Environmental Assessment Using Integrated Risk Based Approach (IRBA) at Cahaya Kencana Landfill Site

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***Abstract*—Cahaya Kencana landfill site located above the land belonging to the local government of Banjar District with land area 35,5 Ha, where used for Cahaya Kencana landfill 16,5 Ha, Kehati park 7,5 Ha, the remaining unused land is 11,5 Ha. Cahaya Kencana landfill site has been implementing the sanitary landfill system since 2014 with the existing area of 8.089,73 m^2 and the calculation results shows that sanitary landfill area can only use until the year 2021. So the goal that is to be achieved from this research is to evaluate the technical aspects and environment of Cahaya Kencana site with decision making tools. One of them through the assessment of environmental risk index or Integrated Risk Based Approach (IRBA). Risk Index (RI) assessment results using IRBA obtained 524,007 value with a category of moderate hazard evaluation, so that Cahaya Kencana site can be forwarded and rehabilitated into controlled landfill gradually. The strategy that needs to be done in the framework of Cahaya Kencana site is modifications of leachate treatment unit design.**

***Keywords*—Leachate, Leachate Tratement Unit, Risk Index, Rehabilitation, Sanitary Landfill.**

I. INTRODUCTION

THE population growth in Banjar District is very rapid and increased especially in the capital of the district, Martapura subdistrict. This condition is also directly proportional to the increase in urban waste production. The increase in waste production led to increased area disposal. Cahaya Kencana landfill has been implementing the sanitary landfill system since 2014 until now with a condition that is almost full. Volume of garbage entered from the year 2014 to 2018 which is transported to the landfill reaches 376.621 m^3 or an average of 206,37 m^3/day. Surely the problem requires environmental management as soon as possible, one of them by doing a risk assessment. It is necessary because lot of open dumping areas that are left abandoned without the proper mitigation [1].

Integrated Risk Based Approach (IRBA) was first used as a decision making tool in the location of Perungudi (PDG) and Kondungaiyur (KDG) in the city of Chennai, India where the calculation obtained the value of RI in the location of PDG of 569 and the location of the KDG 579 [2], [3]. Meanwhile, in the location of Eneka, Nigeria research obtained the value of RI 452,3 [4]. Other studies at Igbatoro landfill [5] have been found that the impacts include high health and environmental risks and the degree of silence on the impact of communities, where the risk index (RI) value gained is 571,58. Rehabilitation landfill needs to be carried out due to soil pollution in the landfill area is usually polluted by leachate [6].

Cahaya Kencana landfill apparently has leachate contamination in the sanitary landfill area with the resistivity value of soil tainted in the range of 1,50 – 4,34 Ωm at a depth between 0,75 meters to 13 meters[7].

II. MATERIAL AND METHODS

A. Description of the Studi Site

The research location is located at Cahaya Kencana landfill at Lihung village, Karang Intan sub district, Banjar district, province South Kalimantan. Where for the retrieval of loose garbage samples is garbage truck that comes from Sekumpul street, while for the sampling of solid waste samples derived from sanitary landfill area. Location of Cahaya Kencana landfill located at 03^{O}27'29.0" Southern Latitude (SL) and 114^{O}55'28.2" East Longitude (EL). Figure 1. explains the location of this research.

B. Risk Assessment

Risk Index/ RI calculated with this formula [3]–[5]:

$$RI = \sum_{i=1}^{n} WiSi \quad (1)$$

Where:
Wi = Weightage of the with variable ranging from 0 – 1000
Si = Sensitive index of the with variable ranging from 0 – 1
RI = Risk Index variable from 0 – 1000

Risk Index (RI) can be used for classification of landfill sites to be closed or rehabilitated. A value of 0 indicates no or less danger, a value of 1 indicating the highest potential danger. The higher the value indicates greater risk to human health and the actions that must be taken immediately at the site of landfill. The next priority decreases with the total decrease in value. Lowest values indicate low sensitivas and small environmental impacts. Hazard-level evaluation criteria based on the risk index value of landfill can be seen in table 1. [2]–[5]. While device risk index assessment can be seen in table 2. [2]–[5], [8].

