ENVIRONMENTAL ASSESMENT OF INDONESIA COAL ASH

A Case study in Bukit Asam Power Plant, South Sumatera Province, Indonesia

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1. Introduction

In 2006, the Government of Indonesia (GoI) announced stage 1 of a "fast track" program followed by a second program at the start of 2010. Each program aimed to accelerate the development 10 GW of generating capacity of electricity. This program has been dominated by development of coal power plant. In 2020, utilization of coal ash will increase dramatically from 50 Twhour become 320 TWhour. Supply of coal will be 108.3 million tones per year[1]. A coal power plant generally produces coal ash about 8-10%. Hence, Indonesia will produce about 21.66 million tons coal ash per year. The great number of coal ash will potentially be serious problem in the future owing to its requirements for storaging. However, there is a limited research of coal ash power plant in Indonesia on a comprehensive environmental risk assesment and utilization especially for reclamation abandoned mine area. The research objectives are to investigate characteristic of coal ash, to identify impact of coal ash on goldfish (*Cyprinus carpio* Linn.) and *Brassica chinensis*, and to predict its possibility for coal mine reclamation or revegetation purpose.

2. Methodology

Coal ash was used directly from coal ash storage facility in Bukit Asam power plant, South Sumatera Province. In order to achieve the objective of research, a total of 100 kg of coal ash samples was collected on July 2010. Coal ash sample was a mixture of fly ash and botttom ash. GoI regulation No 85 Year 1999 regarding management of hazardous material prerequisites characteristic and toxicity test. Characteristic test have been conducted through chemical content analysis of coal ash based on Indonesia National Standard (INS) 13-3608-1994. Toxicity analysis have been conducted by biological and chemical test[2]. Toxicity test through biological test was conducted with Lethal Concentration (LC_{50}-96 hour) and Lethal Dose (LD_{50}-96 hour). Moreover, LD_{50} analysis was conducted on following procedures issued by US. EPA OPPTS 870.1100 and Standard Methods for the Examination of Water and Wastewater[3]. Meanwhile, LC_{50} test was conducted based on ASTM Designation: E729-88a Guide for conducting acute toxicity with fishes, macroinvertebrates and amphibians[4]. The total mortality of goldfish (*Cyprinus carpio* Linn.) was calculated, then probit analysis was used to determine LC_{50} value. Chemical analysis leachate of coal ash used Toxicity Characteristics Leaching Procedure (TCLP). Coal ash has already prepared and tested in accordance to the USEPA SW-846 Method 1311. If these constituent concentrations equal or exceed the concentrations described in both of GoI regulation and EPA standard, then waste is characteristically as hazardous materials .

Furthermore, to identify impact of coal ash utilization on plant, *Brassica chinensis* was selected owing to having high ability on heavy metal absorption. Determination of coal ash proportion on plants growing media consist of 0 %, 5%, 10 %, 12.5 % and 17.5 %, respectively. Other materials were used including overburden and organic material. The cultivation of *Brassica chinensis* repeated three times. Then, content of metal elements (Fe, Cu, Zn, Pb, Cd, Cr and As) of *Brassica chinensis* were analyzed. Finally, this result was compared with WHO heavy metal limits on food[5].

3. Results And Discussions

3.1 Chemical content of coal ash

Chemical content of coal ash is shown in Table 1. This table shows that the main constituent of Bukit Asam coal ash were SiO_2 and Al_2O_3 with 60.6 % and 22.8 %, respectively. Hence, this coal ash had a potential to be utilized as additive material for cement. Another components Fe_2O_3, H_2O, CaO, MgO, TiO_2, MnO, P_2O_5, and total Sulfur were less portion (under 5 %). In general, chemical content of coal ash identical with soil and contains important nutrients for plant. CaO can increase soil pH extensively because of high reactivity. Because of its nutrient content, coal ash has a potential to be used in reclamation of degraded mine land[6]. Loss On Ignition (LOI) result (0.66 %) was influenced due to dehydration or decomposition of minerals in the coal ash and also release of volatile organic compounds[7].

Table 1. Chemical Content

Elements	Content (%)
SiO_2	60.6
Al_2O_3	22.8
Fe_2O_3	4.12
K_2O	0.46
Na_2O	1.33
CaO	2.92
MgO	1.38
TiO_2	0.75
MnO	0.053
P_2O_5	0.66
LOI	0.66
H_2O	2.2
S Total	0.32

3.2 LC_{50}

Result of the acute toxicity test was stated through LC_{50} against goldfish. Probit analysis showed that elutriate procentage of Bukit Asam coal ash as much as 33.71 % or similiar with 337,110 ppm. Elutriate reflected coal ash fraction that moved on into water. Toxicity criteria of LC_{50} test was based on Australia Petroleum Energy Association (APEA) and Energy Research and Development Corporation (ERDC) standards. Generally, these standards separate 6 levels of toxicity criteria from non toxic (>100,000 ppm) until very toxic (<1 ppm). Thus, Bukit Asam coal ash was categorized as non toxic criteria which LC_{50} value exceeded > 100,000 ppm.

