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Utilization of Biosulfur By-Products into Bioferdom Fertilizer Raw Materials at Pt Pertamina Ep Donggi Matindok Field Pertamina Hulu Energi Upstream Subholding Pertamina

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Abstract:
Pertamina EP Donggi Matindok Field has been conducting natural gas exploration and production activities since 2016 in Banggai Regency, Central Sulawesi Province. The company is committed to complying with all regulations and adjacent to innovation efforts in all aspects related to its operational activities. Waste is one aspect that receives great attention and is demonstrated through commitment in the form of Management Policy.
Compliance with regulations related to waste aspects is also continuously carried out to support 2060 net zero emission. One of the waste generated is biosulfur, this non B3 waste is generated as much as 2 tons / day and there is no appropriate program that can be used to treat the waste. but in recent years, we have created an innovation, namely BIOFERDOM where we process the biosulfur into organic fertilizer that can be used for agriculture.
The innovations we have made have also been standardized by making TKI Procedures for Utilizing Biosulfur Side Products as raw materials for BIOFERDOM Fertilizer in Donggi Matindok Field NO: C.08-001/PPC82330/2022-S0 REV-00, and was awarded the top 10 in the 2022 pertamina k3 month innovation event.

Keywords: ESG, Environment, Innovation

SCHEDULE OF ACTIVITIES

No	Uraian	Jam kerja	BOBOT (%)	Apr-22				Mei 22				Juni 22				Juli - Agus 22				Sept sd Nov 22				Des 22 sd Mar 23				Mar sd Juni 23			
				1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	PLAN																														
	1.1 Assesment teknis dan analisa data di lapangan	240.0	6.7	1.7	1.7	1.7	1.7																								
	1.2 Penyusunan rencana dan program kerja	240.0	6.7					1.7	1.7	1.7	1.7																				
2	DO																														
	2.1 Pelaksanaan Sampling dan Lab test Biosulphur	240.0	6.7									1.7	1.7	1.7	1.7																
	2.2 Pelaksanaan percobaan dan penitian pemanfaatan biosulphur	240.0	6.7													3.3	3.3														
	2.3 Pembuatan MOC (Management of Change)	120.0	3.3														3.3														
3	CHECK																														
	3.1 Pembuatan Design dan penyusunan kontrak pemanfaatan biosulphur	600.0	16.7															8.3	8.3												
	3.2 Penyediaan peralatan dan kebutuhan produksi pupuk biosulphur	600.0	16.7																	4.2	4.2	4.2	4.2								
4	ACTION																														
	3.1 Impelementasi pembuatan pupuk dari site product biosphur	840.0	23.3																					5.8	5.8	5.8	5.8				
	3.2 Monitoring hasil, Standarisasi dan Expansi	480.0	13.3																									4.4	4.4	3.0	1.4
	Total	**3,600.0**	**100.0**	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	3.3	6.7	8.3	8.3	4.2	4.2	4.2	4.2	5.8	5.8	5.8	5.8	4.4	4.4	3.0	1.4
	Plant Cumulatif			1.7	3.3	5.0	6.7	8.3	10.0	11.7	13.3	15.0	16.7	18.3	20.0	23.3	30.0	38.3	46.7	50.8	55.0	59.2	63.3	69.2	75.0	80.8	86.7	91.1	95.6	98.6	100.0

WORKFLOW SCHEME

Step 1: Determining Theme and Title (Theme Selection)

1.A. Determining the Theme:

Pertamina EP Donggi Matindok Field is a National Energy Company owned by the Government of Indonesia with the main product in the form of natural gas. Along with the increasingly popular energy transition, Pertamina EP Donggi Matindok Field is committed to innovating with the Utilization of Non Hazardous Waste (Biosulfur) so as to reduce the cost of biosulfur processing.

1.A.1. Problem Identification and Prioritization

Based on operational problems, there are 3 problems in by-product management at Pertamina EP Donggi Matindok Field:

1. Biosulfur at BSRU of 2 tons/day with transportation and processing costs of I1690053,66 USD /year.
2. Bleed Water at the After Treatment Unit amounting to 7 m3/day with a processing cost of 522311,19 USD /year
3. Demin Water in the Neutralization Pit which requires NAOH injection of 0.5 m3 / day with a demin water processing cost of 133250,50 USD / year

The team analyzed the priority level of each problem using Pareto Diagrams to determine the costs involved in processing by-products in Central Processing Gas at Donggi CPP and Matindok CPP.

BEFORE IMPROVEMENT				
Code	**Problem Identification**	**Cost Per Year**	**% Relative**	**% Cumulative**
A	Existence of biosulfur product from BSRU	1690053,66 USD	72,1%	72,1%
B	Existence of bleed water as a product in the After Treatment Unit	522311,19 USD	22,3%	94,3%
C	Existence of demin water in Neutralization Pit	133250,50 USD	5,7%	100,0%

Table 1. Identification problem for cost of own used by-product management

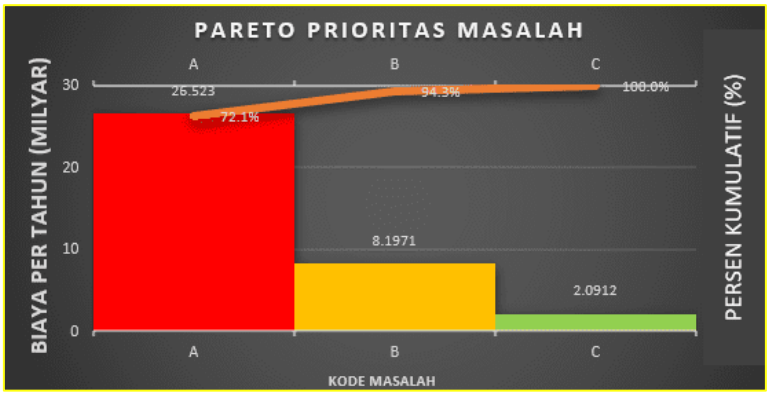


Figure 1. Pareto Diagram problem for cost of own used used by-product management

Based on the result of Cost analysis and Pareto diagram, the team selected the project theme to "**Increase the usefulness of biosulfur by-products at Pertamina EP Donggi Matindok Field"**

1.A.2. Alignment of the Project to the Organization's Goals/Objectives/Vision

The project is expected to contribute to reducing biosulfur processing cost inefficiencies, which in this case includes reducing transportation costs and processing costs. The objectives are in line with the organizational objectives as Pertamina currently has key performance indicators to optimize operating costs and sustainability. The alignment between project objectives and organizational objectives can be seen in Table 2.

Level	Goals
Organization	- Efficient Operational Expenditure with Appropriate by-product processing efficiency
Business Unit	- Environmentally Sustainable Process - ESG Score Improvement

Table 2. Project Alignment

1.B. Determining the Title

1.B.1 The Current Situation Analysis

Pertamina EP Donggi Matindok Field processes several products resulting from natural gas purification. one of them is biosulfur, biosulfur is produced from natural gas purification which absorbs the H2s content in the gas, then the H2S gas is released using hot oil heating media before flowing to the biological sulfur recovery unit.

In the Biological Sulfur recovery Unit process, H2S will be in contact with lean solution to be absorbed and flowed to the Bioreactor. In the bioreactor, H2S will be converted into biosulfur by Thiobacilius bacteria then biosulfur will be pressed with a dewatering device so that it becomes biosulfur cake.

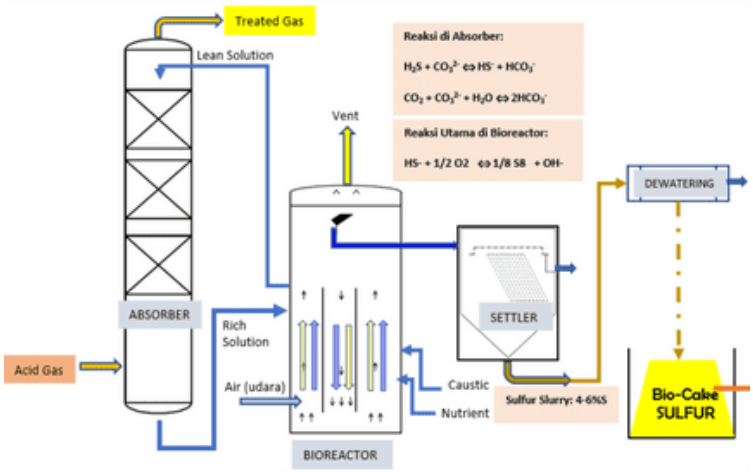


Figure 2. Flow Diagram Biological Sulfur Recovery Unit

The biosulfur produced is as much as 2 tons / day and is non-b3 waste because there is no appropriate method for processing this biosulfur. For this reason, Donggi Matindok Field needs to incur costs to destroy biosulfur with a total transportation and processing cost of I1690053.66 USD / year.

1.B.2. Target Setting

With the background of biosulfur processing problems, Pertamina EP Donggi Matindok Field has made several efforts to analyze potential solutions to problems using the scoring method. The results of the potential solution analysis are listed in Table 2 below.

