



Economic Evaluation of Extraction High Purity Nanosilica from Rice Husk Ash in Industrial Scale for Adsorbent Polutant

Economic Evaluation of Extraction High Purity Nanosilica from Rice Husk Ash in Industrial Scale for Adsorbent Amonnia Polutant

Baariq Fauzaan^{*1)}, Asep Bayu Dani Nandiyanto ^{.2)}

¹⁾Program Studi Kimia, Fakultas Pendidikan Matematika dan Ilmu Pengetahuan Alam, Universitas Pendidikan Indoneisa

Jl. Dr. Setiabudi No.229, Isola, Kec. Sukasari, Kota Bandung, Jawa Barat 40154

Abstract – Material for adsorbent polutant is really needed these days and the material need to eco-friendly which lead to agricultural waste like biomass. With economic evaluation presented a preliminary economic evaluation of the larger scale production of high purity nanosilica from rice husk ash for adsorbent that need produce by large industries. Specificaly, the study was done by making variable in the cost of raw material, which ompared to several economic parameters such as GPM, PBP, and CNPV. The result after calculation of several parameter that the project was profitable by increasing raw material cost below 100% from the estimated raw material cost, informing the fact for the prospective fabrication for fulfilling the demand of nanomaterial like nanosilica with high purity that will use for reduce polutant all over the world.

Keywords – high purtiy nanosilicas; evaluation economic; industrial adsorbent material

I. INTRODUCTION

Many agricultural by-products and wastes are very rich in silica, especially rice husks and wheat straw. Currently, there is increasing interest in the extraction of silica nanoparticles from agricultural by-products and waste. Several research groups have studied the production of silica nanoparticles from rice husks and several other by-products and agricultural waste [1].

Silica (SiO₂) is a constituent of silica sand and mining products, and is the most abundant oxide product formed on this planet [2]. Most silica is currently obtained from the extraction of natural materials in the form of agricultural waste which is usually thrown away or burned without proper treatment and will even have a polluting impact on the environment [3].

The extraction of silica from natural materials and agricultural by-product waste is in great demand because it provides advantages over other conventional methods. The advantages of this method include simplicity, lower costs, higher safety margins and no pollution produced during synthesis [4].

Silica is found in the form of nanoparticles and is the main inorganic constituent of rice husk (85-95%) which is a derivative obtained from milling rice and husk ash

^{*}) Corresponding author (Baariq Fauzaan)
Email: baaryfauzaan@upi.edu

through combustion in different boilers [5]. Apart from that, research has been carried out on silica extraction using an environmentally friendly chemical treatment approach and a yield of $93.08 \pm 0.11\%$ was extracted from rice husk ash. Characterization studies showed that the difference between commercial grade silica (19.49 ± 13.03 nm) and the average particle size of the extracted SiO₂-NPs (17.71 ± 7.53 nm) are shown in **Figure 1** was not significant [6]

Compone nts as oxides	1.5N NaOH	2N NaOH	2.5N NaOH	3N NaOH
SiO ₂	98.192	99.204	99.642	99.714
K ₂ O	0.140	0.062	0.025	0.005
Fe ₂ O ₃	0.462	0.152	0.104	0.092
CaO	0.104	0.039	0.036	0.029
Cr ₂ O ₃	0.093	0.063	0.053	0.017
MnO	0.063	0.057	0.025	0.011
P ₂ O ₅	0.718	0.331	0.092	0.110
Others	0.228	0.092	0.023	0.022

Figure 1. Table of SiO₂ content extracted from rice husk ash using the leaching method [7].

Morphology-controlled nanomaterials such as hollow and mesoporous nanoporous silica nanoparticles play an important role in many applications. Silica nanoparticles have attracted significant attention as nano-adsorbents due to their regular structural characteristics, larger surface area, tunable pore diameter, good thermal and chemical stability, ease of surface modification, organic pollutant selectivity, economical regeneration and reusability [8].

