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PREFACE

Sustainable development that meets the needs of the present without compromising the ability of future generations to meet their own needs should be implemented in all countries. The implementation is of importance especially with the presence of alarming local to global scale anthropogenic environmental problems and how the countries are connected through the earth's natural system. It is thus imperative that countries collaboratively working together to tackle and prevent the problems in order to warrant the successful implementation of sustainable development in the countries.

It is under the above mentioned spirit that the Environmental Technology and Management Conference (ETMC) was initiated. Held every 4 years since 1997 and with growing numbers of participant and expertise, the ETMC brings together policy makers, scientists, engineers, industries, and field expertise in environmental technology and management to discuss current and future local, regional, and global environmental issues. The ETMC is aimed to provide a forum to discuss and disseminate advances in research, technologies, and management, for improving the quality of the environment. Past participants of the conference include researchers, academic staffs, students, industries, public, and government officials.

With theme "Present and Future Challenges in Environmental Sustainability", the 4th ETMC is a global momentum for sustainable development that will lead to practical applications of the engineering and science of sustainability. Participating industries, academics, and governmental bodies will acquire information on the state of the art in environmental technology and management.

Plenary sessions of the 4th ETMC include presentations by:

- **Prof. Toshihiro Kitada**
  Toyohashi University of Technology, Japan
- **Prof. (Hon) Rachmat Witoelar**
  President's Special Envoy for Climate Change Indonesia.

There are invited international distinguished speakers:

- **Prof. Yen Peng Ting**
  National University of Singapore, Singapore
- **Prof. Rudy Sayoga**
  Institut Teknologi Bandung, Indonesia
- **Prof. Naoyoki Funamizu**
  Hokkaido University, Japan
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- **Ir. H. Mulyadi Afmar**
  PT. Benefita, Indonesia
- **Moekti Handajani Soejachmoen**
  Special Assistant to the President's Special Envoy for Climate Change Indonesia
- **Dr. Setiawan Wangsaatmadja**
  Environmental Management Agencyof West Java, Indonesia
- **Dr. Indra Budiman Syawmil**
  Institut Teknologi Bandung, Indonesia

Contributed oral (114 contributions) and poster (26 contributions) presentations are divided into 6 major sessions:

A. Eco-industries
B. Natural Resources Management
C. Water Resources Management
D. Environmental Engineering and Technology
E. Green Cities
F. Climate Change and Air Pollution

Finally, the Organizing Committee wishes that this conference is able to provide beneficial scientific information to the participants and other concerned readers.

Bandung, November 2011

Ir. Edwan Kardena, PhD
Chair of Organizing Committee

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PLENARY LECTURES

Preliminary Study of Sandblasting Waste Utilization for Al & Fe Coagulant Based

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Abstract. Sandblasting waste is a by-product material generated by sandblasting process within specific type of industries. It is on the list of Table 2 hazardous waste from specific source in Annex 1 Government Regulation No.18 Year 1999 due to its amount of metals, heavy metals, and some toxic substances. In response to that concern, transformation of sandblasting waste into soluble concentrated liquid or solid containing high amount of Al and Fe would be a good alternative measure. This study investigates optimal transformation process using acid treatment under various conditions of HCl addition and temperature taking into account mixing period. It has been found that optimal condition for treating sandblasting waste is achieved on 310.25 kg HCl addition per ton sandblasting waste at 110°C for 3 hours leaching period whereas under these conditions Al and Fe recovery yields of 49.41% and 79.16% respectively. By evaporation process of liquid coagulant, 492.15 gram of solid coagulant are produced. Metal Oxide analysis of solid coagulant showed it contain 9.87% of Fe_2O_3 while the American Water Work Association standard state that $FeCl_3$ coagulant should at least contain 12% Fe_2O_3, It is therefore some further processes to improve concentration of Fe_2O_3 are required to be conducted.

Keywords: *Aluminum; coagulant; iron; recovery; sandblasting; waste*

1 Introduction

Sandblasting is a generic term for the process of smoothing, shaping and cleaning a hard surface by forcing solid fine particles across that surface at high speeds. Considering the process as important surface treatment technique often as a method of priming a surface for the application of paint or a sealant, it has been used widely in many industries such as shipyard industry, automotive & aerospace industry, metal industry, refinery, maintenance on transportation and civil infrastructure sector, etc. Apart from those benefits, there is sandblasting waste which is basically refers to by-product generated from it process considered as hazardous waste.