Aspect	Current Situation	Stakeholders Aspirations (Target)
Quality	- Biosulfur side product that cannot be used directly as plant fertilizer - Agricultural yields are not optimum due to lack of fertilizer in the process of planting and breeding plants	Fertilizer standard specifications in accordance with solid organic fertilizer standards based on the Decree of the Minister of Agriculture of the Republic of Indonesia No. 261/KPTS/SR.310/M/4/2019
Cost	- Biosulfur side product processing cost of 1690053,66 USD per year - Donggi Matindok Field production cost is 5.65 USD/BOE	- Eliminated sulfur processing costs by 637184,15 USD - Achieved Donggi Matindok Field production cost target below 6 USD/BOE
Delivery	Donggi CPP and Matindok CPP biosulfur has not been utilized as an organic fertilizer mixture.	Donggi CPP and Matindok CPP biosulfur can be utilized as an organic fertilizer mixture.
Safety	There is no environmentally friendly utilization of biosulfur and solving the problem of non-B3 waste	The process of making and utilizing biosulfur is environmentally friendly and solves the problem of non-B3 waste
Morale	There is no CSR program for agricultural activities in luwuk banggai as the rice granary of sulawesi.	Improve the company's image with the innovation of biosulfur utilization

Table 3. Initial Goals and Advantages

Step 2: Analyzing the Causes

2.A. The Identification of Possible Root Causes by Using Ishikawa Diagram

Some of the problems associated with biosulfur processing are summarized in the Ishikawa Diagram in Figure 2 below.

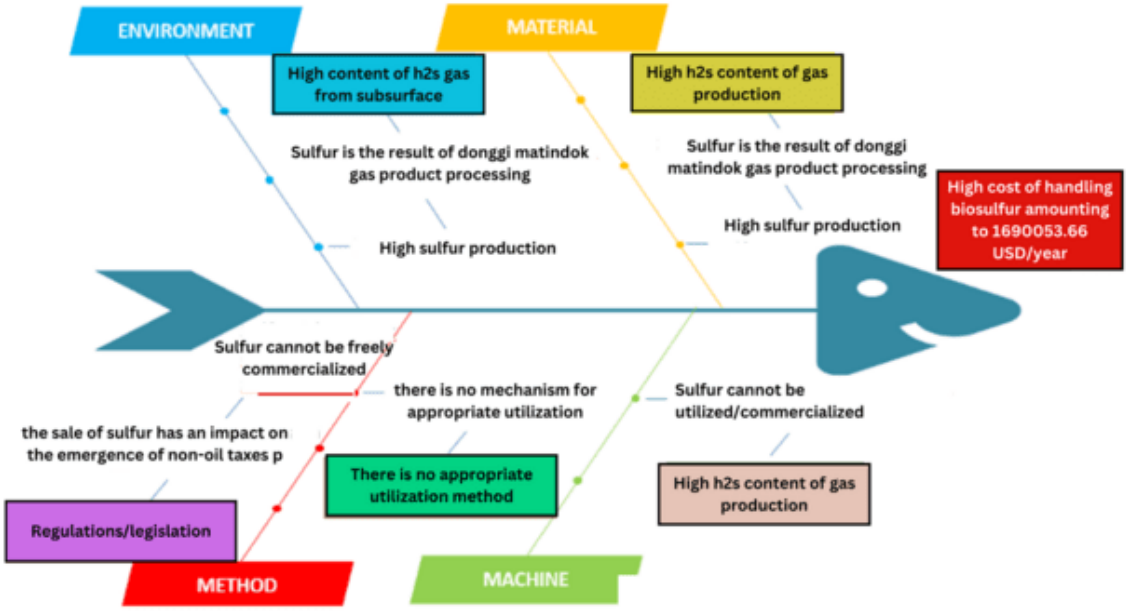


Figure 3. Ishikawa Diagram

2.B. Determining the Dominant Causes

This team analyzes the root of the problem using the Failure Mode and Effect Analysis (FMEA) method. To determine, identify, and eliminate known failures, problems, errors, and the like from a system, design, process

FMEA-Before Improvement								
Point	Causal Factors	Process Description	S	O	D	RPN	%	% Cum
A	Methode	No appropriate sulfur utilization method yet	8	8	8	512	72,1	72,1%
B	Material	High H2S content from Donggi Matindok gas production	6	5	3	90	12,7	84,8%
C	Machine	There is no appropriate sulfur utilization facility	8	3	3	72	10,1	94,9%
D	Environment	High H2S content from subsurface	6	3	2	36	5,1	100,0%

Table 4. Initial Goals and Advantage

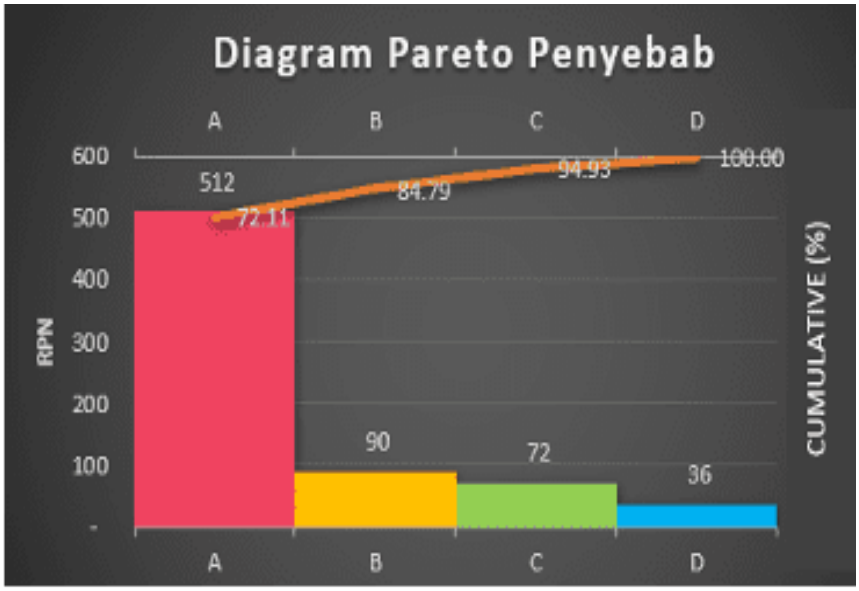


Figure 5. Diagram Pareto Root caused analysis

Explanation of the Ishikawa diagram problem for There is no appropriate sulfur utilization method, as follows:

1. There is no appropriate sulfur utilization method and Regulations / laws and regulations are not yet in place.
   There is no appropriate sulfur utilization method, resulting in high sulfur handling costs at Donggi CPP and Matindok CPP. Regulations/legislation resulted in the sale of sulphur resulting in non-oil and gas taxes that prevented sulphur from being commercialized, resulting in high sulphur handling costs at Donggi CPP and Matindok CPP.
2. High H2S content of Donggi Matindok gas production
   The high H2S content of Donggi Matindok gas production causes the Donggi Matindok gas purification process to be carried out which results in high sulfur production, resulting in high sulfur handling costs at CPP Donggi and CPP Matindok.
3. Lack of appropriate sulfur utilization facilities
   The lack of an appropriate sulfur utilization facility means that sulfur cannot be utilized/commercialized, resulting in high sulfur handling costs at Donggi CPP and Matindok CPP.
4. High H2S content of subsurface
   The high H2S content from the subsurface causes the Donggi Matindok gas purification process to be carried out which results in high sulfur production, resulting in high sulfur handling costs at Donggi CPP and Matindok CPP.

Based on the FMEA table and pareto diagram above, it is concluded that "There is no appropriate sulfur utilization method" is the dominant causal factor because it has the largest RPN with a percentage of 72%.

2.C. The Solution Of Dominant Causes

After knowing the dominant cause, we have several alternative solutions to overcome the dominant cause, including:

NO	Parameter	ALTERNATIVE SOLUTIONS		
		1	2	3
		Investment in processing supplies (biosulfur destruction)	**Processing unit rental (biosulfur destruction)**	**Utilization of biosulfur as raw material for fertilizer**
1	Cost	2230144,52 USD	1338086,71 USD	194341,17 USD
2	Procurement Process	2 years	1 years	3 months
3	Budget	ABI	ABI	ABO
4	Integration with existing systems	Required	Required	No Required
5	Job risk	High risk	High risk	Low risk
6	Installation & commissioning time	120 days	90 days	30 days
7	Man Power Needs	25	20	5
8	Added new location	Yes	Yes	Yes
9	Civil Works	Yes (red zone area)	Yes (red zone area)	Yes (yellow zone area)
10	Benefits to society	No	No	Yes
Conclusion		**Not Selected**	**Not Selected**	**Selected**

Table 5. Alternative Solutions

Based on the table above, we chose alternative 3, namely "utilization of biosulfur as raw material for fertilizer" because the costs required are relatively small, procurement and processing are fast and have low risk.

