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Modification of Wastewater Treatment in Mine Workshop Area

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Abstract **-** Present skyrocketing growth of coal mining business in Indonesia requires the readiness of heavy equipment with proper physical availability hence heavy equipment maintenance is also increasing due to coal production support. High maintenance activity of heavy equipment produces contaminated water with oil, grease and hydrocarbon in workshop area. Contaminated water is treated in conventional sedimentation oil trap then is fetched to be treated in the hazardous waste facility and the treated water is released to the mine drainage. Nevertheless, water recycle using coagulation process is an improvement to minimize contaminated water and to provide water for workshop activity. This study aims to determine the efficiency of wastewater treatment transformation to water recycle in a coal mine workshop. This study used water quality parameters data such as pH, TSS, Fe Mn and COD to define the wastewater treatment and operational cost efficiency between two treatments. The result showed that after coagulation is added, the effluent quality complied the Indonesian's wastewater standards. By the modification treatment, TSS content reduces to 74-79% and COD content to 49-87% comparing to previous treatment. Furthermore, the cost from the shift of treatment reduces to 45%. This treatment is also safe for environment since the wastewater treatment is also shifted to be closed circuit. Water recycle in workshop has also a key point to improve environmental management value in coal mine area.

***Keywords*:** coal mine, oil trap, water, workshop

1. Introduction

Coal production in Indonesia is rocketing due to its price and export (Admi et al., 2022). The expansion of coal exploitation is widespread along the target of power plant establishment and royalty. However, the environmental protection in this industry has a role key in order to conserve the nature. One of the concerns is water management since Indonesia has high precipitation and finds a difficulty to treat the water (Mien, 2012). The wastewater in coal mine area is produced not only from the pit and disposal area, but also from the facilities. For example, domestic wastewater from a coal mine office with huge numbers of employees is treated using activated sludge to reduce the contaminant (Pranoto et al, 2019).

To support coal production, workshop has essential role to provide proper heavy equipment. High volume of heavy equipment requires predictive or preventive maintenance to minimize unscheduled breakdowns (Widjaja et al., 2021; Saputra et al., 2021). The use of water in workshop during maintenance results contaminated water with oil, grease and hydrocarbon compound. Generally, contaminated water is treated using conventional sedimentation oil trap facility. The contaminated water is separated in the first compartment, taken then moved to a drum and managed in hazardous waste facility (Momon et al., 2021). Afterwards, the contaminated water is taken by listed waste collectors to be treated off site the mine area. Meanwhile, the treated water from conventional oil trap is released to the mine drainage. However, there is a possibility that the outlet water from oil trap facility still contains the oil or other hydrocarbon and add contaminant load to settling pond.

Moreover, water recycle in the mine workshop facility has the idea to reduce the contaminant and to provide water for workshop activity. For a massive workshop activity, the coagulation and flocculation process are added to treat the water (Pote, 2017). This treatment also shifts the effluent to be clean water due to close circuit. This study aims to determine the efficiency of wastewater treatment transformation in a coal mine workshop from a conventional to modified treatment using added coagulation process. This study defines the contaminant removal efficiency and cost reduction from two wastewater treatments and the opportunity of water recycle for workshop use.

2. Material and Methods

This study was conducted in a workshop of PT Putra Perkasa Abadi in South Kalimantan Province during October to December 2022. PT Putra Perkasa Abadi is a mine service enterprise that owns an overburden removal and coal getting contract with PT Borneo Indobara, the coal permit holder.

2.1. Oil trap design

The study was taken place in three different oil traps from fuel storage facility in workshop area. The previous design of oil traps adopted conventional sedimentation with only physical treatment. Each oil trap consisted of four compartments which the first compartment was used to separate the water and sedimentation while the second compartment was used to separate the oil layer. The effluent from last compartment was expected to be treated water that released to the mine drainage and was expected to achieve the standards based on South Kalimantan Governor Regulation No. 36 of 2008 concerning Wastewater Quality Standards for Coal Mining, Processing or Washing Activities. The capacity of three oil traps is showed in Table 1. In the previous treatment, the remaining sedimentation and water in the first and second compartment were taken to a hazardous waste drum and placed to hazardous waste facility. The hazardous waste then is treated off-site the mine area.