According to Table 2 hazardous waste from specific source in Annex 1 Government Regulation No. 18 Year 1999 residues produced by sandblasting activity are categorized as hazardous waste from specific source - by product of industry or activity specified by scientific study. Those residues are categorized as hazardous waste due to high amount of heavy metals, metals, and some toxics substances that can effect environment and human health.

There is no official data regarding the quantity of sandblasting waste in Indonesia. In West Java Province, as stated by BLHD sandblasting waste in West Java reach 20.04 drums in 2007 while in others province there are no data available. To figure out how much sandblasting waste generated from it activity, Wolbach and Donal (1987) estimated the waste quantity by measuring the amount of waste generated and normalizing to 100 m^2 of surface area. Their study concluded that generation of sandblasting waste is 545kg/100 m^2 sandblasted surface area.

In term of handling methods of sandblasting waste, the most common measures used are dumping in a secure landfill or storing in a covered and labeled container. Another measure is stabilization/solidification process of sandblasting waste to be used for construction or ceramic material. In fact, those existing measures are not enough to handle sandblasting waste generation that rises dramatically along industry development. Indeed, available spaces to disposed waste are limited. It is therefore now some researches are urgently needed to explore the potential of sandblasting waste utilization.

Sandblasting waste is mainly made of oxides of iron, aluminum, and silica. Considering that Al and Fe are often used as coagulant, it is interesting to investigate sandblasting waste potential be used utilized for Al & Fe based coagulant. Those kinds of coagulant are well known and used widely on water treatment application as it works well to remove contaminant in the water. It can be explained that aluminum and iron salt will form gelatinous hydroxide thus formed carries suspended material with it as it settles [5]. Metal ions in coagulants also react with virus protein and destroy viruses in water [7].

A study carried out by Poulin [8] showed that transformation of red mud containing up to 45-55% iron oxide into coagulant has been done successfully. Production rates of 222 kg Fe/ton red mud and 78.9 kg Al/ton red mud were measured during production of solid coagulant by heating 1765 kg H_2SO_4 at 110 °C for 2 hour. Another research also has been successfully activated coal fly ash containing 10-40 % iron oxide and 5-35 % aluminum oxide into complex coagulant containing both polymeric ferric sulfate (PFS) and polymeric aluminum sulfate (PAS) by extraction using SO_2 [5].

Within national regulation frameworks, utilization of hazardous waste is regulated under Ministry of Environment Regulation No. 2 Year 2008 on Utilization of Hazardous Waste. Whereas the recycle measure are stated as the fist priority of hazardous waste utilization.

In this study, potential of sandblasting waste utilization for Al & Fe coagulant was investigated by heating sample using hydrochloric acid as a solvent extraction and NaCl as solvent aid, in various temperature, and mixing time period.

2 Methodology

2.1 Sample Preparation

Sandblasting waste sample was obtained from one of automotive manufacture in West Java. Samples, which were in fine particle and dry form, then were homogenized using ceramic mortar. The dried samples powders were stored in the dried plastic bag and used for the assays of coagulant production.

2.2 Metal oxide characterization

Metal oxide characterization, which was conducted by Gravimetry method, aims to identify which kind of elements present in sandblasting waste and also to determine the relative amount of each elements. In this case, it provided the data regarding potential element of Al and Fe present in each metal oxides form.

2.3 Al and Fe Characterization

Acid extraction of samples was conducted based on USEPA method 3050B at below boiled point temperature to extract all heavy metals content, which didn't include the element bound to silicate structure. Extract of samples were filtered on Whatman no. 42 to removed particles that might make some interferences on the next measurement analysis. Filtrates of extracted samples were analyzed by AAS method using flame air/acetylene for iron analysis and flame N2O/acetylene for aluminum analysis. This method is done on 2 replicates of samples (duplo)

2.4 Leaching Experiment

2.4.1 Effect of Temperature

10 gram samples with 0.062 mol HCl addition were heated at 85, 110, 200°C and without heated. During leaching process glass beads were put on the beaker glass to avoid liquid evaporation.