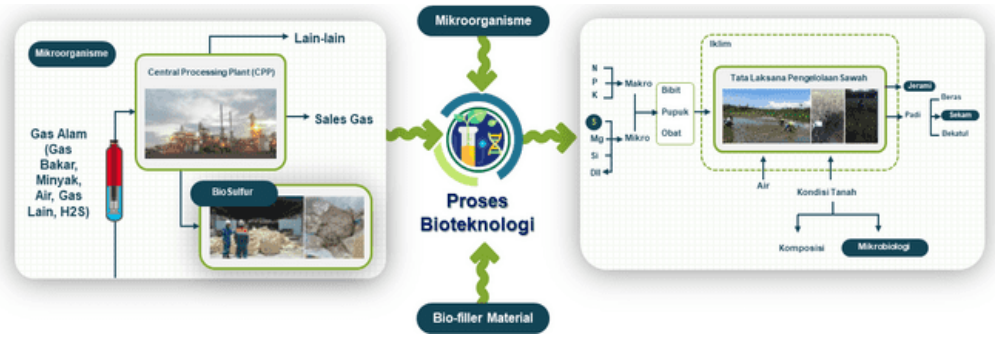


Figure 6. Utilization of biosulfur as raw material for fertilizer Process

No.	Work	Unit	Price
1	Carrying out biosulfur sampling and lab tests	1 lot	**Rp 50,000,000.00**
2	Carrying out experiments and research on the use of biosulfur	1 lot	**Rp 38,500,000.00**

3	Provision of equipment and production needs for biosulfur fertilizer	1 year	**3,209,160,960.00**
Total			**Rp 3,297,660,960.00**

Table 6. Costs Detail

No.	Pekerjaan	Satuan	Harga
1	Pelaksanaan Sampling dan Lab test Biosulphur	1 lot	Rp 50,000,000.00
2	Pelaksanaan percobaan dan peniltian pemanfaatan biosulphur	1 lot	Rp 38,500,000.00
3	Penyediaan peralatan dan kebutuhan produksi pupuk biosulphur	1 Tahun	Rp 3,209,160,960.00
Total			**Rp 3,297,660,960.00**

3.A. The Conclusion

Pertamina EP Donggi Matindok Field utilizes biosulfur as raw material for organic fertilizer "Bioferdom" to be used on rice and corn farms in Minahaki Village and Cendana Pura Village in Toili District, Banggai Regency, Central Sulawesi. Based on studies that have been conducted, food crops treated using biosulfur fertilizer become more fertile.

3.A.1 Standard design / Testing

In implementing the use of biosulfur fertilizer in community agricultural areas, Pertamina EP Donggi Matindok Field:

1. Sulphur side product testing to ensure that it is not toxic or toxic based on the Minister of Environment and Forestry Regulation No.6 of 2021 with the OECD 425 Test Method: Acute Oral Toxicity - Up and Down Procedure
2. Product testing of Donggi Matindok Biosulfur Fertilizer (Bioferdom) based on the Indonesian Minister of Agriculture Regulation for Solid Fertilizers No. 261/KPTS/SR.310/M/4/2019, with Testing Method SNI 7763: 2018 Point 6
3. Testing the results of food products (rice) from the use of BIOFERDOM fertilizer based on food product standards, namely SNI 2970: 2015 and SNI 01-2891: 1992.

3.A.2 Internal and external validation

- For the innovation of utilizing biosulfur side products into BIOFERDOM PUPUK products, it has been validated by the PEP internal team (Appendix 3.8).
- External validation regarding the utilization of biosulfur as fertilizer is stated in several documents such as:

1. External Validation from ALS Enviromental Laboratoratorium with test result number JW2300909001 for LD50 and TCLP Toxicity Test Based on PermenLHK No. 6 of 2021

2. External Validation from the Center for Surfactant and Bioenergy Studies - Institut Pertanian Bandung (IPB) related to the study of Biosulphur utilization in Donggi Matindok Field

3. External Validation from the Laboratory of Soil Chemistry and Plant Nutrition of Padjajaran University with sample number O-0216/06/2022 for the Test Results of Fertilizer Products from Biosulphur Based on the Indonesian Minister of Agriculture Decree No. 261/KPTS/SR.310/M/4/2019

4. External Validation from the Test Services Laboratory of the Faculty of Agricultural Industrial Technology, Padjadjaran University with test number 049/lab-test-DT/FTIP/SF/2023 based on food product standards, namely SNI 2970: 2015 and SNI 01-2891: 1992.

3.A.3 Bioferdom Process

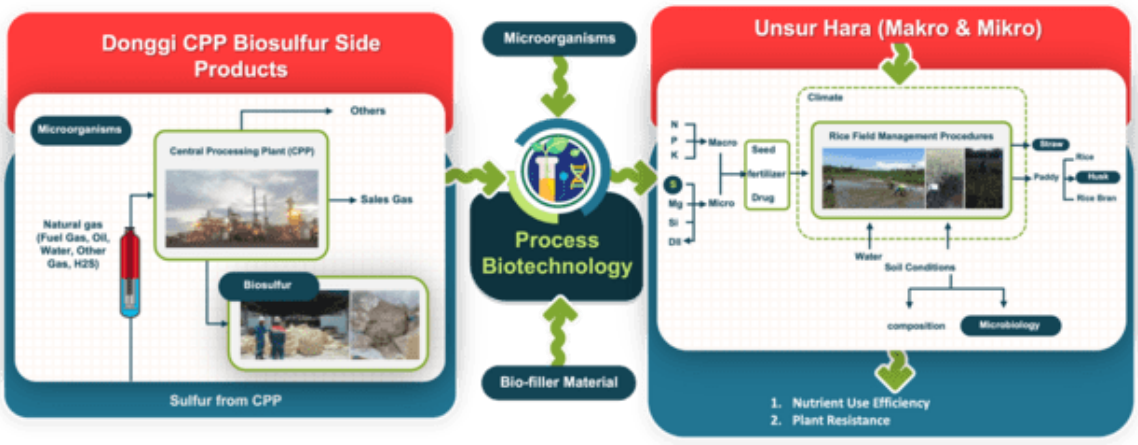


Figure 7. Bioferdom Process

Based on the picture above, one of the nutrients needed by plants to grow is S (Sulfur). By using biosulfur as a plant fertilizer, it will be able to meet the nutrients needed by plants. In addition, farmers can save the cost of purchasing fertilizers

3.A.4 Statement of Biosulfur as NON hazardous waste

Figure 8. Statement of Biosulfur as NON hazardous waste

3.A.5 Toxicity Test Data Summary

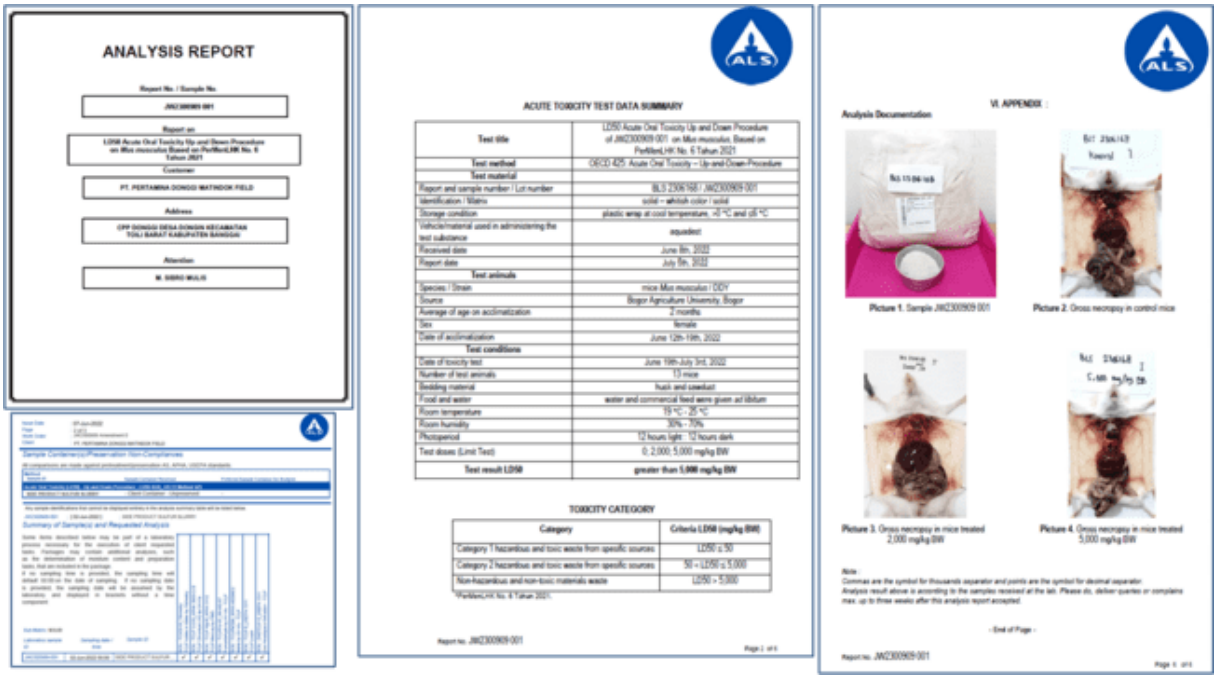


Figure 9. Toxicity Test Data Summary

The results of this Toxicity Test are the basis for the safety of biosulfur produced by Donggi Matindok Field to be processed and utilized outside the company sector.

