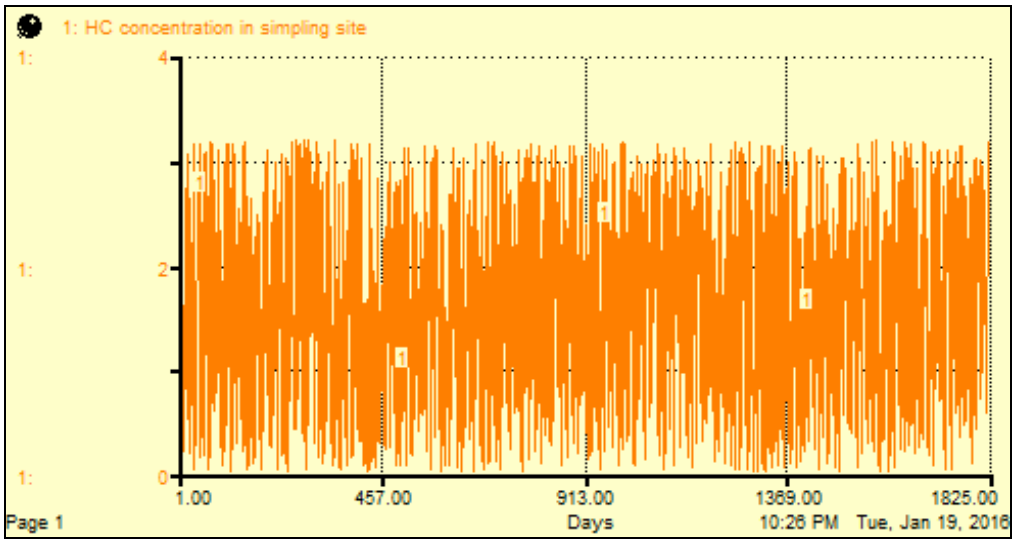

Figure 7. Five year projection of HC concentration in sampling site

Table 2. Five Year Projection of Incinerator Medical Pollutant Emission in Sidoarjo Regency

Time (days)	Dust (µg/m3)	SOx (µg/m3)	NOx (µg/m3)	CO (µg/m3)	HC (µg/m3)
1	3.45	1.67	0.31	1.89	0.2
2	3.15	0.61	0.75	4.79	1.6
3	0.35	0.03	1.79	6.85	0.92
4	2.14	0.14	1.88	1.57	1.24
5	1.77	1.37	1.4	6.38	1.32
6	4.22	0.5	0.44	2.58	2.73
7	0.55	1.32	1.98	6.85	0.8
8	4.24	1.85	2.32	3.78	2.03
9	2.24	1.53	2.21	2.12	1.46
10	2.89	0.69	0.84	0.85	0.51
::	::	::	::	::	::
1820	3.28	1.46	2.17	1.51	1.08
1821	2.71	0.12	0.13	2.81	1.37
1822	4.17	0.19	2.21	1.73	0.61
1823	1.66	1.9	1.3	3.16	0.57
1824	1.07	1.49	0.69	2	3.19
1825	3.7	1.82	0.43	1.33	2.04

Table 3. The projection record of parameters that exceed the minimum standard quality

Parameter	Threshold	Highest value gathered	Total Exeeding Occurance (in 1825 days)	Percent over threshold
Dust (µg/m3)	260	4.5	0	0%
SOx (µg/m3)	262	2.3	0	0%
NOx (µg/m3)	92.5	2.69	0	0%
CO (µg/m3)	22.6	9.1	0	0%
HC (µg/m3)	160	3.2	0	0%

As it was shown in from Table 3, the information gives a projection on how incinerator medical pollutant emission in Sidoarjo regency will work in every day for five years. In the Table 4 result, the entire parameters fulfilled the minimum standard. It can be said that incinerator burns the medical waste parameters in accordance with Government Regulation.

Conclusions

1. The 5 years projection result by system dynamics shows that the dispersion of incinerator emission of dust, SOx, NOx, CO, and HC parameters were in the standard quality.
2. A monitoring activity is needed when the medical institution develops the incinerator, so the height of the incinerator pipe meets the plan and according to the prediction that is 20 meters. The change of height will produce the different prediction result.
3. An emission quality monitoring is needed when the medical institution operates the incinerator. The differences of monitoring result and the data used for Gauss prediction will create the difference prediction and it is necessary to redoing the prediction to ensure safety for the public around the incinerator site.

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