2.4.2 Effect of Acid Concentration

10 gram of sandblasting waste was placed in 200 ml beaker glass, then each samples was treated using hydrochloric acid (HCl 32%, Pro Analysis) with 5 variation of HCl concentration (0.062 mol, 0.072 mol, 0.078 mol, 0.085 mol, 0.095 mol). Variation of acid concentration is determined based on stoichiometry of reaction. The reactions are described as follows. Al_2O_3 and Fe_2O_3 in sample react with the added HCl to produce Al^{3+} and Fe^{3+} as shown in following equation

$Al_2O_3 + 6\ H^+ \rightarrow 3\ H2O + 2\ Fe^{3+}$

$Fe_2O_3 + 6\ H^+ \rightarrow 3\ H2O + 2\ Fe^{3+}$

The next reaction occurred are described as follow

$Al^{3+} + 3\ Cl^- \rightarrow AlCl_3$

$Fe^{3+} + 3\ Cl^- \rightarrow FeCl_3$

According to that reaction total amount of HCl (mol) that will perfectly react with Al and Fe is 0.062 mol. Another variation of acid concentration is added 10% more (in volume) than previous acid volume. After optimal temperature has been known, those samples then heated with magnetic stirrer hotplate (thermolyne) to leach metals content on samples for 3 hour.

2.4.3 Effect of Leaching Period

To reach homogenous solution, mixing was applied to those samples using magnetic stirrer, with leaching period variation 1, 2, 3 and 4 hour. This experiment was done after optimal temperature and optimal acid concentration has been known.

2.4.4 Effect of NaCl

NaCl has been known as salt, which can improve solvent extraction works. Various NaCl mass (3, 4, and 6 gram) were added into 10 gram sample that has been added with optimal HCl concentration, leach at optimal temperature during the optimal leaching period. The result then was compared with sample without NaCl addition.

2.5 Coagulant Production

2.5.1 Separation of residual sandblasting waste

After leaching experiment has been done, the next phase aims to separate residual sandblasting waste from liquid fraction. It can be carried out by several

methods such as decantation, filtration, centrifugation, or any other equal standard. On this study, to separate residual sandblasting waste from extract of sample, the sample solution was filtered on Whatman no. 42 membranes to removed particles that can make some interference on the next measurement analysis using vacuum filtration without any flocculating agent addition.

2.5.2 Washing of residual sandblasting waste

The third phase of this process is washing of residual sandblasting waste in order to recover remains Fe and Al present in the sample solution. Washing is conducted using process water to reduce the acidity of residual sandblasting waste. This step is simply done by rinsing the solid residue resulting from filtration. This step can be repeatedly done for more recovery

2.6 Coagulant production

Under the optimal leaching condition, the next phase consist of mixing the filtrates of extracted sample with washing water resulting from the third process. Thus this mixture considered as liquid coagulant that contains high amount of Al and Fe. This liquid coagulant then was analyzed by AAS method using flame air/acetylene for iron concentration analysis and flame N2O/acetylene for aluminum concentration analysis. The liquid coagulant also then heated in water bath to produce solid coagulant

3 Results and Discussion

Transformation process of sandblasting waste into liquid coagulant is an effective and relatively inexpensive process to extract Fe and Al present in sandblasting waste into solution rich in Fe and Al. Fig. 1 shows a diagram of the various stages of treatment constituting this process.

