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The Formulation of Pineapple Liquid Waste (PLW) as Liquid Organic Fertilizer for Agricultural Crops

Agus Sutanto[a,*] , Suharno Zen[a], Rasuane Nor[a]

[a]*Biology Education Study Program, Department of Science Education, Faculty of Teacher Training and Education, Universitas Muhammadiyah Metro, Jl. Ki Hajar Dewantara no. 116, Kel. Iringmulyo, Kec. Metro Timur, Lampung – 34111, Indonesia*

Abstract

Pineapple Liquid Waste (PLW) is acidic, high in organic content and has not fulfilled the minimum threshold so needs bioremediation, an environmentally sound of waste management. Therefore, through this research, it is important to determine the formula of indigene bacteria consortia which able to degrade the PLW before applying in agriculture. This research is conducted in two steps: 1) isolation and identification of indigene bacteria and examination of their remediation capability; 2) formulating the potential consortial and applying the degraded PLW into plants (orchid and pineapple). This research has found 15 isolates of indigene bacteria in PLW. Whole isolates are able to live in pH 2 and 4. They also have varied ability in hydrolysing the amylum and protein. Thus, those 15 isolates are formulated in several ways to degrade the PLW. The formulas are: 1) Consortia A (CA) consists of isolates 1-5; 2) Consortia B (CB) consists of isolates 1-10; 3) Consortia C (CC) consists of isolates 1-15. It is revealed that CA is able to degrade the organic matters, meanwhile, CB can degrade the acidic organic matter so raise the pH and CC is able to do the both. The pilot plan has shown that CB is potentially better than other consortia in neutralizing the pH and degrading organic matters. In results, the addition of CB produces a promising liquid organic fertilizer that contains decent elements for Storer method agriculture. The liquid organic fertilizer then is applied into pineapple and orchid cultivation, which results in the significant growth of both plants.

Keywords: pineapple liquid waste (PLW), liquid organic fertilizer, the growth of pineapple and orchid

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1. Introduction

Ultisol soil spreads in 25% of Indonesian land and most of it is in Lampung Province. Its depth section and medium cation exchange capacity make this soil as an important part of Indonesian agriculture development. Almost all types of plants can be cultivated in this soil. However, weather and relief affect the cultivation as well. The natural fertility of this soil is in the thin layer of horizon A. Macro elements like phosphor and potassium are low, soil pH is acidic, and aluminium saturation is high. Those characteristics are generally obstructed the plant growth so need a good management [1]. Soil erosion commonly happens as micro and macro pores getting lessen and the runoff getting more intense [2].Unfortunately, agriculture and agroindustry in Lampung mostly use this kind of soil.

Beside of the soil problem, waste management is also a problem of the industrial sector in Lampung. One of the important industries in Lampung is pineapple industry. In this industry, liquid and solid wastes need a better management.

*Corresponding author Tel.: +62725 42445, Fax: +62725 42454
E-mail: sutanto11@gmail.com
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The characters of Pineapple Liquid Waste (PLW) are acidic and contain high organic matters. Based on the analysis, PLW pH is 3.44; BOD 338 mg/L; COD 4200 mg/L, and TSS 390 mg/L (personal communication). PLW is wasted every day in huge amount. This waste contains ±87% of water, 10.54% of carbohydrate, 1.7% of crude fiber, 0.7% of protein, 0.5% of ash and 0.02% of fat [3]. Without proper management, its acidic pH and bromelin content will cause pollution in the soil and water

The volume of the waste is around 5000-7000 m^3. PLW acidic pH and high organic matters will damage the watershed [4]. Moreover, when it gets into ultisol soil in the agricultural area, it will burden the land. Usually, before being disposing into the river, pineapple liquid waste is treated and collected in the wastewater treatment plant (a lagoon) for 2-3 months (Julius, personal coimmunication). However, this wastewater management is not efficient in terms of time and cost.