3.A.6 Research report on sulfur requirements for soil and crops

1. Increases the process of forming the amino acids cystine and methionine as building blocks of protein in plants (Tisdale et al, 1990)
2. Plays a role as an activator, cofactor, or enzyme regulator in plant physiological processes (Epstein, 1972)
3. Increases the formation of chlorophyll for photosynthesis and stimulates several metabolic reactions in plants (Tisdale et al, 1990)
4. Helps stimulate root and fruit formation (Suseno 1974)
5. Helps reduce disease attacks on plants (Jones et al, 1991)

The benefits of sulfur in general are important for plant metabolism, both in the process of making protein, supporting the photosynthesis process, forming plant body parts, and preventing plant disease.

Meanwhile, soil conditions in Central Sulawesi with a pH>7 which tends to be high compared to the normal high pH (5.5-7) apparently causes the natural sulfur content in the soil to be low, so additional sulfur is needed through fertilization activities.

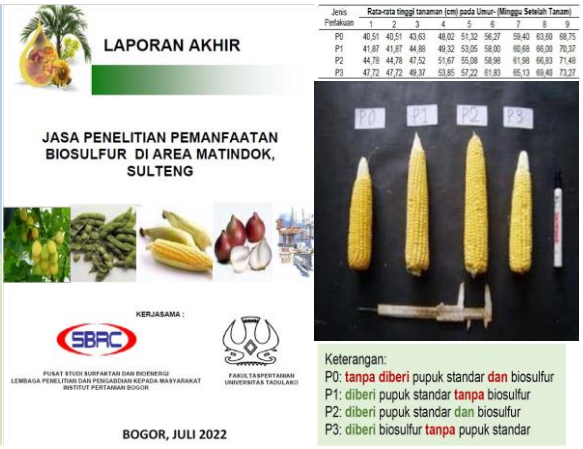


Figure 10. Research report on sulfur requirements for soil and crops

3.A7 Details of biosulfur fertilizer production stages

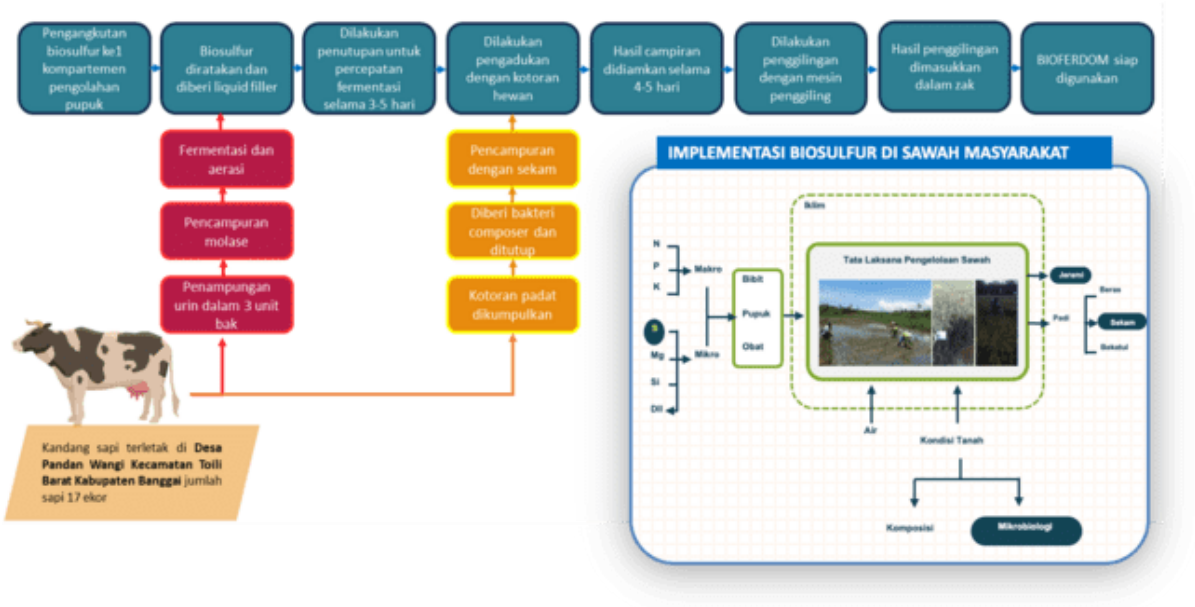
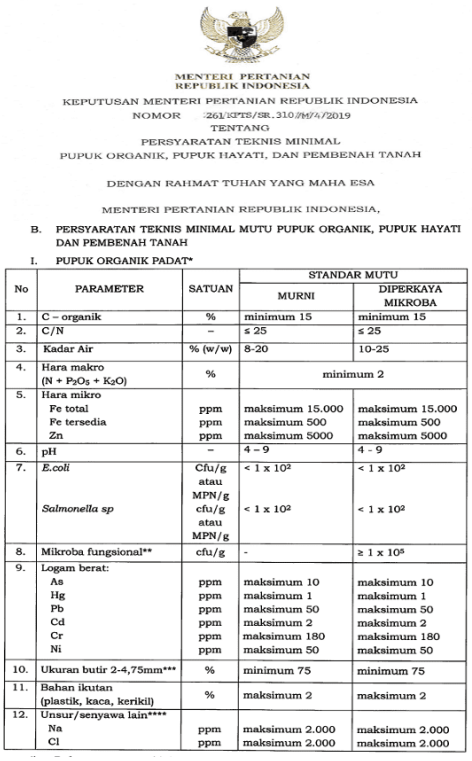


Figure 11. Details of biosulfur fertilizer production stages

3.A.8 Study Design Innovations

Figure 12. Study Design Innovations



MENTERI PERTANIAN
REPUBLIK INDONESIA

KEPUTUSAN MENTERI PERTANIAN REPUBLIK INDONESIA
NOMOR 261/KPTS/SR.310/M/4/2019
TENTANG
PERSYARATAN TEKNIS MINIMAL
PUPUK ORGANIK, PUPUK HAYATI, DAN PEMBENAH TANAH

DENGAN RAHMAT TUHAN YANG MAHA ESA

MENTERI PERTANIAN REPUBLIK INDONESIA,

B. PERSYARATAN TEKNIS MINIMAL MUTU PUPUK ORGANIK, PUPUK HAYATI DAN PEMBENAH TANAH

I. PUPUK ORGANIK PADAT*

No	PARAMETER	SATUAN	STANDAR MUTU	
			MURNI	DIPERKAYA MIKROBA
1.	C – organik	%	minimum 15	minimum 15
2.	C/N	–	≤ 25	≤ 25
3.	Kadar Air	% (w/w)	8-20	10-25
4.	Hara makro ($N + P_2O_5 + K_2O$)	%	minimum 2	
5.	Hara mikro Fe total Fe tersedia Zn	 ppm ppm ppm	 maksimum 15.000 maksimum 500 maksimum 5000	 maksimum 15.000 maksimum 500 maksimum 5000
6.	pH	–	4 – 9	4 - 9
7.	*E.coli* *Salmonella sp*	Cfu/g atau MPN/g cfu/g atau MPN/g	< 1 x 10^2 < 1 x 10^2	< 1 x 10^2 < 1 x 10^2
8.	Mikroba fungsional**	cfu/g	-	≥ 1 x 10^5
9.	Logam berat: As Hg Pb Cd Cr Ni	 ppm ppm ppm ppm ppm ppm	 maksimum 10 maksimum 1 maksimum 50 maksimum 2 maksimum 180 maksimum 50	 maksimum 10 maksimum 1 maksimum 50 maksimum 2 maksimum 180 maksimum 50
10.	Ukuran butir 2-4,75mm***	%	minimum 75	minimum 75
11.	Bahan ikutan (plastik, kaca, kerikil)	%	maksimum 2	maksimum 2
12.	Unsur/senyawa lain**** Na Cl	 ppm ppm	 maksimum 2.000 maksimum 2.000	 maksimum 2.000 maksimum 2.000

Figure 13. Indonesian Standard fertilizer

Step 4: Planning and Implementing the Improvement

4.A 5W2H - Planning

After knowing the results of the priority scale for each stage of the process, the detailed analysis work process through the 5W2H method is shown in Table 4.