Economic evaluation is one of the important points in building industrial chemicals. Some information from commercial sites was adopted to support engineering and economic analysis, such as chemical prices, components used, and equipment specifications [9]. The aim of this analysis is to evaluate the possibility of producing silica extraction from olive stones which is then made into nano silica and an ammonia adsorbant on a large scale. This method was evaluated using two main perspectives of silica extraction from olive stones: method and economic evaluation. Several parameters are calculated to support economic evaluation [10].

- Gross Profit Margin (GPM) as a prediction in the calculation determines the level of profitability from economic conditions.
- Break Even Point (BEP) is a capacity calculation where the project does not benefit.



- Payback Period (PBP) is used to assume how long it will take for an investment to return the total initial capital spent.
- Cumulative Net Present Value (CNPV) is used to predict the condition of performance in a function of annual production.

Pre-washing rice husks or a leaching process using a heated and concentrated acid solution under pressure before burning has been proven to be effective in removing most metal impurities and producing completely white silica with a high specific surface area [11]. A schematic of the process carried out is in **Figure 2**.

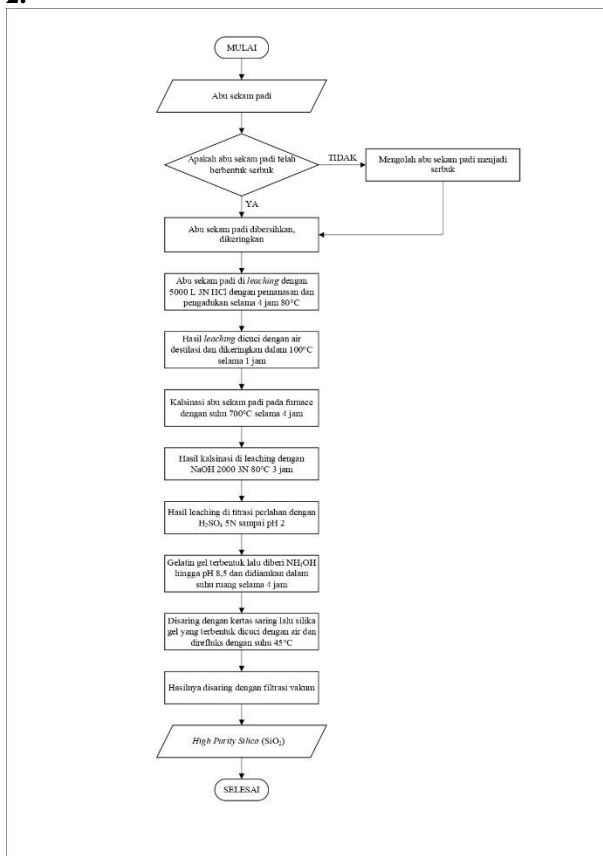


Figure 2. Flowchart extraction & synthesis high purity nanosilica from biomass rice husk ash [7]

II. EXPERIMENTAL METHOD

The method used is based on an analytical study of the prices of the materials used and the equipment, namely the tools in the extraction and synthesis process. As specifications for materials and equipment, price data circulating from several e-commerce sources such as Tokopedia, Shopee and Alibaba are used. The data obtained was processed in the Microsoft Excel application in order to determine 4 economic evaluation parameters: GPM, BEP, PBP, and CNPV. The calculations are based on literature results which include the calculation formula, namely.

- Gross profit margin (GPM; its purpose is as a formula for calculating profitability predictions. Gross profit margin is the ratio of net sales

minus COGS to net sales or the ratio of gross profit to net sales [12].