Table 1: Oil trap capacity

Oil trap	Volume of Compartment 1 (m^3)	Volume of Compartment 2 (m^3)	Capacity of Compartment 3 (m^3)	Capacity of Compartment 4 (m^3)	Total Capacity (m^3)
Oil trap 01	0.774	0.774	0.774	0.774	3.096
Oil trap 02	3.779	3.779	3.779	3.779	15.116
Oil trap 03	0.774	0.774	0.774	0.774	3.096

The modification of oil trap design applies close circuit system so that there is no discharge water. This improvement employs no modification in the capacity of oil trap compartment. The wastewater is recycled to clean water for cleaning the workshop bay, washing the heavy equipment and watering the plants use. around the workshop area. The coagulation process is added to recycle the water using coagulant (rollfloc containing aluminum oxide (Al_2O_3) and alum or $Al_2(SO_4)_3$) for sedimentation process (Pote, 2017). Rollfloc is added in the third compartment and alum is added in the last compartment while the treated water in the last compartment is pumped to water tank.

2.2. Wastewater quality

The oil trap effluent quality in the previous design was taken in September 2022, before the oil trap modification was conducted. The modification is used to reduce the water quality in the last compartment since there is no discharge. The water quality in the last compartment was taken weekly during October to December 2022. The samples were tested to analyse pH, Total Suspended Solid (TSS), Fe, Mn and COD using HACH DR 900 Colorimeter on-site.

2.3. Cost comparison

In this study, there is a consideration to determine that the modification of treatment is sufficient from financial aspect. In the previous treatment, the hazardous waste management cost was spent to clean up the contaminated water and sludge from the oil trap facility which cost IDR900,000 per 0.02 m^3 for contaminated water and IDR500,000 per drum for contaminated sludge. The scope of contaminated water and sludge management cost starts from clean up from oil trap to collection by third parties who collect hazardous waste. After the modification, the coagulant purchasing (rollfloc IDR11,520 per kg and alum IDR6,000 per kg) is added to operational cost with significant reduction of hazardous waste management cost because only contaminated sludge is taken from the oil trap. The operational cost of previous treatment was calculated during June to August 2022 whereas the operational cost of improvement treatment was calculated during October to December 2022.

3. Result and Discussion

Wastewater from mine workshop comes from heavy equipment wash and floor cleaning activity. It contains colloid from soil, oil, diesel fuel, grease, thinner and gasoline. Therefore, wastewater from workshop with similar activities generally generally has high content of TSS and COD (Nimassari and Purnomo, 2021). Wastewater treatment in the workshop is possible to implement physical, chemical and biological treatment based on the contaminant load. Physical treatment using sedimentation is generally used in workshop to remove colloid and oil (Maharani, 2017).

The oil trap in this study consists of four compartments that applies sedimentation method. In the previous treatment, there was no chemical amendment added to settle the colloid. Insufficient treatment resulted high TSS and COD content of effluent (Table 2) although it was released to the mine drainage and flowed to the settling pond before release to the water body. In the previous treatment, visual monitoring was performed as of undetected wastewater quality occurred. Therefore, modification was performed to avoid adding contaminant load to settling pond and recycle water for workshop activity use.