One of the save and environmentally sound wastewater treatments are applying the potential degrading bacteria. This technology is cheaper than both chemical and physical treatments [5]. This effort has been conducted in several countries so there is various starter that ready to be used and packaged as liquid and solid forms. Naturally, the bacteria can be collected by isolating the wastewater itself (indigene bacteria) and cultured the laboratory in-vitro [6]. The usage of potential bacteria consortia as the starter can restore the PLW [7].

Bio-remediated PLW contains indigene bacteria which able to neutralize the acid wastewater as well as the acid land. Instead of vaporized and leached like calcium oxide and dolomite, microbes given will get into the soil and neutralize it [8]. Previous research identified 15 isolates of PLW degrading bacteria as well as potential *nata de pina* raw material from PLW [9]. This research found [2] bioremediation formula to neutralize the PLW pH and organic matters, and then the bio-remediated PLW is applied as liquid organic fertilizer, [1] this liquid organic fertilizer then tested to plants (orchid and pineapple).

2. Material and Methods

The research is divided into two stages. The first stage is the analysis of bioremediation effectiveness, which comprises of a) the effectiveness examination on the formula of isolate consortia (three potential consortia were chosen); b) determination of consortia variant, starter volume, and the most effective incubation time. The second step including a) the examination of formula effectiveness in ultisol soil and b) pilot plan test of bio-remediated PLW to the irrigation of laboratory farmland and experiment station in Universitas Muhammadiyah Metro.

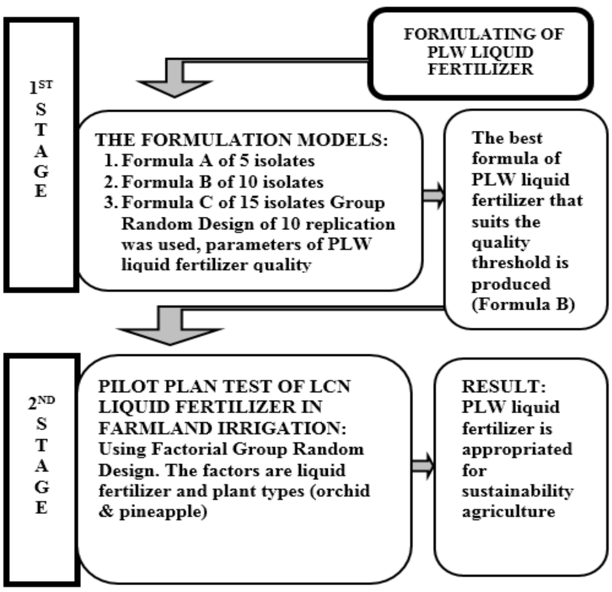

Fig 1. The stages of the 1st and 2nd research

3. Results and Discussion

3.1. *The Observation of Degrading Potential Bacteria Isolates Characteristics.*

The first stage of this research comprises of collecting the water sample of PLW before getting into water-waste treatment plant from 2 outlets and pools. The samples then are isolated and identified. The results showed that there are 15 isolates that able to live in the acidic pH environment as well as hydrolyse amylum and protein. The details can be seen in Figure 2.

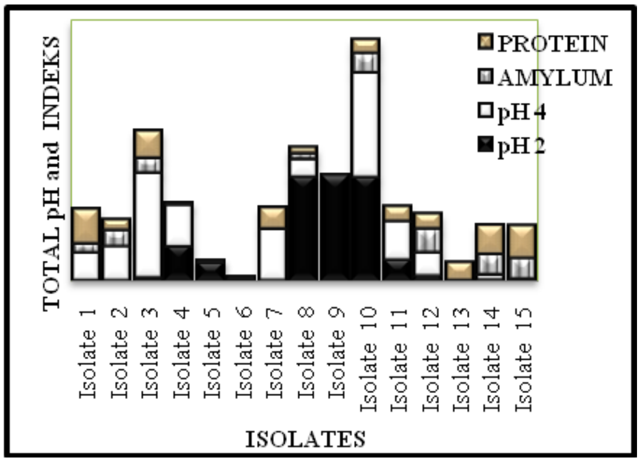

Fig 2. The Ability of PLW Indigene Bacteria to live in pH 2, 4 and Hydrolysis Index of amylum and protein.

