CHAPTER 6

CONCLUSION & RECOMMENDATIONS

6.1. Conclussions

Based on the previous discussions as described in chapter 5, there are conclusion that can be given for a corrective action plan as follows:

1. The results show that DEE in DOZ underground mining causes environmental pollution. The concentration exceeding the permissible exposure limit (PEL) for DPM will range in value 643.26 to 618.23 $\mu g/m^3$. Pursue principles of sustainable development in continual improvement of environmental performance, cumulative environmental impacts of mining are needed to mitigate or ameliorate adverse environmental and health impacts. In order control environmental pollution, to keep the sustainability of environmental functions, and to comply the regulations on environmental quality standards and/or the standard criteria of environmental damage have been stated in Article 68 of *Indonesian Act Number 32, 2009 on Environmental Protection and Management*. Air is an environmental media that needs to be concerned and target of the area, especially work environment. The indoor air quality is a problem that needs attention because it will affect human's health. The results of this survey are useful to assess the impact of diesel engine emission on health, especially for DOZ underground miners from estimation of

exposure and intake in adequate occupational safety and health manner. It is also can be concluded that the mapping of pollutant concentration can be used to evaluate exposure response relationships.

2. The distribution of DEE pollutants in the DOZ area exceeded air quality index because the DPM rate was higher than 160 $\mu g/m^3$. The mapping results revealed that the DPM concentration was homogenous. The current study applied a GIS analysis based on a kriging method in mapping the air pollutant at the area of the DOZ underground mining. Although the mining site was a micro environment, the universal kriging was applied to estimate the air pollutant concentration, CO and DPM, of the mining activities with the use of diesel engine (*off-road*) in the haulage process. The monitoring data and the air pollutant measurement consisted of coordinates and concentration at the location. The universal kriging can be used and is capable to estimate non-stationary data because they tended to direct to a particular trends. The estimator obtained by the universal kriging method was at best linier unbiased in characteristic and had a minimum variance value.
3. Effect of DEE exposure on DOZ underground miners health shows that 26 miners (8.3 %) experienced COPD (post-bronchodilator <0.70). From the severity measurement of airflow obstructive to miners experiencing COPD, severity of airflow limitation for moderate (GOLD 2: *50%<FEV1<80% predicted*) is obtained 14 miners (54%), severe (GOLD 3: *30%≤FEV1≤50%*) is 10 miners (38%), and very severe (GOLD 4: *FEV1≤30% predicted*) is 2 miners (8%). It can be concluded that the amount of working duration (DEE exposure) against severity of airflow limitation with COPD by 3%, in which the other factors are age and

smoking habits also affects the severity. From the results of spirometric measurement to diagnose COPD that is done to all the 314 miners working in DOZ, it indicates that the miners are in the productive age in accordance with the 'age range under observation', with height average 1.64 meters with average duration 15 years in line with existence of DOZ that began to operate in 1998. The work duration is in line with the duration of exposed by DEE.

4. There are to develop model of safety and environmental management in underground mine especially to obtain spatial interpolation analysis is using kriging method is a common method used and represents spatially continuous phenomena. A kriging method has formed the basis for environmental pollution mapping. This study applied a spatial analysis for mapping the POC and DPM pollutant concentration in the DOZ underground mining. This method has been believed to apply to sample points, which tended to have particular trend in estimating the air pollution concentration from the off-road emission in the underground mining operation. The spatial distribution of the pollutant concentration is part of air quality management, in addition to analytical monitoring of the pollutant concentration, factor evaluation of the affected environment, and health risk mapping. Design criteria that should be used for planning safety management system in term of fresh air supply into underground mines are: airflow quantity per miners; airflow quantity for dilution of diesel exhaust gases; diesel equipments operating factors that an item of equipment will be operate and and applied; airway size and air velocity criteria; and specific area that must be vented direct to exhaust.

6.2. Recommendations

Based on the conclusion above, there are recommendations that can be given for a corrective action plan as follows:

1. The survey results that have been conducted in DOZ can be mapped which is useful as a reference in evaluating exposure on miners. It can also be applied to other underground mines that are in the work area PTFI, such as Deep Mining Level Zone (DMLZ) and Big Gossan which currently operates, as well as to other underground mines that are likely to be carried out exploitation. Mapping of DEE concentrations in other mining areas when applicable may also be used to measure their impact on miner health based on its exposure estimation in other underground mining operation. The estimated exposure of the DPM pollutant was recommended to perform as the part of the study on predicting whether the pollutant gives any impact on health condition of the mining workers in a long-term exposure.

2. With the result of measurement that has been known exceeding the PEL, it can be anticipated to manage the DEE to not exceed air quality index by using diesel filter technology which is able to filter DPM so that it can not be harmful for health and source of air pollution. In addition to this, protection to miners can be more closely watched through a respiratory protection program, such as the use of special particulate masks. The existence of work rotation system for miners which has exceeded the specified time limit, such as after 15 years, the employee may rotate to the open mine area or other assignment outside the mine area if possible.

3. Although only 8.3% miners 'who have experienced severity of airflow obstructive, monitoring and measurement of health status especially lung function for miners' should be more closely watched with spirometric measurement periodically not only once a year but can be done every semester. So that if the miners are indicated experiencing COPD, precaution and treatment can be done immediately. In addition to this, increasing knowledge of clean and healthy lifestyles is not only focused on miners from underground mining. It also raises awareness of healthy behavior through counseling either about the dangers of smoke for miners as smoker or non-smoker. Increasing knowledge of clean and healthy lifestyles can also be done by implementing program of stop smoking for those suffering COPD to prevent higher level of severity.

4. In addition to preventive and health promotive, use engineering controls such as: wet dust before to prevent becoming airborne and dust collection systems application. Miners' personal hygiene should be implemented; do not eat, drink or use tobacco products in dusty areas, wash hands and face before eating, drinking, or smoking; change into disposable or washable work clothing at worksite only. And respirators should not be the primary means of minimizing exposures; selection and proper use of approved respirators with P100 masker and do respirator fit testing; maintenance, inspection, cleaning, and storage of respiratory protection equipment. Recommendations to the management are appliying policies to the use of respirators and work practices controls in collective labour agreements and industrial relations guidelines in the form of disciplinary action by warning letter and/or termination in the event of violation of them. In addition, management

must take a planning action againts better technology use for operation in underground mine in the use of the latest diesel filter technology and the use of robotic mobile operators, and job rotation considerations for miners.