III. RESULTS

The measurement of maps with ArcGIS 10.2 software is derived data that the closest water source used in operational and maintenance activities in Cahaya Kencana landfill site is the river used for irrigation with the closest distance is 967 meters (Figure 2. (a)). Estimation of soil type in Cahaya Kencana landfill site is done by the approach of geological map of Banjar district in accordance with Banjar district spatial plan in year 2013-2032, where Cahaya Kencana landfill site is on the geological kwarter mud aluminum

Figure 1. Cahaya Kencana Landfill Site Layout.

pebble sand, which can be assumed as a rough sand that has a permeability value between 1-0.01 cm/sec [9]. Distance Cahaya Kencana site with conservation forest or critical habitats that is the education forest based on Banjar district spatial plan year 2013-2032 is 2.205 meters (2,2 km) (Figure 2. (b)). Closest airport to Cahaya Kencana site is Syamsudin Noor International Airport located in Banjarbaru City, with the airport distance is 19.082 meters (Figure 2. (c)). Surface water closest to Cahaya Kencana site is a river with a distance of about 1.154 m (Figure 2. (d)). Basic soil layer type of sanitary landfill in Cahaya Kencana site based on map of land type in Banjar district spatial plan year 2013-2032 ie alluvial land. The alluvial soil itself is formed from a young sedimentary material (aluvium), has an occric, Umbrik, hystics, or sulfide, a smoother texture of the flaky sand at a depth of 25-100 cm [10]. In the type of alluvial hydrik usually contains clay > 8% [10]. The approach taken for the base layer of sanitary landfill in Cahaya Kencana site, from some research of characteristics of clay percentage in the alluvial soil is > 8%. The resident area close to the location of Cahaya Kencana site is located in Padang Panjang Village, where based on measurements obtained by distance of 1.163 m (Figure 2. (e)). The capital of Banjar district is located in Martapura subdistrict and is the source of the major solid

Table 1.
Criteria for Hazard Evaluation Based on the Risk Index

No	Risk Index	Hazard Potential	Recommended Action
1	750-1000	Very High	Close the dump with no more land filling in the area. Take remedial action to mitigate the impacts
2	600-749	High	Close the dump with no more land filling in the area. Remediation is optional
3	450-599	Moderate	Immediate rehabilitation of the dumpsite into Sustainable Landfill
4	300-449	Low	Rehabilitate the dumpsite into Sustainable Landfill in a phased manner
5	<300	Very Low	Potential Site for future Landfill

