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Increase of Serum SOD Level in Steel Smelter Workers Expresed To Air Sulfur Dioxide (SO_2)

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Abstract-Human exposured to Sulfur dioxide (SO_2) resulting from contribution of the natural factor is low. Nevertheless, effect of this pollutan in industrial sectors especially in steel smelter has resulted in a significant increase of it's concentration in the environment. SOD is an antioxidants enzyme that neutralize free radicals that leads to oxidative stress. The aim of this study was to look at the differences in serum SOD levels and air SO_2 influence on serum SOD levels on several smelter workers in Sidoarjo.The design of this study was an analytic observational with cross-sectional study. The study sample consisted of 24 male workers who were divided into two different groups. In the first group were smelter workers, while in the second group were administrative staff as control for comparison. The result are showed that SOD was significant increased, t test analysis for 2 independent samples ρ(<0,05) in smelter workers compared to administrative staff. There were significant long exposure Pearson correlation ρ(<0,05) on serum SOD levels. The conclusion of this study is the air SO_2 exposure can increased serum SOD levels in steel smelter workers. Suggestions for smelter workers to use a respirator while on duty in the smelting area.

Keyword: SO_2, SOD, Smelter, Antioxidants, Free radical

1. INTRODUCTION

The steel industry is part of the basic metal industry which is included in the upstream industry and one of the most strategic industries in Indonesia. In 2013, Indonesia's steel consumption reached 61,6 kg/capita/year and ranked sixth among ASEAN. [1]

Steel smoke in smelting activities contain SO_2 can produce gas that forms the OH-radical in the Haber-Weiss Fenton system. OH- radicals are Reactive Oxygen Species (ROS) precursors and triggers and initiate further downstream damage and associated respiratory and inflammatory signaling.[2]

The chemical composition of the steel has a significant impact on ROS generating capacity with Cr and Ni content can cause more damage. Increased oxidative stress associated with environmental air pollution can lead to oxidative damage to DNA, lipids, or proteins.[2][3]

The concentration of ROS in human body depends on the production and removal by the antioxidant system. Cells that contain considerable amounts of antioxidants can repair damages caused by ROS and regulate redox-sensitive signal pathways.[4]

The major antioxidant enzymes contained in mammalian cells considered important for life are superoxide dismutase (SOD), glutathione peroxidase (GPx) and catalase (CAT). Decreased SOD activity may lead to a anion superoxide accumulation, which causes membrane lipid peroxidation by Reactive Oxygen Species. [4][5]

Oxidative stress occurs when the ROS is not sufficiently neutralized by antioxidants and measured with MDA levels.Consumption of non-enzymatic antioxidants derived from fruits containing vitamin A, vitamin C, vitamin E, glutathione and selenium are also indispensable. These vitamins can play a role in free radical scavengers and prevent the radical damage caused by lipoproteins and other macromolecules.[6][7]

Research conducted over the past decade has shown that there was statistically significant of air SO_2 exposure with serum SOD level. According to research by Kusumaningrum *et al*., 2017, in vivo studies where there is an increase in SOD levels in the exposed group with the unexposed group. SOD serum concentrations of the group were exposed to 43.53 U/mL while the group was not exposed to 28.78 U/mL. So the longer the exposure to SO_2, serum SOD levels are increasing.[8]

Serum SOD levels is influenced by subject characteristics such age, smoking habits and fruit consumption. In this study age using matching techniques between smelter workers and administrative staff.The aim of this study was to determine the effect SO_2 on serum SOD levels in smelters workers in Sidoarjo.

2. METHODS

This research was an observational research with cross-sectional study, and using simple random sampling. The population in this study consisted of two groups, smelter worker and administrative staff.

The sample size was 12 people for each group by using the formula,[9][10]

$$\frac{n = 2\,\sigma^2(Z\alpha + Z\beta)^2}{(\mu_1 - \mu_2)^2}$$

Explanation:

n : sample size each group
σ : SD response to the comparison group
Zα: adjusted standart deviasion for α (1,96)
Zβ : adjusted standart deviasion for β (0,84)
μ_1 : the mean of sample group (4,28)
μ_2 : the mean of comparison group (3,34)

Air SO_2 levels analyzed were using by pararosanilin method with spectrophotometric. Then serum SOD levels used *The Enzyme-linked immunosorbent Assay* (ELISA) categorized by U/mL unit and categorized by average with the results: (1) 0.189 < (2) 0, 189 ≥.

Data collection technique by interview using questionnaire include age, smoking habits, and fruit consumption.

Data analysis was using by chi square statistical test to show difference in fruit consumption, t-test analysis for 2 independent samples statistical test to show the difference in serum SOD levels and Pearson correlation statistical test to determine the effect long exposure of SO_2 to serum SOD levels.

3. RESULT

Description of the results of subject characteristics in smelter workers and administrative staff can be seen in Table 1.

Tabel 1. Subject Characteristics in Smelter Workers and Administrative Staff

Subject Characteristics	Smelter Workers		Administrative Staff	
	n	%	n	%
Age				
<30	2	8,3	2	8,3
31-40	6	25,0	6	25,0
41-50	4	16,7	4	16,7
Smoking Habits				
Not smoking	6	25,0	9	37,5
Few	6	25,0	2	8,3
Medium	0	0	1	4,2
Mean±SD	40,25 ± 60,36		29,25 ± 89,38	
Fruit Consumption				
Yes	11	45,8	8	33,3
No	1	4,2	4	16,7
ρ	0,317			

Table 1 showed that smelter worker classified as light smokers based on the brinkman index with a mean of 40,25 cigarettes/year. And based on chi square test of fruit consumption obtained ρ=0,317 which mean there is no difference between exposed group and unexposed in consuming fruit.