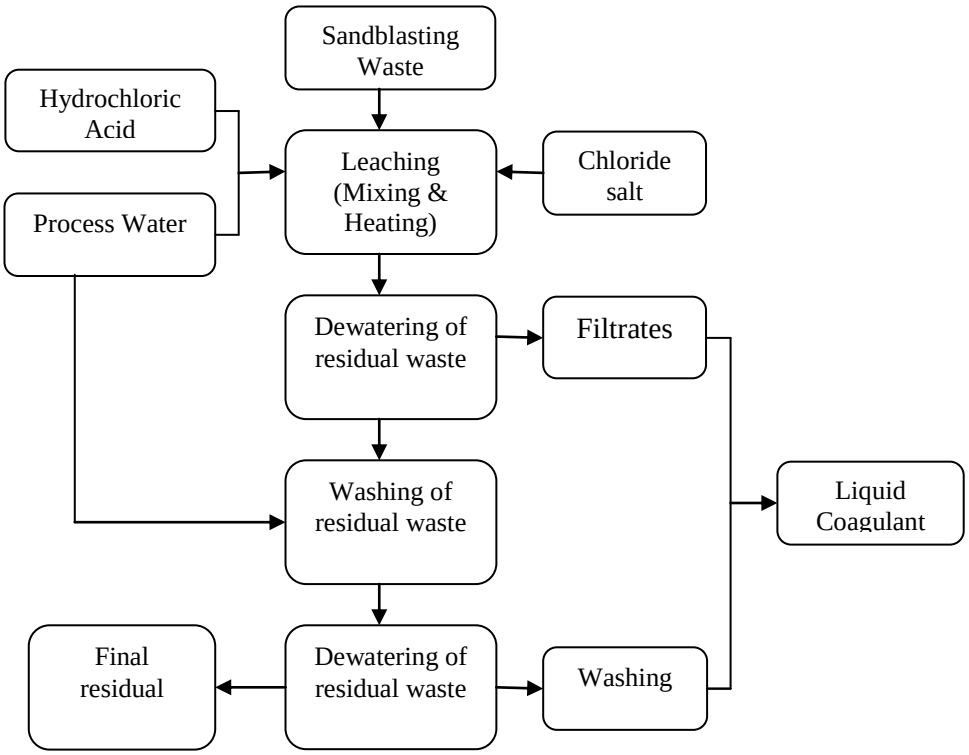

Figure 1 Flowchart of transformation process

3.1 Al and Fe Component of Sample

The process of metal oxide characterization demonstrated that sandblasting waste is mainly made of oxides of iron, aluminum, and silica (table 1). Based on the table it should be noted that the ratio between Iron oxide and Aluminum oxide is 3.2.

Tabel 1 Metal oxide composition of sample

No.	Metal Oxide	Results (wt% oxides)
1	SiO_2	63.1
2	Fe_2O_3	22.3
3	Al_2O_3	6.96
4	MgO	2.79
5	K_2O	0.80
6	CaO	0.63
	Total	96.58

While total of Al and Fe composition of sandblasting waste is given in table 2.

Tabel 2 Total of Al and Fe compounds in sample

Parameter	(mg/kg sandblasting waste)
Fe	78461
Al	21033

3.2 Leaching Experiment

The mixture is maintained without heating and heating at 85, 110, 200°C. Equilibrium between ion in solution and solid phase will be affected by temperature changes in accordance with the van't Hoff equation. Dissolution of solid compounds in water is usually endothermic which means the solubility product of corresponding oxide increase with increasing temperature [8]. This theory is accordance with the experiment results (Fig. 1). This result showed that the optimal temperature of coagulant production is 200°C, but preferentially maintained at 110 °C to reduce the operating costs. Furthermore, temperature has different effect on extraction of Al and Fe. It has been found that extraction of Fe increases gradually along with the increase of temperature, while Al have relatively stable extraction.

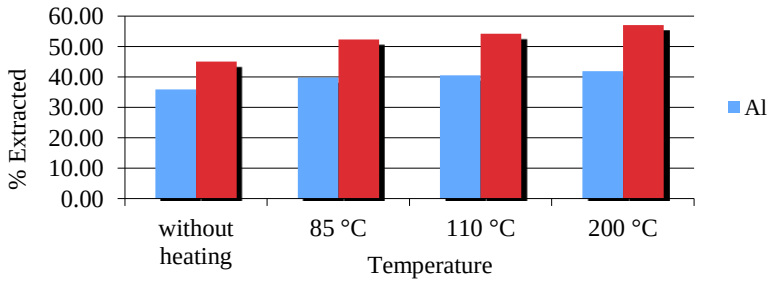

Figure 1 Effect of temperature on extraction of Al and Fe

The second phase of process includes acidification of sample using four different HCl concentrations; 0.065 mol, 0.072 mol, 0.078 mol, 0.085 mol, and 0.092 mol at 110 °C. As seen in the Fig.2 the optimal extraction of Al and Fe were reached using 0.085 mol HCl which were equal to 310.25 kg HCl/ton sandblasting waste. It also can be seen that extraction of Al is less affected by Hydrochloric acid than extraction of Fe since Fe more reactive than Al to react with the solvent extraction (HCl)