- $GPM = \frac{SR(S)}{S}$ is sales minus (R) raw materials
- Break-Even Point (BEP; is when the total profit and loss is at point 0, which means that at this point the company does not experience profits or losses in its operational activities [13].
- Payback period (PBP; is the period where the total amount of expenditure is equal to income [14]. PBP can be known from the CNPV curve by looking at when CNPV reaches zero for the first time.
- Cumulative Net Present Value (CNPV; to predict project conditions as a function of production year. Obtained by adding the NPV from the start of the project. NPV is a value that expresses the expenses and income of a business [15].
- $CNPV = \sum NPV$
- This NPV value is obtained from the state of income and expenditure. NPV itself is calculated by considering the discount value (i). NPV can also estimate Cash Flow (CF) that will occur in the following years. The data needed for this NPV calculation is TIC, depreciation, operational expenses and profits.
- $NPV = \frac{CF}{i}$
- TIC (Total Investment Cost), initiation costs need to be provided at the start of production. TIC needs to be a prediction based on Lang Factor. To calculate the economic evaluation, the Lang Factor is used to calculate the estimated total investment costs and estimated production costs. Lang factor to estimate total investment costs and estimate production costs [16].

III. HASIL DAN PEMBAHASAN

A. Engineering Perspective

Based on assumptions based on the process shown in **Figure 2**. Stoichiometric calculations in **Figure 3** and **Figure 4**, after increasing the scale of the project to larger production, it produces 900 kg of nano silica derived from rice husk ash.

- All chemicals such as hydrochloric acid, distilled water, sodium hydroxide, ammonia solution, the scale is increased by 2000 times and calculated based on the literature [7].
- The overall conversion ratio of the reaction is 90% it can see in **table 1** and **table 2** [7]
- The nano silica obtained from production has a purity of 98-99%.

Table 1. Leaching process for the formation of Rice Husk Ash [7].

Rice Husk	HCl	Reaction conversion
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1000 kg	5000 L	90%
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Table 2. Silica formation reaction [7]

Rice Husk	HCl	Reaction conversion
1000 kg	5000 L	90%

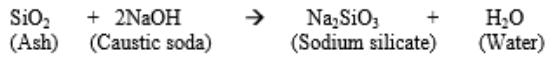


Figure 3. Reaction in the formation of Sodium Silica [7].

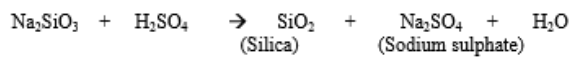


Figure 4. Reaction in the formation of Sodium Silica [7]

- Addition of 5N H₂SO₄ to pH 2 and gelatin (silica gel) is formed.
- Add NH₄OH to pH 8.5 to form
- Reflux as a form of purification (High Purity Silica) for 6 hours.
- The costs of raw materials, utilities and laboratories are shown in **Figure 4**.

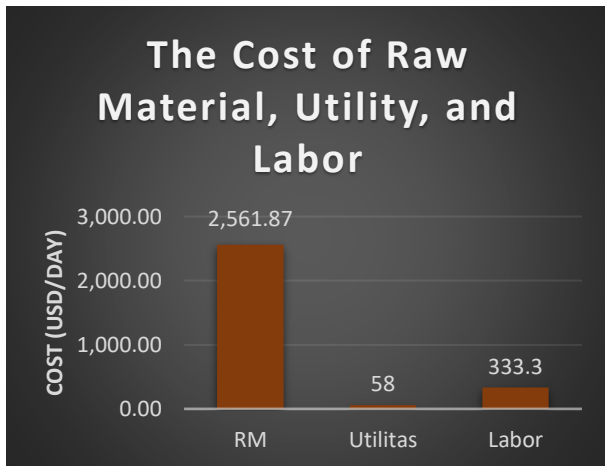


Figure 4. Costs of raw materials, utilities, and laboratories

B. Economic Evaluation

Several factors are assumed to analyze some economic parameters:

- The American currency (USD) can be converted into Indonesian currency (IDR) which is currently at a value of 1 USD = 15692.15 IDR [17].
- Prices for all materials and components are based on (<https://indonesian.alibaba.com>) And (<https://shopee.co.id>). Briefly, the prices of sodium hydroxide (1.10 USD/kg), chloric acid

(1.93 USD/L), sulfuric acid (11.85 USD/L), ammonia hydroxide (11.60 USD/L), and for Rice husks are obtained from rice farming waste so they do not require costs to source.