Fig 2 shows that there is similarity of the physiological characteristic in found bacteria isolates. They are able to live in acidic pH and produce more than one hydrolysing enzymes. The One-Way Analysis of Variance showed that there is a significant living ability in acidic pH and hydrolysis index of indigene bacteria. The further test of Duncan is presented in Table 1 below.

Table 1 shows that several isolates able to live in acidic pH and has high hydrolysis index significantly ($\alpha = 0.05$). The average of living ability in pH 2 is high in isolates 10 and 8. Meanwhile, the average of living ability in pH 4 is high in isolates 10 and 3. Moreover, a high amylum hydrolysis index is found in isolates 1, 10, 14, and 15, and protein hydrolysis index in isolates 1, 3, 14, and 15.

The ability of bacteria isolates in degrading the wastewater is tested using sterile PLW, which their ability in raising pH, decreasing BOD, COD and TSS in six incubation days was observed.

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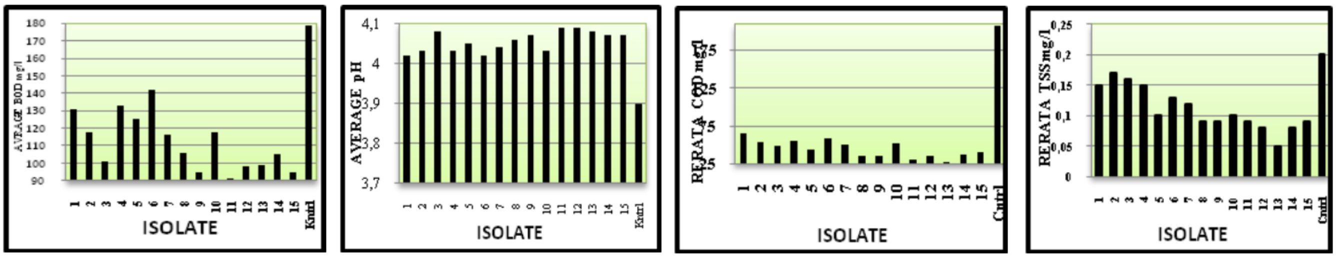

a b c d

Fig 3. The ability of bacteria isolates in degrading the PLW based on the parameters of pH alteration (a); BOD alteration (b); COD alteration (c), and TSS alteration (d).

Table 1
The Duncan Notation of the Average of PLW Liquid Fertilizer Isolates Living Ability in pH 2, 4 and Hydrolysis Index of Amylum and Protein

Living Ability in pH 2			**Living Ability in pH 4**			**Amylum Hydrolysis Index**			**Protein Hydrolysis Index**		
Isolates	Average	Notation	Isolates	Average	Notation	Isolates	Average	Notation	Isolates	Average	Notation
1	0.00	a	9	0.00	a	7	0,00	a	4	0,00	a
2	0.00	a	13	0.00	a	9	0,00	a	5	0,00	a
6	0.00	a	15	4.00	a	11	0.00	a	6	0,00	a
7	0.00	a	5	4.33	a	13	0.00	a	9	0,00	a
13	0.00	a	6	7.33	a	6	0.10	a	8	1.71	b
14	0.00	a	14	15.33	a	4	0.13	a	2	2.83	b
15	0.00	a	8	50,00	b	5	0.17	a	10	3.67	bc
5	4.33	a	12	60,00	bc	8	1.50	b	11	4.13	bc
11	6.33	a	1	81,00	cd	1	2.83	b	12	4.23	bc
3	10.00	a	2	94,00	cde	3	4.67	cd	13	5.00	bc
12	15.00	a	11	105,00	cde	2	4.63	cd	7	6,00	cd
9	94,67	b	4	116,67	de	10	5.67	cde	3	7,67	de
4	98,33	b	7	141,67	e	14	5.90	cde	14	8,33	de
10	163,3	c	3	232,67	f	15	6.23	f	15	9,00	f
8	323,00	d	10	299,33	g	12	7.10	g	1	9,67	f