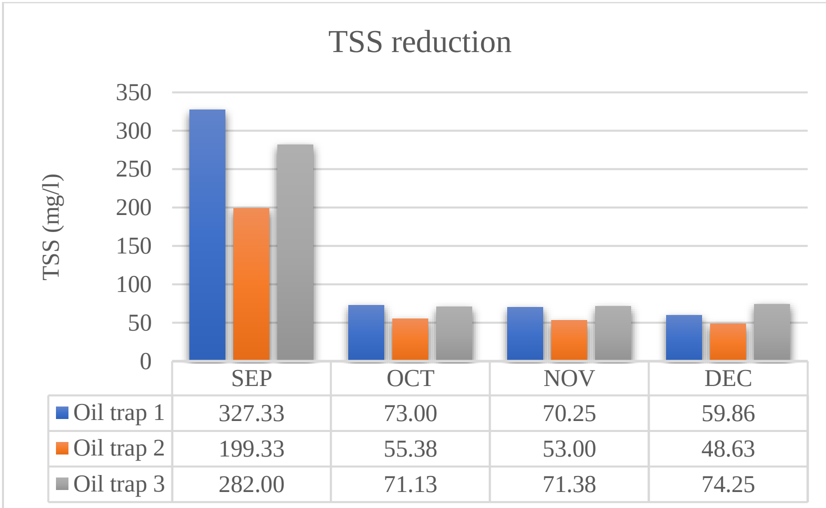
Table 2: Outlet quality test result

Parameter	Units	Standard	Oil trap 01	Oil trap 02	Oil trap 03
pH		6-9*	7.1	6.27	7.23
TSS	mg/l	200*	327.33	199.33	282
Fe	mg/l	7*	0.71	0.32	0.31
Mn	mg/l	4*	0.10	0.04	0.08
COD	mg/l	100**	593	132	692.33

Note: * South Kalimantan Governor Regulation No. 36 of 2008
** Minister of Environment and Forestry Regulation No. 5 of 2022

3.1. Removal of TSS

After the modification treatment using coagulant is applied to the oil traps, TSS content was decreased to 74-79% comparing to previous treatment (Figure 1). As described in the Figure 1, the previous treatment released effluent with high TSS content (average 199.33-327.33 mg/l) as tested in September 2022. In mine area, discharge from workshop area is still treated in the settling pond together with runoff water and before release to the water body. Therefore, the selection of wastewater treatment technology should be implemented conveniently. Alum is effective to remove turbidity from muddy water (Malik, 2018) and is a low-cost coagulant for treatment in workshop.



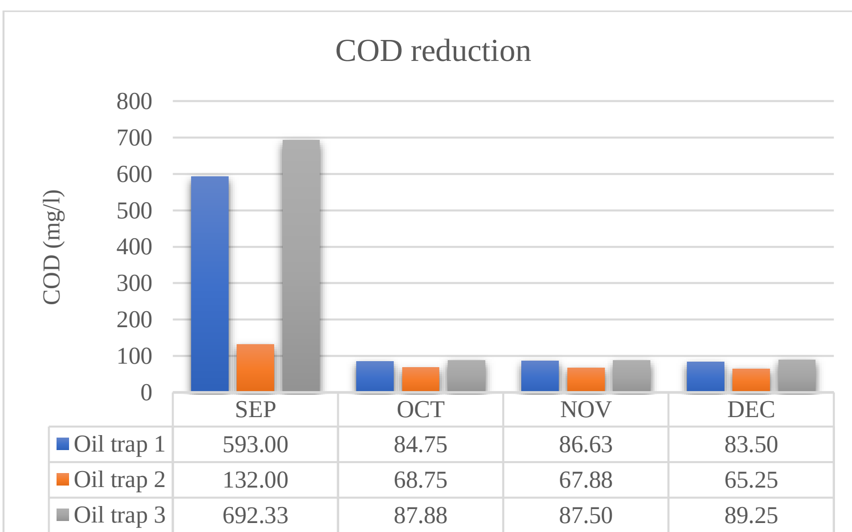
	SEP	OCT	NOV	DEC
Oil trap 1	327.33	73.00	70.25	59.86
Oil trap 2	199.33	55.38	53.00	48.63
Oil trap 3	282.00	71.13	71.38	74.25

Fig. 1: TSS reduction between two treatments.

From Figure 1, Oil trap 1 and 3 had the higher TSS content than Oil trap 2 due to trucking activity in the fuel station. Soil spill from the tyre is left and is carried away with the water during floor cleaning. The modification treatment is able to comply the effluent standards comparing to South Kalimantan Governor Regulation No. 36 of 2008 (TSS < 200 mg/l). Moreover, the removal of TSS results the water is available to recycle for workshop activity use.