No	WHY	HOW	WHAT	WHEN	WHERE	WHO	HOW MUCH	
							BIAYA	HASIL
1	The cost of handling biosulfur reaches 26 billion per year Donggi Matindok Field	Melakukan Innovasi pemanfaatan site product bioslphur menjadi bahan baku pupuk	Technical assessment, data analysis and benchmarking regarding biosulfur utilization	Weeks I – IV April 2022	Office Donggi	Reza P Sibro Arief	Rp. 0	Efficiency in processing costs for biosulfur side products amounting to 20 billion from the utilization of biosulfur side products at CPP
2			Preparation of plans and programs for utilizing biosulfur side products into fertilizer	Weeks I – IV May 2022	Office Donggi	Firman, Arief Nixon	Rp. 0	

3			Implementation of Biosulfur Sampling and Lab tests	Weeks I – IV June 2022	Laboratorium Kimia Tanah dan Nutrisi Tanaman	M. Sibro Nixon P Nurul	Rp. 50.000.000,-	Donggi and CPP Matindok amounting to 60 tons/month
4			Carrying out experiments and research on the use of biosulfur	Weeks I – IV July 2022	IPB dan Donggi	Nixon, A. Setiadi Nurul	Rp. 38.500.000,-	
5			Making MOC (Management of Change)	Week II – III July 2022	Office Donggi	M. Sibro Reza P Nixon	Rp. 0	
6			Finalization of utilization technology and preparation of biosulfur utilization contracts	Weeks I - IV August 2022	Office Donggi	Reza P Arief P M. Sibro	Rp. 0	
7			Provision of equipment and production needs for biosulfur fertilizer	Weeks I-IV of September - November 2022	CPP Donggi	Reza P Arief Edward	Rp. 267.430.080,- /Bulan	
8			Implementation of fertilizer production from bioslufur side products	Weeks I-IV of December 22 - March 2023	Desa Pandanwangi	Edward A. Setiadi Nixon	Rp. 0	
9			Monitoring results, standardization and expansion	Weeks I-IV of April to May 2023	Luwuk Banggai	Arief Sibro A. Setiadi	Rp. 0	

Table 6. 5W2H Analysis

Panca Mutu (**)	Conditions Before	Initial Target (SMART-C)
Quality	- Biosulfur side products that cannot be used directly as plant fertilizer - Community agricultural results are not optimal due to a lack of fertilizer in the process of planting and propagating plants	Fertilizer standard specifications are in accordance with solid organic fertilizer standards based on Decree of the Minister of Agriculture of the Republic of Indonesia No. 261/KPTS/SR.310/M/4/2019
Cost	- There are costs for processing biosulfur side products of 26 billion per year - The production cost of Donggi Matindok Field is 5.65 USD/BOE	- Eliminates sulfur processing costs by 10 M - Achieved the Donggi Matindok Field production cost target below 6 USD/BOE
Delivery	Biosulfur CPP Donggi and CPP Matindok have not been used as a mixture of organic fertilizer	Bioulfur CPP Donggi and CPP Matindok can be used as a mixture of organic fertilizer
HSSE	There is no use of biosulfur that is environmentally friendly and solves the problem of non-B3 waste	The process of making and utilizing biosulfur is environmentally friendly and solves the problem of non-B3 waste
Moral	There is no CSR program for agricultural activities in Luwuk, which is proud to be the rice granary of Sulawesi	Improving the company's image with innovation in the use of biosulfur

Table 7. Predection Value Creation

No	Uraian	Jam kerja	BOBOT (%)	Apr-22				Mei 22				Juni 22				Juli - Agus 22				Sept sd Nov 22				Des 22 sd Mar 23				Mar sd Juni 23			
				1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	PLAN																														
	1.1 Assesment teknis dan analisa data di lapangan	240.0	6.7	1.7	1.7	1.7	1.7																								
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2	DO																														
	2.1 Pelaksanaan Sampling dan Lab test Biosulphur	240.0	6.7									1.7	1.7	1.7	1.7																
	2.2 Pelaksanaan percobaan dan peniltian pemanfaatan biosulphur	240.0	6.7													3.3	3.3														
	2.3 Pembuatan MOC (Management of Change)	120.0	3.3														3.3														
3	CHECK																														
	3.1 Pembuatan Design dan penyusunan kontrak pemanfaatan biosulphur	600.0	16.7															8.3	8.3												
	3.2 Penyediaan peralatan dan kebutuhan produksi pupuk biosulphur	600.0	16.7																	4.2	4.2	4.2	4.2								
4	ACTION																														
	3.1 Impelementasi pembuatan pupuk dari site product bioslphur	840.0	23.3																					5.8	5.8	5.8	5.8				
	3.2 Monitoring hasil, Standarisasi dan Expansi	480.0	13.3																									4.4	4.4	3.0	1.4
	Total	3,600.0	100.0	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	3.3	6.7	8.3	8.3	4.2	4.2	4.2	4.2	5.8	5.8	5.8	5.8	4.4	4.4	3.0	1.4
	Plant Cumulatif			1.7	3.3	5.0	6.7	8.3	10.0	11.7	13.3	15.0	16.7	18.3	20.0	23.3	30.0	38.3	46.7	50.8	55.0	59.2	63.3	69.2	75.0	80.8	86.7	91.1	95.6	98.6	100.0

Table 8. S-Curve Planning

4.B Implementation of Improvements After planning, then carry out repairs.

No	How		When	Where	Who	Information
	Plan	Actual				
	Repair	Implementation				
1	Technical assessment, data analysis and benchmarking regarding sulfur utilization	**Survey :** **- Technical data assessment** **- Data analysis** **- historical data on energy consumption.** **- Benchmarking & Brainstorming methods regarding sulfur utilization**	Weeks I – IV April 2022	**Office Donggi**	**Reza P Sibro Arief**	Obtain initial data on yield, volume of sulfur product, and potential utilization
2	Preparation of plans and programs for utilization of biosulphur site products into fertilizer	Preparation of plans and programs for utilization of biosulphur site products into fertilizer	Weeks I – IV May 2022	**Office Donggi**	**Firman, Arief nixon**	Obtain a method for utilizing bioslphur that is tailored to the needs of stakeholders
3	Implementation of Biosulphur Sampling and Lab tests	Carrying out delivery and analyzing the sulfur content and its toxic properties with the Unpad lab and the Soil Chemistry and Plant Nutrition Lab (PT. ALS)	Weeks I – IV June 2022	**Laboratorium Kimia Tanah dan Nutrisi Tanaman**	**M. Sibro Nixon P nurul**	2 lab analyzes were carried out, with the lab containing the composition of biosulfur and the toxic properties of biosulfur with the results that it was not a dangerous substance (attached)

4	Carrying out experiments and research on the use of biosulphur	Carrying out experiments and research on the use of biosulphur in collaboration with IPB and Tandaluka Univ	Weeks I – IV July 2022	**IPB dan Donggi**	**Nixon, A. Setiadi Nurul**	Results of experiments and research on the use of biosulphur products on a lab scale in collaboration with IPB and Univ. sign of injury
5	Making MOC (Management of Change)	Making MOC (Management of Change)	Week II – III July 2022	**Office Donggi**	**M. Sibro Reza P Nixon**	Making MOC for the fertilizer making process
6	Finalization of utilization technology and preparation of biosulfur utilization contracts	Finalization of utilization technology	Weeks I - IV August 2022	**Office Donggi**	**Reza P Arief P M. Sibro**	Preparation of process flow and stages in making fertilizer
7	Provision of equipment and production needs for biosulfur fertilizer	Preparing sulfur making equipment such as mixing equipment and decomposition processes	Weeks I-IV of September - November 2022	**CPP Donggi**	**Reza P Arief Edward**	Provision of compartment equipment, mixing and grinding fertilizer
8	Implementation of fertilizer production from the bioslphur product site	Implementation on 7 hectares of rice fields in Pandanwangi village	Weeks I-IV of December 22 - March 2023	**Desa Pandanwangi**	**Edward A. Setiadi Nixon**	The process of applying fertilizer during pre-planting and maintenance
9	Monitoring results, standardization and expansion	Carry out monitoring of panel results, standardization and expansion by making an MOU	Weeks I-IV of April to May 2023	**Luwuk Banggai**	**Nurul Sibro A. Setiadi**	Panan Raya process with stake holders and Lanut workshops and MOU for cooperation in

		with the Regional Government				fertilizer utilization

Table 9. 5W2H Implementation

No.	Uraian	Jam kerja	BOBOT (%)	Apr-22				Mei 22				Juni 22				Juli - Agus 22				Sept sd Nov 22				Des 22 sd Mar 23				Mar sd Juni 23				Ket.
				1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
1	PLAN																															
	1.1 Assesment teknis dan analisa data di lapangan	240.0	6.7	1.7	1.7	1.7	1.7																									
	1.2 Penyusunan rencana dan program kerja	240.0	6.7					1.7	1.7	1.7	1.7																					
2	DO																															
	2.1 Pelaksanaan Sampling dan Lab test Biosulphur	240.0	6.7									1.7	1.7	1.7	1.7																	
	2.2 Pelaksanaan percobaan dan peniltian pemanfaatan biosulphur	240.0	6.7													3.3	3.3															
	2.3 Pembuatan MOC (Management of Change)	120.0	3.3														3.3															
3	CHECK																															
	3.1 Pembuatan Design dan penyusunan kontrak pemanfaatan biosulphur	600.0	16.7															8.3	8.3													
	3.2 Penyediaan peralatan dan kebutuhan produksi pupuk biosulphur	600.0	16.7																	4.2	4.2	4.2	4.2									
4	ACTION																															
	3.1 Impelementasi pembuatan pupuk dari site product bioslphur	840.0	23.3																					5.8	5.8	5.8	5.8					
	3.2 Monitoring hasil, Standarisasi dan Expansi	480.0	13.3																									4.4	4.4	3.0	1.4	
Plan		3,600.0	100.0	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	3.3	6.7	8.3	8.3	4.2	4.2	4.2	4.2	5.8	5.8	5.8	5.8	4.4	4.4	3.0	1.4	
Plant Cumulatif				1.7	3.3	5.0	6.7	8.3	10.0	11.7	13.3	15.0	16.7	18.3	20.0	23.3	30.0	38.3	46.7	50.8	55.0	59.2	63.3	69.2	75.0	80.8	86.7	91.1	95.6	98.6	100.0	
Actual				1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	3.3	6.7	8.3	4.2	9.9	4.2	4.2	3.8	3.8	0.0	5.8	5.8	4.4	8.9	3.0	1.4	
Actual Cumulatif				1.9	3.8	5.8	7.7	9.6	11.5	13.5	15.4	17.3	22.3	27.3	32.3	35.4	38.5	53.8	59.6	73.1	80.8	88.5	92.3	96.2	96.2	96.9	97.7	98.5	100.0	100.8	100.8	