Table 2.
Duncan Notation of the Average of pH, BOD, COD, and TSS of each bacteria isolates

pH 2 alteration			**BOD alteration**			**COD alteration**			**TSS alteration**		
Isolates	Average	Notation	Isolates	Average	Notation	Isolates	Average	Notation	Isolates	Average	Notation
Kntrl	3,90	a	8	75.84	a	12	27.00	a	12	80,00	a
1	4.02	b	10	85,27	b	10	30.00	ab	10	85.50	b
6	4.02	b	12	89,25	b	3	32,00	bc	3	85.50	b
2	4.03	bc	3	90,42	b	8	35,00	cd	8	86.50	b
4	4.03	bc	11	100	c	13	36,00	cde	13	87.00	b
7	4.05	bcd	13	104	c	14	38,00	de	14	87.00	b
5	4.05	bcd	15	105	c	15	40,50	ef	15	90.50	b
13	4,06	cde	14	106	c	5	43,50	f	5	91.00	b
15	4,06	cde	7	118	d	7	49,50	f	7	91.00	b
14	4,07	def	2	119	d	11	52,00	fg	11	100	c
9	4.07	def	9	126	e	2	54,00	g	2	121	d
11	4.07	def	5	121	e	4	55,00	g	4	131	e
12	4.09	fg	1	131	ef	6	59,00	gh	6	152	f
10	4.10	gh	4	133	f	9	65,00	i	9	155	f
8	4.10	gh	6	143	g	1	66,00	i	1	170	g
3	4.15	h	Cntrl	179	h	Cntrl	208,00	j	Cntrl	210	h

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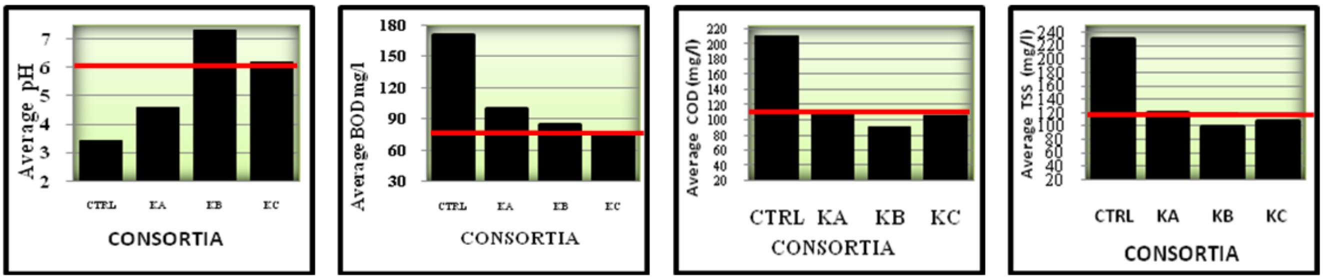
Table 2 presents that the ability of bacteria isolates in degrading PLW can be seen from pH, BOD, COD, and TSS parameters. There are 15 isolates of bacteria that significantly degrade PLW, based on their ability in living within acidic (pH 2 and 4) and the number of their hydrolysis index.

3.2. Determining the PLW Liquid Organic Fertilizer Consortia Formula

All 15 isolates have varies degrading ability. For PLW bioremediation formula, consortia A (CA, isolate 1-5), consortia B (CB, isolates 1-10), and consortia C (CC, isolate 1-15) are selected. CA was chosen since it able to break down the organic matters, especially amylum; CB is able to neutralize acidic media; and CC is able to degrade the organic matters and acidic pH. The test results of all three consortia can be seen in the following figures.



a b c d

Fig 4. The test results of bacteria consortia on PLW degradation parameters: pH (a); BOD (b); COD (c); and TSS (d). Red lines indicate the Maximum Threshold Value

Based on the results above, it can be concluded that CA formula is potential in degrading organic matters and organic acid. A further test is to determine which fertilizer produced by bioremediation using those formulas has the best quality. In this test, *Storer* analysis method is used.