Tabel 2. Air SO_2 Levels in Smelter Workers and Administrative Staff

Level Measurement	Smelter Workers	Administrative Staff
SO_2	0,3162	0,0023
Temperature	42,7	25,7
Humidity	33	55

Based on Minister of Manpower and Transmigration No.Per.13/MEN/X/2011 on the Threshold Limit Value Factor Physical and Chemical Factors at Work, that the threshold values of SO_2 in the workplace air is 0,25 mgr/m^3.So that SO_2 levels in the air in the workplace smelter workers above the threshold value and can be causing impaired lung function in workers.[10]

Tabel 3. Serum SOD Levels in Smelter Workers and Administrative Staff

Serum Superoxide Dismutase Levels (U/mL)		
Subject	Mean±SD	ρ
Smelter Workers	0,258 ±0,161	0,019
Administrative Staff	0,120 ±0,101	

Table 3 showed that serum SOD levels smelter worker higher than administrative staff. It was caused by every day they are exposed to SO_2 which is a free radical that triggers an increase in ROS that requires SOD as it's neutralizer. There are very significant difference between serum SOD levels in smelter worker and administrative staff ρ(<0,05). Thereafter SOD levels before being grouped (exposed and unexposed) were then classified into two categories with mean values $\bar{x}$ =(0.189), and the result was < $\bar{x}$ =19 and ≥ $\bar{x}$ =5.

Tabel 4. Analysis of The Effect of Air SO_2 Levels to Increase Serum SOD Levels in Smelter Workers and Administrative Staff

Variable	Serum SOD Levels	
	ρ	Coefficient Value
Long exposure of Air SO_2	0,012	0,502
Age	0,177	0,285
Smoking Habits	0,782	0,060
Fruit Consumption	0,631	0,123

Based on the results of Pearson correlation showed that long exposure of SO_2 affect to serum SOD levels (ρ(<0,05) with coefficient value 0,502). Indicate that high exposure of SO_2 in the air can increase serum SOD levels in smelter workers.

ROS gives an initial signal in caspase-dependent and caspase-independent setup to initiate neuron cell death. In the nervous system, microglia is the most important cell type to clean dead cells such as macrophages.[11] Then the formation of free radicals will be neutralized by antioxidants produced by the body in a balanced amount. Negative effects of free radicals occur when the amount exceeds the ability of detoxification by the body's antioxidant defense system so as to give rise to oxidative stress conditions.[12] SOD is the first line of defense against oxygen toxicity in the body. SOD can catalyze superoxide radicals into hidrogen peroxide (H_2O_2).[13]

4. DISCUSSION

Sulfur is a contaminant in the metal and easily produces sulfur from abrasive (rough iron and iron). Therefore, SO_2 is produced as a by-product in the metal industry and will automatically accumulate in the air. SO_2 is an oxidizing agent in the air. Leads to health impact such as ROS, increased SOD, GPx, and catalase levels as *scavenger enzyme*. Then the chemical composition of steel such Cr, Ni, Fe, Mn and Cu is known trigger a fenton reaction.[14]

ROS in cells can increase with increasing amounts of hydrogen peroxide, hypochlorite acid (HClO), radical hydroxyl (OH*) and anion superoxide(O_2-) (Luay and Tareq, 2014). Increased cytotoxic levels of ROS causing oxidative stress and major physiological mechanisms include cell differentiation, apoptosis, cell proliferation, regulation of sensitive redox signal transduction pathways, mutations, chromosomal aberrations, and carcinogenesis.[4] Oxidative stress is an imbalance between ROS production and antioxidant defense systems of cells or tissues[5] Oxidative stress can cause various pathological conditions such as diabetes mellitus, cancer, untimely aging, liver damage, atherosclerosis etc.[5]

The concentration of ROS in the body depends on the production and removal by the antioxidant system. Cells that contain considerable amounts of antioxidants can repair damages caused by ROS and regulate redox-sensitive signal pathways.[4] SOD is one of the most abundant antioxidant enzymes in the body most of which is located in the liver. [16]

The formation of free radicals can be eliminated by scavenger enzymes such as superoxide dismutase. SOD has the role of converting the anion superoxide (O_2-) into hydrogen peroxide (H_2O_2).[17] SOD activity is measured by the rate of inhibition of reduction of cyitochrome c by anion superoxide produced by xanthine or xanthine oxidase. Xantin is oxidized to uric acid, while the superoxide anion which is formed subsequently reduces ferisitochrome c (Winarsi *et al*., 2012).

In this study showed that age, smoking habit and fruit consumption did not have a significant influence with increase of serum SOD levels, this is because the results obtained that the smoking habit of the smelter worker is low, moreover many of whom do not smoke, so the smoking habit in this study is not has a correlation with elevated serum serum SOD levels. Likewise on fruit consumption, the possibility of fruit consumption by the subject is still relatively low, so it can not help improve their serum SOD levels.

5. CONCLUSION

The mean of smelter workers as exposed group was 0,258±0,161 U/mL and in administrative staff as unexposed group was 0,120 ±0,101 U/mL. Long exposure of air SO_2 in the air in the workplace of smelter workers is higher than in administrative staff. And had a positive relationship with increase of serum SOD levels. Air SO_2 was effects serum SOD levels smelter workers, ρ(0,012) with coefficient value 0,502 which means that the higher air SO_2 levels can increase the levels of smelter worker's serum SOD levels. Air SO_2 received by exposed and unexposed groups had an effect on the level of SOD enzyme in both body.

6. SUGGESTION

Air quality monitoring in the workplace of smelter workers and expected to smelter worker to always wear Personal Protective Equipment (PPE), a special gas respirator in the work and more consumption of vitamins A, C and E as a booster immune system.

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