Table 10. S-Curve Realitation

Notes :

1. There is an accelerated implementation of the technology for making BIOFERDOM sulfur and the application of fertilizer on designated rice fields
2. After installing BIOFERDOM fertilizer and carrying out QA/QC, it is declared that PUPUK has succeeded in replacing inorganic FERTILIZER
3. The technology for making BIOFERDOM fertilizer is made in a self-managed manner

4.B.1 Quantification of Biosulfur Fertilizer Management

1. Feed Requirements

Information	Amount
Lawn Needs	25 kg/head/day ~ 325 kg/day
Hay Needs	4 kg/head/day ~ 52 kg/day
Grassland Area	8.6 m2/head/day ~ 111.8 m2/day

Time for Grass to Grow	60 days
Grassland Area Requirements	6708 m2 ~ 0.671 Ha

2. Cow Profile

Information	Amount
Number of Cows	13 heads
Urine Production	12 L/head/day
Urine Flow Rate	156 L/day ~ 0.16 m3/day
Water Flow Rate	2.4 m3/day
Total Liquid Flow Rate	2.56 m3/day
Animal Manure Production (Kohe)	15 kg/head/day ~ 195 kg/day

3. Underground Liquid Filler Capacity

Information	Amount
Underground Liquid Filler Tub	10.1 m3
Total Liquid Flow Rate	2.56 m3/day
Dwell Time	3.95 days

4. Rice Field Profile

Information	Amount
Rice Field Area	35.8 Ha
Bioferdom Needs	1000 kg/Ha
Need for Liquid Filler	0.07 m3/day/Ha

Bioferdom Adequacy Projections	0.78 kg/day ~ 0.78 Ha/day
	120 days/season
	93.6 tonnes/season ~ 93.6 Ha/season

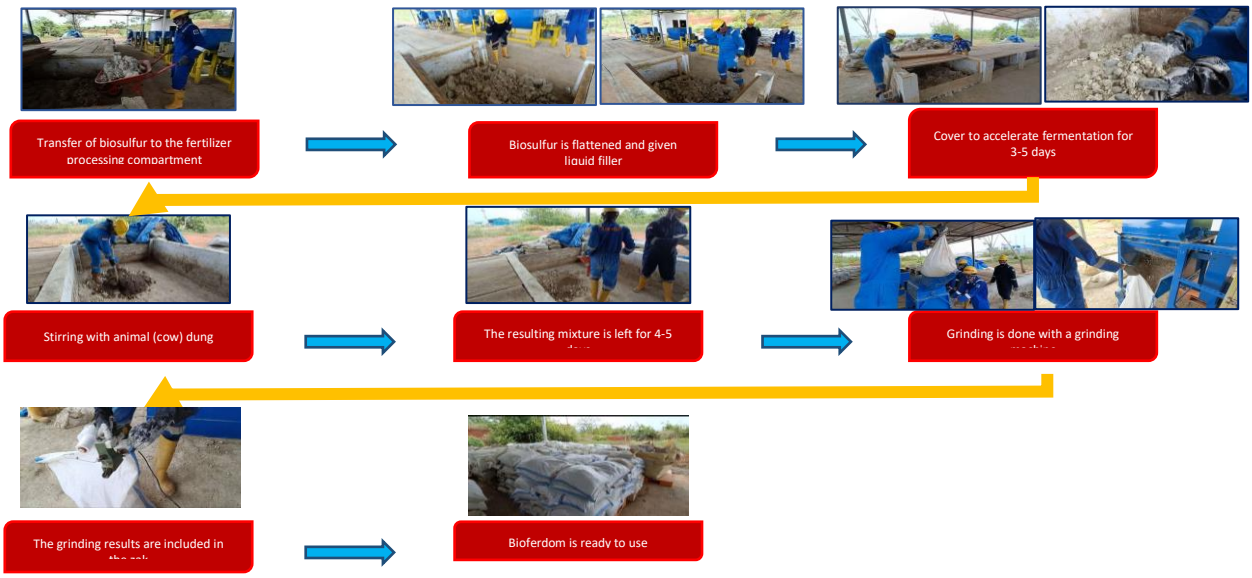
5. Composition of Biosulfur Fertilizer

Information	Amount
Animal Manure Production (Kohe)	15 kg/head/day ~ 195 kg/day
Biosulfur	390 kg/day
Solid Fillers	195 kg/day
Additional Solid Filler	195 kg/day
Bioferdom Production	780 kg/day

6. Biosulfur Fertilizer Plant Capacity

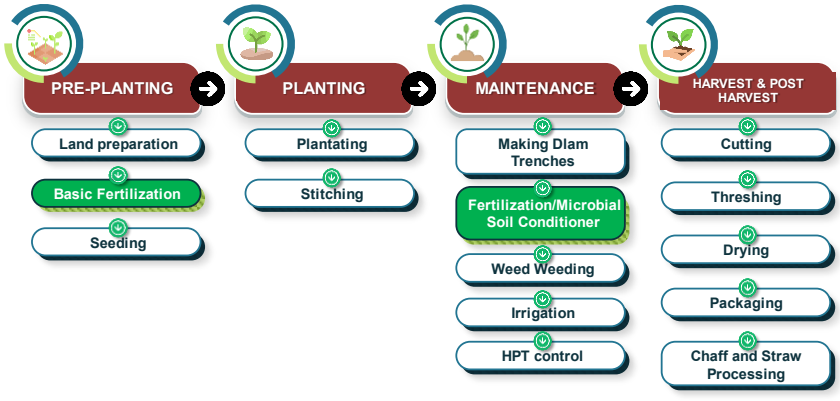
Information	Amount
Bioferdom Plant Capacity	5000 kg
Bioferdom Production	780 kg/day
Dwell Time	6.41 days

4.B.2 Implementation of the creation of BIOFERDOM

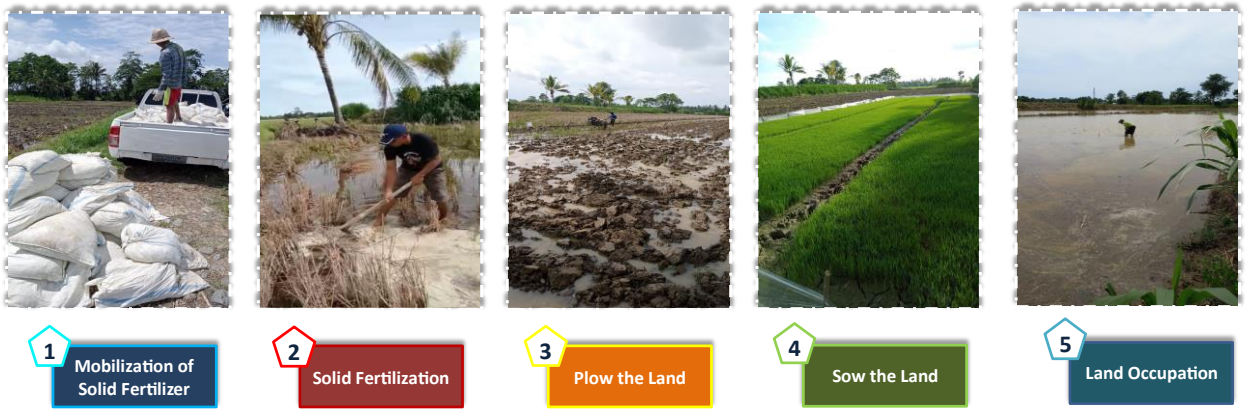


4.B.3 Existing Condition of BIOFERDOM PLANT

4.B.4 BIOFERDOM implementation flow on agricultural land



4.B.4 Pre-planting pilot farming activities



4.B.5 Pilot farming activities – planting and maintenance

Step 5: Evaluate the Result

5.A. Results Achieved in The QCDSEM Aspect

The team compared the conditions before and after the improvement by using the dimensions of quality, cost, delivery, health, safety, security, and environment, and morale. Table 6 shows the results of this project.