3.3. The Qualities of Three Formula of PLW Liquid Organic Fertilizer

The test results of quality on three formula of PLW liquid organic fertilizer can be observed in Table 3 below. Table 3 shows that build upon Storer method, CA, CB and CC are classified as GOOD. Qualitatively, CB has the best score (-4) with physical and chemical parameters meet the standard at the very best.

Table 3
The Agricultural Quality Threshold Value using Storer Method on Organic Fertilizers

No.	**Parameters**	**Unit**	**Threshold value**	**CA**		**CB**		**CC**		**CONTROL**	
				Data	score	Data	Scor	Data	Scor	Data	Scor
Physical											
1.	temperature)	^0C	Normal	27	0	27	0	25	0	26	0
2.	(residual solution	Mg/l	1000-2000	720	0	600	0	650	0	1720	0
3.	(electrical conductivity	Mikrosom/cm^3 (25^{0}C)	1750-2250	1425,3	0	1262,44	0	1321,252	0	2115,441	0
Chemical											
1.	pH	-	5-9	5.6	0	7,3	0	6,2	0	3,4	-2
2.	Mn (Manganese)	Mg/l	2	1,314	0	1,314	0	1,314	0	1,314	0
3.	Cu (Copper)	Mg/l	0,2	0,4351	-1	0,26120	0	0,331438	-1	1,157525	-1
4.	Zn (zinc)	Mg/l	2	1,6477	0	1,17064	0	1,403058	0	3,458104	-2
5.	(Cr (chromium)	Mg/l	1	16,477	-2	11,339	-2	14,03	-2	34,581	-2
6.	Cd(cadmium)	Mg/l	0,01	164,77	-2	113,394	-2	140,306	-2	345,810	-2
7.	Hg (Mercury)	Mg/l	0,005	0,0010	0	0,00076	0	0,00086	0	0,002464	0
8.	Pb (lead)	Mg/l	1	1,5138	0	1,09120	0	1,28563	0	4,032883	-2

Table 3. Continued

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No.	Parameters	Unit	Threshold value	CA		CB		CC		CONTROL	
				Data	score	Data	Scor	Data	Scor	Data	Scor
Chemical											
9.	As (arsenic)	Mg/l	1	0,0934	0	0,06803	0	0,090984	0	0,308197	0
10.	Se (selenium)	Mg/l		0,0205	0	0,01596	0	0,026277	0	0,085384	0
11.	Ni Nickel	Mg/l	0,5	0,2685	0	0,20297	0	0,231778	0	0,411519	0
12.	Co Cobalt	Mg/l	0,2	0,2290	0	0,09857	0	0,110476	0	0,245238	0
13.	Br Boron	Mg/l	1	0,1146	0	0,08146	0	0,094397	0	0,213793	0
14.	Garam Alkali (Na)	Mg/l	60	33	0	28,5752	0	30,69912	0	16,196	0
15.	Sodium Absorptiom Ratio (SAR)	Meo/l	10-18	6,711	0	4,983	0	5,882	0	16,225	0
16.	Residual Sodium Carbonat (RSC)	Meo/l	1,25-2,50	0,844	0	0,716	0	0,761	0	1,533	0
		Total scores			-5		-4		-5		-11
	Conclusion			Good		Good		Good		Moderate	
17.	Elements	N Total (%)		0,6653		0,77044		0,63036		0,1751	
18.		Total P_2O_5(%)	<5	0,002		0,001		0,001		0.067	
19.		Total K2o (%)	<5	0,0023		0.003		0,0018		0,0056	
20.		Total Ca (%)	-	0,0157		0,0116		0,0141		0,0346	

3.4. The Expedience of Formula B for Liquid Fertilizer to the Plants

3.4.1. Pineapple Plant

Previous research [10] compared pineapple plant growth, which using PLW fertilizer through the roots and leaves. Measurements were done on 40 samples (20 samples that fertilized through the roots and 20 through the leaves) of pineapple plants for their number leaves, leaf area, and the leaf length. The data collected can be seen in Figure 5 below:

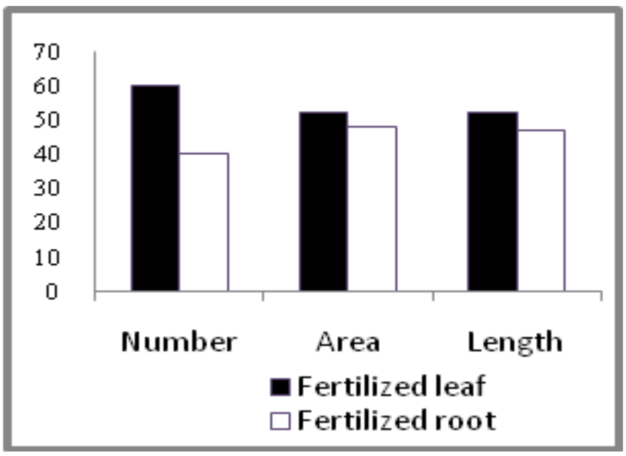

Fig 5. The leaf number, leaf area, and leaf length of pineapple plants that fertilized through the roots and leaves

There are a significant different between pineapple plants that fertilized through the roots and through the leaves. The last one gives better results in three parameters (leaf number, leaf area, and leaf length). It is because fertilizer moves faster within the plants when it is given through the leaves than the roots. In results, plants will grow faster and the soil will not be damaged [11]. Meanwhile, the treatment did not affect the production of pineapple (fruit).

3.4.2. The Effect of Dose Variation to the Height of Orchid (Dendrobium sp)

A research [12] showed that dose variation of PLW liquid organic fertilizer affects the growth of orchid *Dendrobium* sp as seen in figure 6. From the Figure 6 above, it can be concluded that treatment B (3mL) affects the plant growth, However, the plant height is not significantly affected ($p<0.05$). Furthermore, the average of leaf number is presented in Fig 6.

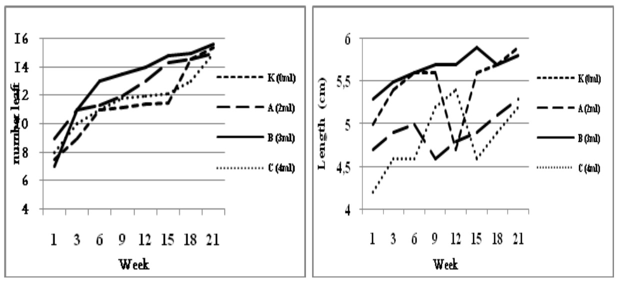

Fig 6. The Average Height (cm) and number of the Orchid *Dendrobium* sp.

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The growth of the orchid (*Dendrobium* sp) in this research showed that PLW liquid organic fertilizer addition (2 mL, 3mL, and 4mL) results in better height and leaves the number. Treatment B (3mL) gives the best results as the macro and microelements in PLW liquid fertilizer are balance and fulfilled [12]. The orchid plant does need a balanced macro and microelements. Otherwise, its growth will be disturbed, such as rot in the shoot and turn yellow in the leaf tip. Applying PLW liquid organic fertilizer to the plants (pineapple and orchid) has shown that this fertilizer has fulfilled the plant nutrition and results in better growth. As known, this fertilizer is produced through bioremediation of PLW. The bioremediation uses biology agents to neutralize pH within PLW. They even can turn the dangerous material into safe material for plants and environment [13]. Hence, bioremediation can be utilized to transform wastewater into liquid organic fertilizer.

Furthermore, the use of PLW liquid organic fertilizer optimizes the utilization of ultisol soil productively. It is even better by planting appropriate plants. Therefore, bioremediation using bacteria consortia can reuse the useless pineapple liquid waste into beneficial liquid organic fertilizer, give benefit to the agricultural industry as well as keep the sustainability of long-term agricultural that environmentally sound.

4. Conclusion

1. This research succeeds in testing three consortia formula of PLW liquid organic fertilizer.
2. The CB formula (isolate 1-10) is the potential formula to degrade the organic matters as well as neutralize pH.
3. The CB formula also produces the best liquid organic fertilizer based on physical and chemical parameters.
4. The liquid organic fertilizer produced by PLW bioremediation significantly affects the growth of pineapple and orchid plants.

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