Table 2.
Tool of Rapid Risk Assessment for Dumpsite

No	Attribute	Attribute Weightage	Sensitivity Index			
			0,0-0,25	0,25-0,5	0,5-0,75	0,75-1,0
	I. Site Spesific Criteria					
1	Distance from nearest wáter supply source (m)	69	>5000	2500-5000	1000-2500	<1000
2	Depth of filling of waste (m)	64	3	3-10	10-20	>20
3	Area of the dumpsite (Ha)	61	<5	5-10	10-20	>20
4	Groundwater depth (m)	54	>20	10-20	3-10	<3
5	Permeability of soil (1×10^{-6} cm/s)	54	<0,1	1-0,1	1-10	>10
6	Groundwater quality	50	Not a concern	Potable	Potable if no alternative	Non-Potable
7	Distance to critical hábitats such as wetlands and reserved forest (km)	46	>25	10-25	5-10	<5
8	Distance to the nearest airport (km)	46	>20	10-20	5-10	<5
9	Distance from surface water (m)	41	>8000	1500-8000	500-1500	<500
10	Type of underlying soil (% clay)	41	>50	30-50	15-30	0-15
11	Life of the site for future use (years)	36	<5	5-10	10-20	>20
12	Type of waste (MSW/ HW)	30	100% MSW	75% MSW, 25% HW	50% MSW, 50% HW	>50% HW
13	Total quantity of waste at site (t)	30	$<10^4$	10^4-10^5	10^5-10^6	$>10^6$
14	Quantity of waste disposed (t/day)	24	<250	250-500	500-1000	>1000
15	Distance to the nearest village in the predominant wind (m)	21	>1000	600-1000	300-600	<300
16	Flood proness (flood period in years)	16	>100	30-100	10-30	<10
17	Annual rainfall at site (cm/y)	11	<25	25-125	125-250	>250
18	Distance from the city (km)	7	>20	10-20	5-10	<5
19	Public acceptance	7	No public concerns	Accepts dump rehabilitation	Accepts dump closure	Accepts dump closure and remediation
20	Ambient air quality - CH_4 (%)	3	<0,01	0,05-0,01	0,05-0,1	>0,1
	II. Related to characteristics of waste at dumpsite					
21	Hazardous contents in waste (%)	71	<10	10-20	20-30	>30
22	Biodegradable fraction of waste at site (%)	66	<10	10-30	30-60	60-100
23	Age of filling (years)	58	>30	20-30	10-20	<10
24	Moisture of waste at site (%)	26	<10	10-20	20-40	>40
	III. Related to of leachate quality					
25	BOD of leachate (mg/L)	36	<30	30-60	60-100	>100
26	COD of leachate (mg/L)	19	<250	250-350	350-500	>500
27	TDS of leachate (mg/L)	13	<2100	2100-3000	3000-4000	>4000

waste source dumped into Cahaya Kencana site, it is known that the city distance to landfill is 6.840 m (6,8 km) (Fig. 2. (f)).

Life of the site for the future use calculation is obtained from population projection data from year 2018-2028 by using least square method with value of $R^2 = 0,9991$ as well as standard deviation of 18.833. Loose waste composition measured dominated by 3 types of garbage composition of food remnants + leaves (organic) 51,12%, plastic 22,44% and diapers & sanitary pads 8,83% and the value of loose waste density is 216,68 kg/m^3. Meanwhile solid garbage composition measured also dominated by 3 types of garbage composition that is food remnants + leaves (organic) 45,86%, plastic 29,94% and diapers & sanitary pads 11,93% and obtained the value of solid waste density of 724,00 kg/m^3. Accumulation rate uses 2,75 liters/person/day according to the major city classification [11].

The level of garbage in sanitary landfill in Cahaya Kencana site is 10 meters high with land area of 8089,73 m^2. The results of future landfill age are obtained 1 year or until year 2021. While based on the results of the community kuisoner, it is obtained that the average community as much as 60% received the existence and rehabilitation of open waste landfill.

Laboratory test results obtained leachate results for the BOD parameter has value of 210 mg/L, COD has value of 501,73 mg/L, and the TDS has value of 2.254 mg/L. Solid waste moisture content is 58,23%. Quality of water well in Cahaya Kencana site can not be used as a source of drinking water. Because the parameter of hardness water has a value of 1444,20 mg/L, E. Coli as much as 1,3 x 10^3 amount/100mL