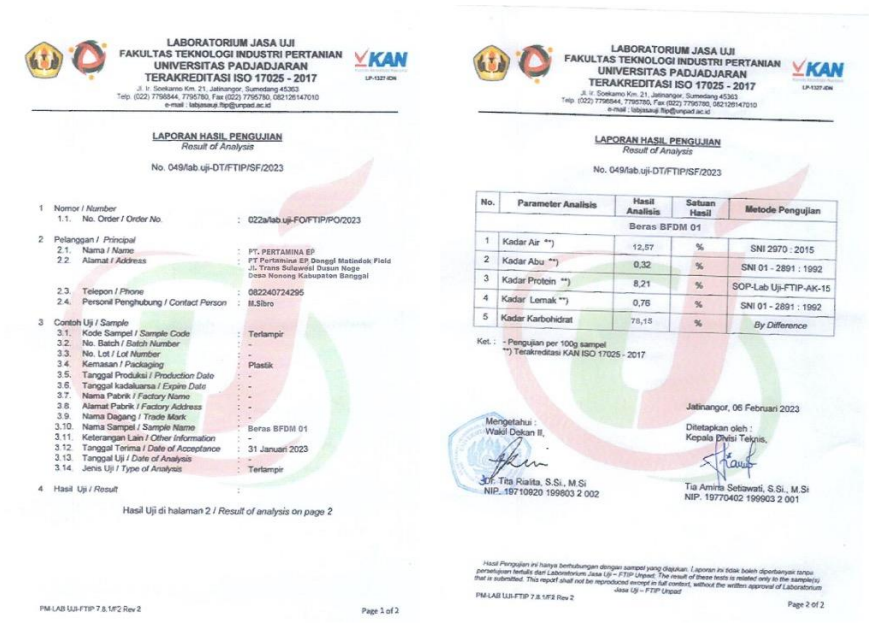
Panca Mutu (**)	TARGET	RESULT	ACHIEVEMENT (%)	POSITIVE IMPACT
Quality	Fertilizer standard specifications in accordance with solid organic fertilizer standards based on the Decree of the Minister of Agriculture of the Republic of Indonesia No. 261/KPTS/SR.310/M/4/2019	- The quality of food products produced from agricultural land using biosulfur fertilizer is better than without the use of fertilizers - Can provide solutions to the community and stakeholders on the issue of fertilizer scarcity	200%	There is a suitability of biosulfur products as a mixture of organic fertilizers that are suitable for soil conditions in local rice fields so that it becomes a solution to fertilizer scarcity (exceeds the target)
Cost	■ Eliminated sulfur processing costs by 10 M ■ - Achieved Donggi matindok field production cost target below 6 USD/BOE	-- Eliminated sulfur processing costs by 23 M - Achieved Donggi Matindok Field production cost target of 5.65 USD/BOE	183%	Increased company profit from biosulfur handling revenue and decreased production costs (exceeded target)
Delivery	Donggi CPP and Matindok CPP biosulfur can be utilized as an organic fertilizer mixture.	Donggi CPP and Matindok CPP biosulfur utilized as a mixture of organic fertilizer in community rice fields	150%	Fertilizer with biosulfur mixture was successfully implemented in community -owned rice fields (exceeded target)
HSSE	The process of making and utilizing biosulfur is environmentally friendly and solves the problem of non - B3 waste	The process of making and utilizing biosulfur is environmentally friendly and solves the problem of non - B3 waste	150%	The process of making and utilizing biosulfur uses environmentally friendly methods and does not use chemicals that are B3 (exceeds the target)
Moral	Improve the company's image with the innovation of biosulfur utilization	Improving the company's image with the innovation of biosulfur utilization	200%	Utilization of biosulfur as a mixture of organic fertilizers succeeded in improving the company's image (exceeded the target)

5.B. Results Achieved in the other aspect

5.B.1 Achievements in ESG

ASPEK	HASIL
E ENVIROMENT	• Utilization of non-hazardous waste from biosulfur (by-product) that has been well implemented. • The use of Bioferdom has a positive impact on the soil compared to the use of non-organic fertilizers
S SOCIAL	▪ Can provide solutions related to the lack of fertilizer supply to local farmers ▪ Reduce farming operational costs, thereby increasing farmers' net income ▪ Increase community crop yields thus adding to the country's food security
G GOVERNMENT	▪ Provide food security for the country and the Central Sulawesi region can become a national rice granary ▪ Provide a stimulus for local governments to be able to independently provide optional fertilizers to farmers

5.B.2 Quality & Quantity of harvest



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FAKULTAS TEKNOLOGI INDUSTRI PERTANIAN
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LAPORAN HASIL PENGUJIAN
Result of Analysis

No. 049/lab.uji-DT/FTIP/SF/2023

1 Nomor / *Number*
1.1. No. Order / *Order No.* : 022a/lab.uji-FO/FTIP/PO/2023

2 Pelanggan / *Principal*
2.1. Nama / *Name* : PT. PERTAMINA EP
2.2. Alamat / *Address* : PT Pertamina EP Donggi Matindok Field Jl. Trans Sulawesi Dusun Nogo Desa Nonong Kabupaten Banggai
2.3. Telepon / *Phone* : 082240724295
2.4. Personil Penghubung / *Contact Person* : M.Sibro

3 Contoh Uji / *Sample*
3.1. Kode Sampel / *Sample Code* : Terlampir
3.2. No. Batch / *Batch Number* : -
3.3. No. Lot / *Lot Number* : -
3.4. Kemasan / *Packaging* : Plastik
3.5. Tanggal Produksi / *Production Date* : -
3.6. Tanggal kadaluarsa / *Expire Date* : -
3.7. Nama Pabrik / *Factory Name* : -
3.8. Alamat Pabrik / *Factory Address* : -
3.9. Nama Dagang / *Trade Mark* : -
3.10. Nama Sampel / *Sample Name* : Beras BFDM 01
3.11. Keterangan Lain / *Other Information* : -
3.12. Tanggal Terima / *Date of Acceptance* : 31 Januari 2023
3.13. Tanggal Uji / *Date of Analysis* : -
3.14. Jenis Uji / *Type of Analysis* : Terlampir

4 Hasil Uji / *Result* :

Hasil Uji di halaman 2 / *Result of analysis on page 2*

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LABORATORIUM JASA UJI
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LAPORAN HASIL PENGUJIAN
Result of Analysis

No. 049/lab.uji-DT/FTIP/SF/2023

No.	Parameter Analisis	Hasil Analisis	Satuan Hasil	Metode Pengujian
	Beras BFDM 01			
1	Kadar Air **)	12,57	%	SNI 2970 : 2015
2	Kadar Abu **)	0,32	%	SNI 01 - 2891 : 1992
3	Kadar Protein **)	8,21	%	SOP-Lab Uji-FTIP-AK-15
4	Kadar Lemak **)	0,76	%	SNI 01 - 2891 : 1992
5	Kadar Karbohidrat	78,15	%	*By Difference*

Ket. : - Pengujian per 100g sampel
**) Terakreditasi KAN ISO 17025 - 2017

Jatinangor, 06 Februari 2023

Mengetahui :
Wakil Dekan II,

Dr. Tita Rialita, S.Si., M.Si
NIP. 19710920 199803 2 002

Ditetapkan oleh :
Kepala Divisi Teknis,

Tia Amira Setiawati, S.Si., M.Si
NIP. 19770402 199903 2 001

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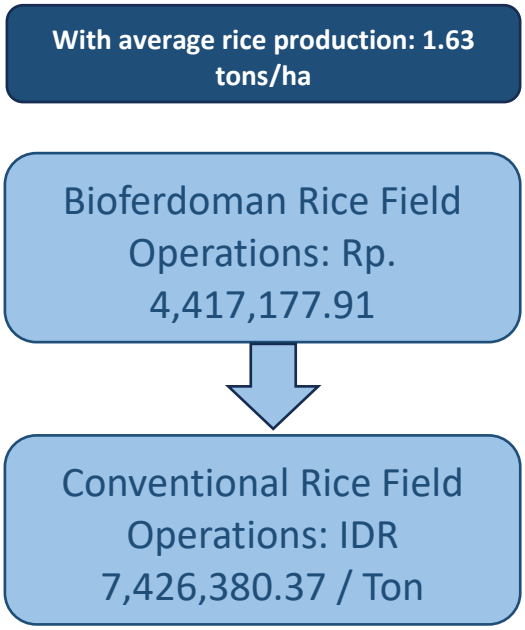
Kandungan Normal Padi Organik (%)	Beras BFDM	Beras Putih	Beras Merah	Beras Hitam
Karbohidrat Total	78,15	77,1	73-16-795,8	75,8-78,68
Lemak Total	0,76	1,7	1-2,07	0,22-0,42
Protein	8,21	8,4	7,72-9,10	7,44-10,08
Kadar Air	12,57	12	-	-
Kadar Abu	0,32	0,8	0,43-1,01	0,14-0,78