3.2. Removal of COD

Similar with TSS content, COD content in the modification treatment was reduced to 49-87% comparing to previous treatment (Figure 2). The previous treatment released effluent with high COD content (average 132-593 mg/l) as tested in September 2022. Not only to reduce TSS content, alum is effective to reduce COD content (Kumar et al., 2009). From Figure 2, COD reduction in Oil trap 2 had the lowest percentage because the initial COD in the previous treatment was also the lowest (COD = 132 mg/l). For COD content, the wastewater standard adopts on the Minister of Environment and Forestry Regulation No. 5 of 2022 (COD < 100 mg/l).



	SEP	OCT	NOV	DEC
Oil trap 1	593.00	84.75	86.63	83.50
Oil trap 2	132.00	68.75	67.88	65.25
Oil trap 3	692.33	87.88	87.50	89.25

Fig. 2: TSS reduction between two treatments.

3.3. Cost saving

The additional coagulation results saving cost of wastewater treatment operational expense. The substitution of hazardous waste management to coagulant purchasing reduces 45% of operational cost (Figure 3). It also minimizes the hazardous waste volume in the hazardous waste storage facility as there is no contaminated water clean up from oil trap.

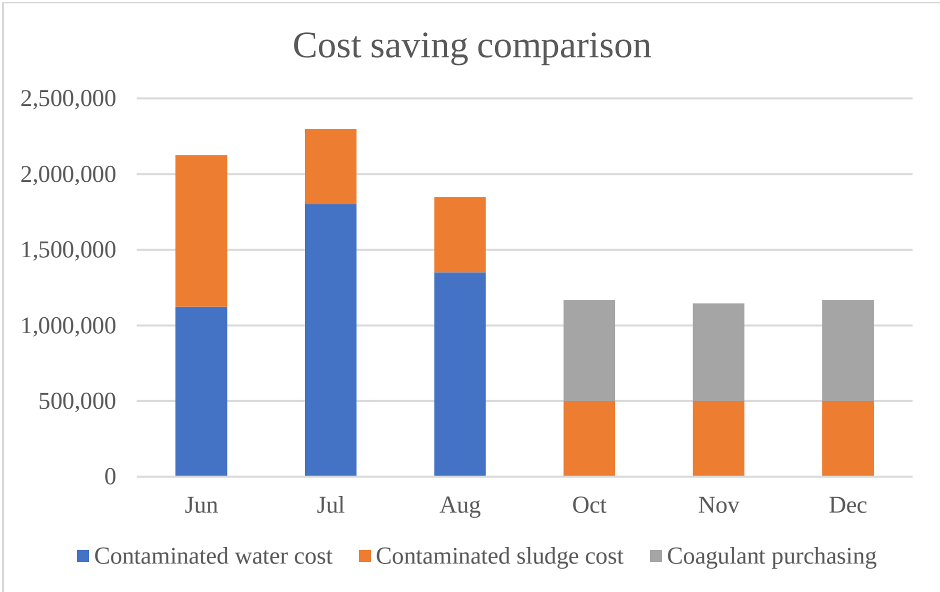


Fig. 3: Cost saving comparison between two treatments.

3.4. Water recycle opportunity

Before the modification, water for workshop activity was taken from the final void or ex-pit. It required water pumping over long distances. After the modification, 1000 litres of treated water daily from the last compartment is pumped into water recycle tank and it is sufficient to serve the water for workshop use. Water recycle in workshop becomes other improvement for environmental management in coal mine area.

4. Conclusion

The additional coagulant in wastewater treatment for fuel station area is excellent. The modification treatment allows the quality improvement and cost saving. It also recycles the water for heavy equipment maintenance, floor cleaning and watering use in workshop area. The reduction of TSS and COD content is sufficient to comply the wastewater standards. This treatment is also safe for environment due to close circuit system.

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