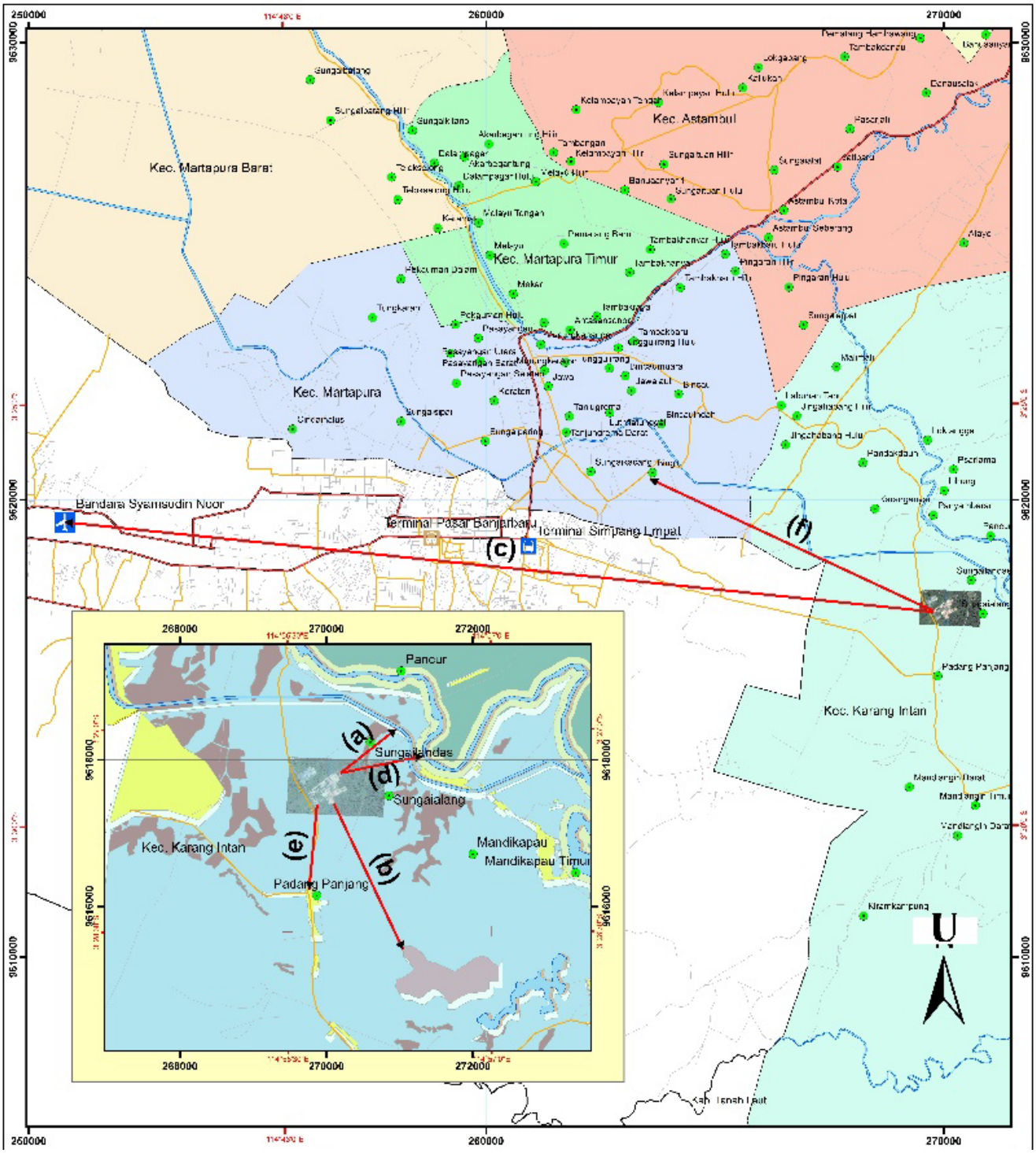

Figure 2. Measuring IRBA Parameter with S*oftware* ArcGIS 10.2.

and Coliform as much as 1,1 x 10^4 amount/100mL which exceeds the quality of Permenkes No. 492/Menkes/Per/IV/2010 about the requirements of drinking water quality.

Risk Index (RI) assessment results use IRBA, as can be seen in table 3. obtained a value of 524,007 with a category of moderate hazard evaluation, so that Cahaya Kencana site can be forwarded and rehabilitated into controlled landfill gradually. One important aspect of this rehabilitation landfill process is leachate treatment unit. Based on the results of comparison of leachate treatment unit existing with the calculation result then obtained data according to table 4.