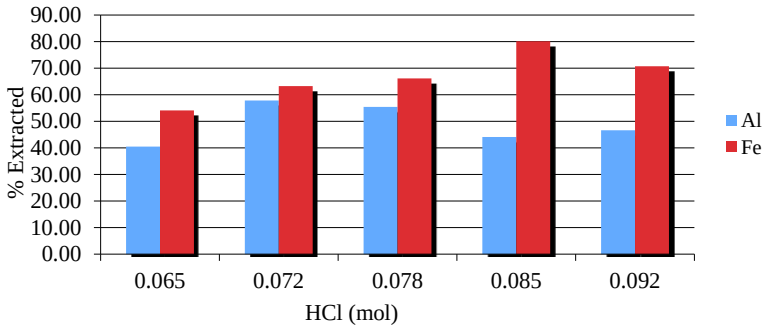

Figure 2 Effect of HCL concentration on extraction of Al & Fe

Rosenqivst [9] has studied that NaCl addition will contribute Cl^- ions to increase activity of solvent extraction. Thus it is included in this study to investigate effect of NaCl on extraction of Al and Fe. As showed in Fig.3 NaCl addition ranging between 3-6 kg NaCl/ton sandblasting waste, produce constant extraction of Al, on the other hand it resulted in a decrease of Fe extraction. Those results can be explained by salting out effects whereas NaCl addition will cause an excess of Cl^- ions that will be compete with metal oxide to binds water. At high concentrations Cl- ions in sample solution tends to bind with water rather than metal oxide. Within the study carried out by Hasseine [5] salting out explained as the phenomena that when the ions are solvated, some of the water becomes unavailable for the solute which is the salted out from aqueous.

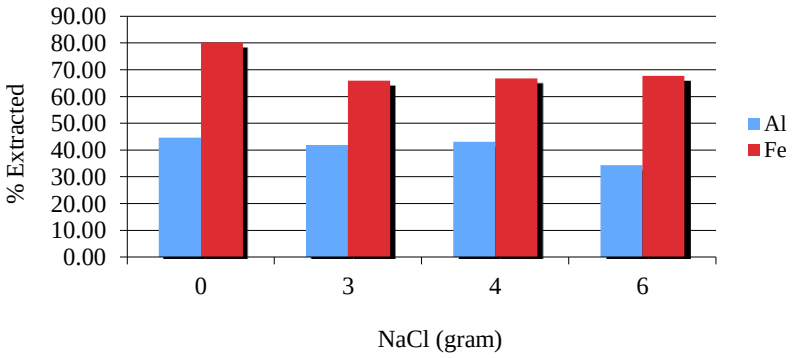

Figure 3 Effect of NaCl on extraction of Al and Fe

The sample solution is then leached in various time; 1, 2, 3, and 4 hour in order to adequately extracting Fe and Al present in the sandblasting waste. Effect of leaching period on extraction of Al and Fe showed varied results (Fig. 4)

whereas in the first two hours leaching there was rapid extraction for both Al and Fe then after 3 hour they were remain stable.