3.3 LD_{50}-96

Observation result shows that the mortality of mice was not found in every dose (500, 5000, 15000, 30000, and 50000 mg/kg BW) from 0-96 hours observation. Fig. 1 shows the daily weight mean of mice between control and treated mice. Each of control and treated mice contained 5 mices. Daily weight mean of mice generally inclined between 0.04–1.00 gr every 24 hours. It can be seen that the weight of mice of all treatment increased gradually. Coal ash influenced to the daily weight growth of mice.The lowest growth weight was reached on dose 15000 mg/kg BW. Based on mice mortality result, sample was classified as a non hazardous material regarding to the GoI regulation.

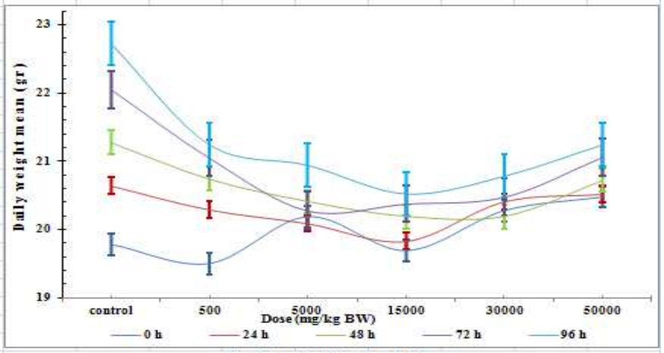

Fig. 1. Daily Weight of Mice

3.4 Toxicity Characteristics Leaching Procedure (TCLP)

The result of Bukit Asam power plant coal ash TCLP test is shown in Table 2. It can be seen that the concentrations of all the heavy metals under study in the leachates were invariably well below the permissible limits for discharge of effluents either GoI regulation No 85 Year 1999 or US. EPA standards. Thus, it can be concluded that Bukit Asam power plant coal ash categorized as non hazardous material.

Table 2. TCLP Value Standard Comparation Between GoI Regulation and US. EPA

Elements	Sample (mg/L)	TCLP Standard (mg/L)	
		GoI Reg. 85/99	US. EPA
Arsen (As)	0.001	5	5
Barium (Ba)	0.452	100	100
Boron (B)	2.891	500	-
Cadmium (Cd)	0.011	1	1
Chromium (Cr)	0.001	5	5
Copper (Cu)	0.022	10	-
Lead (Pb)	0.001	5	5
Mercury (Hg)	0.0001	0.2	0.2
Selenium (Se)	0.015	1	1
Silver (Ag)	0.001	5	5
Zinc (Zn)	0.142	50	-

3.5. Heavy Metals Content of *Brassica chinensis*

Result of heavy metals content on a mixture of all *Brassica chinensis* tissues for three times cultivation is shown in Table 3. For all elements, the element contents in 0 % treatment excessed the WHO limits. It means that this growth media is inappropiate and re-experiment should be conducted. It was noted that the mean of all heavy metals on samples were above the WHO limits level and it had potential for human health risk due to consumption of plant. However, this research also showed that addition coal ash to the soil had positive impact for decreasing concentration of heavy metals on *Brassica chinensis.* Generally, mean content of all heavy metals (Cu, Pb, Cd, Cr) under study were fluctuated on every addition of coal ash. Addition of 17.5% coal ash in growth media have already drastically decreased all heavy metals on the lowest content. Heavy metals on *Brassica chinensis* tissues could be possibly emerged from the overburden which also contained some heavy metals.

Because of its chemical characteristics, coal ash has a vast potential for use in reclamation of degraded land such as in mining area. Application of coal ash into degraded soil changed the soil texture and structure in a way to improve the availability nutrient. Combination of coal ash with another material such as farm yard manure has been found improve the growth and nutrients uptake of plants[8].

Table 3. Content of Heavy Metals on *Brassica chinensis*

Elements and WHO Limitation (ppm)	Coal Ash Content in Growth Media (%)	Mean (ppm)	SD
Copper (Cu) (5-20)	0	13.00	2.000
	5	13.33	1.155
	10	8.33	0.577
	12.5	11.00	3.000
	17.5	9.67	0.577
Lead (Pb) (0.2-20)	0	5.00	5.292
	5	6.00	4.583
	10	3.37	1.528
	12.5	2.67	1.155
	17.5	1.67	1.528
Cadmium (Cd) (0.1-2.4)	0	1.76	0.404
	5	1.67	0.574
	10	0.93	0.115
	12.5	1.27	0.643
	17.5	0.90	0.173
Chromium (Cr) (0.03-14)	0	4.22	3.365
	5	4.53	3.393
	10	4.93	3.690
	12.5	4.43	3.958
	17.5	3.87	4.456

4. Conclusion

Based on the results and discussion obtained from several laboratory tests, it can be concluded about Bukit Asam coal ash :

a. The main constituent of Bukit Asam coal ash were SiO_2 and Al_2O_3.
b. The toxicity test result of LC_{50}-96 H shows that Bukit Asam coal ash was considered as non toxic material. The LD_{50}-96 H and TCLP test results show that Bukit Asam coal ash was categorized as non hazardous material.
c. The mean concentration of all metals under study on a mixture tissue of *Brassica chinensis* were above the WHO limits level, but addition of the number volume of coal ash could reduce the concentration of heavy metals on plant.

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