Through Table 4. we can perform optimal processing efficiency on each pond, with a modification design. For example for anaerobic pond lenght, the comparison is 1/5, so the existing pond can be blocked into 5 parts. So that leachate can be processed optimally according to the hydraulic retention time (HRT). This also applies to each other pond with the addition of the connecting floodgates of each partition. This water door can be opened at the time of the

Table 3.
Risk Index Worksheet for Cahaya Kencana Dumpsite

No	Attribute	Attribute Weightage	Attribute Measurement	SI	Score
1	Distance from nearest wáter supply source (m)	69	967	0,750	51,750
2	Depth of filling of waste (m)	64	10	0,500	32,000
3	Area of the dumpsite (Ha)	61	16,5	0,663	40,413
4	Groundwater depth (m)	54	3,78	0,528	28,504
5	Permeability of soil (1×10^{-6} cm/s)	54	1	0,500	27,000
6	Groundwater quality	50	Groundwater quality from laboratory test results, not a concern	0,000	0,000
7	Distance to critical hábitats such as wetlands and reserved forest (km)	46	2,2	0,860	39,560
8	Distance to the nearest airport (km)	46	19	0,475	21,850
9	Distance from surface water (m)	41	1154	0,664	27,204
10	Type of underlying soil (% clay)	41	8	0,883	36,217
11	Life of the site for future use (years)	36	2	0,100	3,600
12	Type of waste (MSW/ HW)	30	69,40	0,847	25,410
13	Total quantity of waste at site (t)	30	186485	0,524	15,721
14	Quantity of waste disposed (t/day)	24	102,18	0,102	2,452
15	Distance to the nearest village in the predominant wind (m)	21	1163	0,041	0,856
16	Flood proness (flood period in years)	16	200	0,000	0,000
17	Annual rainfall at site (cm/y)	11	247	0,744	8,184
18	Distance from the city (km)	7	6,8	0,590	4,130
19	Public acceptance	7	Accepts dump rehabilitation	0,325	2,275
20	Ambient air quality - CH_4 (%)	3	5	0,500	1,500
21	Hazardous contents in waste (%)	71	1,48	0,037	2,627
22	Biodegradable fraction of waste at site (%)	66	11,06	0,263	17,375
23	Age of filling (years)	58	8	0,950	55,100
24	Moisture of waste at site (%)	26	58,23	0,826	21,475
25	BOD of leachate (mg/L)	36	210	1,000	36,000
26	COD of leachate (mg/L)	19	501,73	1,000	19,000
27	TDS of leachate (mg/L)	13	2254	0,293	3,806
				RI	524,007
				Potential Hazard	Moderate

Table 4.
Dimensions Comparison Between Existing and Calculation of Leachate Treatment Unit

IPL	Discharge	Discharge	HRT	HRT	Depth (h)	Calculate		Existing		Comparison	
	L/second	m^3/day	(day)	(hours)	(m)	L (m)	W (m)	L (m)	W (m)	L (m)	W (m)
Collector Unit	0,018	1,550	0,042	1	0,500	1	0,2	1	1	1	1/5
Anaerobic Pond	0,018	1,550	18,700		3,000	6	2	30	16	1/5	1/8
Fakultative Pond	0,018	1,550	37,400		2,000	9	3	45	24	1/5	1/8
Biofilter (2 unit)	0,018	1,550	0,197	9	1,500	1	0,3	7	5	1/6	0
Constructed Wetland	0,018	1,550	3,000		0,500	6	4	26	10	1/4	2/5

leachate discharge that enters exceeds the leachate discharge from calculation results.

IV. CONCLUSION

Risk Index (RI) assessment results using IRBA obtained 524,007 value with a category of moderate hazard evaluation, so that Cahaya Kencana landfill site can be forwarded and rehabilitated into controlled landfill gradually. Leachate treatment unit can be design modification, so that the resulting effluent will be in accordance with the quality standards that have been set.

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