5.B.2 Evaluate equipment operating costs

No.	OPERASIONAL	Operational Price of Rice Fields with Conventional Fertilizer	Operational Price of Rice Fields with Bioferdom	Unit
1	Farmer's Field 1	1	1	Ha/Musim
2	Material			
a	Rice Seeds 825,000.00	825.000,00	400.000,00	Rupiah/musim.ha
b	Nutrient and Fertilizer 5,130,000.00	5.130.000,00	1.000.000,00	Rupiah/musim.ha
	Total Material Expenditure 5,955,000.00	5.955.000,00	1.400.000,00	Rupiah/musim.ha
3	Handling paddy fields			
a	Post-harvest land conditioning 1,650,000.00	1.650.000,00	-	Rupiah/musim.ha
b	Paddy field rental -	-	-	Rupiah/musim.ha
a	Fertilization 300,000.00	300.000,00	500.000,00	Rupiah/musim.ha
b	Seeding 150,000.00	150.000,00	350.000,00	Rupiah/musim.ha
e	Planting 150,000.00	150.000,00	1.200.000,00	Rupiah/musim.ha
f	Pulling seedlings 900,000.00	900.000,00	400.000,00	Rupiah/musim.ha
g	Watering Bio-M 300,000.00	300.000,00	500.000,00	Rupiah/musim.ha
h	Weed Weeding 1,200,000.00	1.200.000,00	750.000,00	Rupiah/musim.ha
i	Packing and Harvesting Materials 1,500,000.00	1.500.000,00	400.000,00	Rupiah/musim.ha
	Total Paddy Field Handling Expenses 6,150,000.00	6.150.000,00	4.100.000,00	Rupiah/musim.ha
4	Overhead			
a	Rent for transportation of	-	500.000,00	Rupiah/Musim/lot (4 Ha)

	solid fertilizer materials -			
b	Rent for transportation of liquid fertilizer material -	-	1.200.000,00	Rupiah/Musim (1 Ha)
-	Jumlah Pengeliaran Overhead	0	1.700.000,00	Rupiah/musim.ha
Total Biaya Sawah per Hektar		12.105.000	7.200.000	Rupiah/musim.ha



5.B.3 Evaluation of agricultural operational costs

No.	Fertilizer Use	Operational Costs/ Hectare	Yield tons/hectare	Plant type	Market price per kg	Gross Income Per Hectare	Net income per hectare
1	Bioferdom Fertilizer	IDR 7,200,000.00	1,64	Padi Organik	Rp 25.000	41.075.000,00	33.875.000,00
2	Conventional Fertilizer	IDR 12,105,000.00	1,64	Padi Non-organik	Rp 10.500	17.251.500,00	5.146.500,00
Increase in community (farmer) income per hectare						28.728.500,00	
Increase in community (farmer) income per hectare in 1 year (3 seasons)						86.185.500,00	

5.B.4 Positive Impact of Implementation

Positive Impact for the Company
1. Achieved the Donggi Matindok Field production cost target of 5.65 USD/BOE
2. Reducing sulfur processing costs by IDR 23 billion per year
3. Improving the company's image with innovations in the use of sulfur on community agricultural land

Positive Impact on Society and Government
1. Biosulfur fertilizer has been proven to comply with the criteria for organic solid fertilizer so it has succeeded in being a solution to fertilizer shortages
2. Biosulfur fertilizer can increase the sulfur nutrient content in the soil, as proven by improving the quality of crop yields
3. The process of processing biosulfur as fertilizer uses environmentally friendly methods and addresses pollution problems from livestock activities
4. Reducing agricultural operational costs thereby increasing farmer income by IDR 86,168,500/year
5. Increasing the country's food security through increasing crop yields
6. Support Banggai Regency as a rice granary for Central Sulawesi Province
7. Providing stimulus to local governments to be able to provide organic fertilizer options to farmers independently

5.B.5 Risks of program implementation

Negative Risk	Mitigation and Treatment
1. There are social problems related to interests in the fertilizer distribution business	1. Fertilizer cooperation is carried out through the Regional Government with BUMD Luwuk Regency
1. There was a problem with the local fertilizer business	2. Strengthen cooperation with support from the Regional Government and other stakeholders

5.B.6 Financial Verification

Verifikasi Keuangan

Continuous Improvement Program (CIP)

Judul CIP :	MENINGKATKAN KEBERMANFAATAN PRODUK SAMPING BIOSULPHUR MENJADI BAHAN BAKU PUPUK BIOFERDOMAN DI PT. PERTAMINA EP DONGGI MATINDOK FIELD	☐ FT Prove ☒ PC Prove ☐ RT Prove ☐ I Prove Nama Gugus LSM	Unit Kerja : PEPC Donggi Matindok Field

Rincian Keekonomian :

No.	Deskripsi	Real (Sept 22 sd Agus 23)	Potensi (Okt sd Des 23)	Potensi (Jan - Des 24)
A	**Revenue**			
1	Effisiensi biaya dari penanganan limbah non b3 biosulphur dengan jumlah produksi 2 ton perhari sebesar Rp. 23.314.625.946,-/Tahun	Rp 23,314,625,946.00	Rp 5,828,656,486.50	Rp 23,314,625,946.00
2	Effisiensi biaya penyediaan pupuk di persawahan masyarakat dalam 1 tahun melakukan 3 x proses tanam yang digunakan di 35.8 hektar sawah dengan Effisiensi biaya penyediaan pupuk adalah Rp. 4.905.000,- Perhektar	Rp 515,025,000.00		
3	Meningkatkan pendapatan Petani (masyarakat) dari hasil panen di persawahan dari sebelumnya padi jenis non-organik menjadi padi organik yang berkualitas tinggi pada 35 Hektar sawah selama 1 tahun	Rp 4,321,275,000.00		
B	**Biaya pelaksanaan Innovasi**			
1	Pelaksanaan Innovasi pembuatan Pupuk Bioferdom dari bahan baku site product biosulphur	Rp 3,030,230,880.00		
Value Creation (Real Revenue + Potensi Kerugian)		**Rp 25,120,695,066.00**		

Catatan & Asumsi :
- 1 USD = 14.350 Rupiah (Mengacu pada Kurs WP&B)
- Harga gas = sesuai lampiran

Conclusion ☒ Penambahan Revenue ☒ Penghematan Biaya

Tanggal : 25 Oktober 2023

Pengusul		Verifikator	
Ketua CIP	Manager Field Donggi Matindok	Finance Analyst Zona 13	Asst. Manager Field Finance Zona 13 & 14
M Sibro mulis	Ridwan Kiay Demak	Fredy Yuwando	MS. Rusman Napitupulu

Step 6: Making Re-Standardization

This innovation has been standardized by making TKI Procedures for Utilizing Side Product Biosulfur as raw material for BIOFERDOM Fertilizer in Donggi Matindok Field NO: C.08-001/PPC82330/2022-S0 REV-00

No.	Standardization	Description (Guidelines – TKI)
1	Input Standard	1. Input data on unutilized biosulfur side products at Donggi Matindok Field 2. Input biosulfur analysis data in qualifications at Donggi Matindok 3. Input data on stakeholder needs in the use of Donggi Matindok biosulfur
2	Process Standards	1. Conduct engineering studies for the use of bioslufur 2. Carry out the process of making fertilizer with additional components 3. Conduct small-scale experiments on the use of bioslphur for use as a fertilizer

		4. Analyze fertilizer results using existing standards 5. Carrying out large-scale utilization in the rice fields of Luwuk area, Banggai Regency
3	Output Standard	1. Increase the usefulness of biosulfur side products for the benefit of society 2. Reducing dependence on inorganic fertilizers which are often scarce by substituting biosulfur fertilizer 3. Produce harvests from the community with healthier (organic) harvests

Step 7 : Result Sharing (Coordination with the Related Unit/Department and Customers)

• Upload KOMET No. 202310083 (Appendix 7.2)
• Internal Knowledge Sharing, among others (Appendix 7.2)
1. Sharing session at Donggi Matindok Field
2. Sharing session at the Internal Persero level at the 2023 HSSE Innovation event
• External knowledge sharing (Appendix 7.3)
1. Luwuk Banggai Company National Level at the USDS Forum monthly meeting with SKK Migas, PT. DSLNG, JOB Pertamina Medco Tomori and PT. PAU
2. Workshop with a team from the Regent of Banggai and related departments
3. Workshop with academics and stakeholders
• Contest innovation events
1. Become the top 10 in the HSSE Innovation event at Pertamina (Persero) level

"BIOFERDOM" fertilizer innovation or called (Biofertilizer Donggi Matindok) in a process that produces biosulfur which cannot be utilized, especially in KKKS companies. This innovation is one of the breakthroughs that provides solutions to KKKS companies and to stakeholders, namely the community around the work area, the Department of Agriculture and related agencies, so that the problems in KKKS are solutions for the community

So with this explanation, many internal and external Oil & Gas companies and other industries are interested in replicating the "BIOFERDOM" fertilizer innovation, including (attachment 7.5):

1. PT. Pertamina EP CPP Gundih at Cepu Field
2. PT. Pertamina EP CPA Mudi at Sukowati Field
3. JOB Pertamina Medco – Tomori
4. Etc.