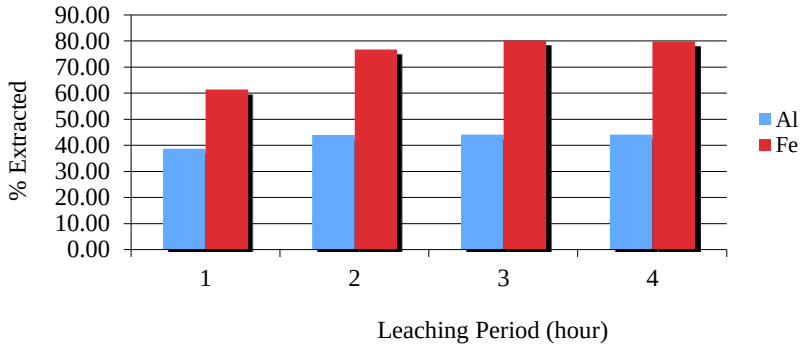

Figure 4 Effect of leaching period on extraction of Al and Fe

Within all those experiments, it has been found that extraction of Al percentage less than extraction of Fe percentage. It can be understood since Ksp, the solubility product constant of Iron oxide higher than KSp of Aluminium Oxide. Another reasons can be explained by Pourbaix diagram, which plots the equilibrium potential between a metal and its various oxidized species as a function of pH. Pourbaux diagram for Aluminium presented that Aluminium would react under a pH of 4 and above a pH of 10. Since the reaction occurred under acid condition it is therefore percentage of Aluminium extraction less than Iron.

3.3 Produced Coagulant

3.3.1 % of Al and Fe Extraction

As presented in table 3 it can be seen that under optimal condition of transformation process the % extracted for Al and Fe is % and % respectively.

Tabel 3 % of Al and Fe Extraction

Parameter	Initial (mg/kg)	Final (mg/kg)	% Extracted
Al	78461	10392	49.41
Fe	21033	62108	79.16

3.3.2 Chemical Composition

Ideally based on stoichiometry reaction, transformation process of 10 grams sandblasting waste into solid coagulant would produced 3.3 gram of solid, in fact there was 4.92 gram of solid coagulant was produced. It might occurred since there are also reactions between another ion and HCl which then precipitated as solid. Therefore this number implies the production rates of coagulant is 492.15 kg coaulant/ ton sandblasting waste.

Produced coagulant expected from this study is Al and Fe coagulant based in the form of anhydrous,- $FeCl_3$ and $AlCl_3$. Meanwhile there are many characteristics should be taken into account in determining quality of coagulant, this study only focused on character of chemical composition (metal oxide).

Physically the color of liquid coagulant is turquoise while the solid coagulant is green. The turquoise color is caused by the present of Fe^{2+} ions, which contributes pale green color while Fe^{3+} ion contributes pale purple color. Furthermore, green color of solid coagulant was assumed as a result of FeCl3 present. This argument supported by Cotton [3] who stated that the color of FeCl3 in anhydrous form is green.

Gravimetry method applied on solid coagulant give the result given in Table 4.

Tabel 4 Metal Oxide of Solid Coagulant

No.	Metal Oxide	Results (wt% oxides)
1	Fe_2O_3	9.87
2	MgO	4.61
3	K_2O	0.55
4	Na_2O	0.42
5	SiO_2	0.24
6	Al_2O_3	0.11
7	CaO	0.02
8	TiO_2	0.01
	LOI	35.6

Based on Ministry of Environment Regulation No. 2 Year 2008 on Utilization of Hazardous Waste final product from hazardous waste utilization that usable as a product, should meet the standard requirement exist. In this study produce coagulant was compared to the standard set by American Water Work Association (AWWA) [4] which required minimum 12% of Fe_2O_3. Therefore it means the produced coagulant that only contains 9.87% of Fe_2O_3 was not

fulfilling the requirement. It might be occurred because there were reactions between impuritants metals with HCl. Accordingly it is important to purify produced coagulant, which can be carried out by several measures such as using ions exchange resins or adding chemical precipitators.

It also has been showed in the table that ratio between Iron oxide and Aluminium oxide is 89.7 increased sharply if compared by the initial ratio between Fe_2O_3 and Al_2O_3. This results occurred due to the ability differences between Al and Fe to bind with HCl.

4 Conclusion

Sandblasting waste contains high amount of Al and Fe that usable to be utilized as coagulant. Highest percentage of Al and Fe extracted was achieved under acid treatment using 310.25 kg HCl/ ton sandblasting waste, at 110 °C, and 3 hours leaching period. There was 492.15 kg coagulant/ ton sandblasting waste was produced. Concerning the quality, it has been found that solid coagulant contains 9.87% of Fe_2O_3 while the standard requires at least 12% of Fe_2O_3. Some further process therefore urgently required to improve purity of coagulant which means improvement of iron oxides content.

5 Acknowledgments

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