- Total investment cost (TIC) is calculated based on (Lang Factor) [16].
- This production process is carried out at the place or land that has been purchased. However, the purchase of land for production is still counted in the initial costs of industrial development and the returns from the costs of purchasing this production land will be returned after the project is underway.
- The process takes 18 hours to produce 900 kg of high purity nano silica. One day only allows one process cycle to take place.
- The minimum product in one package is 1 kg and the maximum product is 10 kg
- The process of forming high purity nano silica takes 13 hours and purification takes 1 hour [18].
- There are 300 working days in one year and the rest are national holidays and preparations for the production process.
- The cost for electricity is 58 USD/kWh in 5 days.
- The total cost for labor workers is 6.67 USD/day.
- The discount value and income tax are 15% and 10% every year constantly.
- The length of this production project lasts for 23 years with 3 years of pre-production or after 3 years it will reach 100% production capacity.

Optimum condition needed to be pictured. In the picture of ideal conditions, a payback period will be obtained and will occur after 3 years after production starts and profits will continue to increase for the next 20 years. The graphic data is displayed in **Figure 5**. From the data displayed, the production of high purity nano silica will be considered a project with several parameter of economic evaluation in **table 3**.

CNPV/Investment (Production High Purity Nanosilica) From Rice Husk Ask

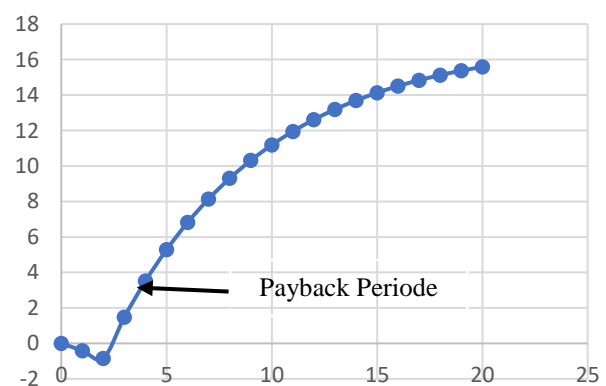




Figure 5. Ideal conditions for CNPV in several parameter conditions from economic evaluation

Table 3. Several Parameter condition from economic evaluation.

Economic Evaluation Parameter	value
GPM/y	1.931.440,00;USD/y
GPM/pack	1.931.440
PBP	4,513 years
BEP	15.493,55 process
Break Event Capacity	5,38%
IRR	1,86%
Last CNPV/Total Invesment	15,59%
ROI per year	31,16%
Total ROI	398,01%

In the picture of ideal conditions, a payback period will be obtained and will occur after 3 years after production starts and profit will continue to increase for the next 20 years. The graphic data is displayed in Figure 5. From the data displayed, the production of high purity nano silica will be considered a project.

Effects of raw materials (Sodium Hydroxide, Chloric Acid, Sulfuric Acid, and Ammonia Hydroxide) calculated by entering the seller's value of the product. Revenue from all products that are capable and have been sold, with the initial cost of purchasing raw materials [19], to describe the effect of raw materials in GPM. The results show that this raw material is able to give a negative result in the value of the GPM itself. By increasing the cost of raw materials, it will create value and negative effects on production. The significance is in the effect that occurs when changing sulfuric acid which has the most expensive price compared to the other three materials. Meanwhile, materials such as sodium hydroxide, ammonium hydroxide and sulfuric acid have almost the same effect. The influence of this raw material can be seen in **Figure 6 and Figure 7**.

Effect of Changing Raw Material

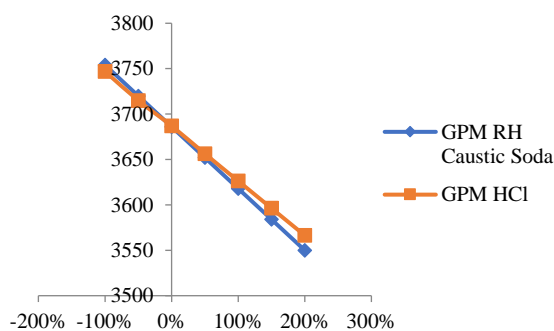


Figure 6. Effects of raw materials (for example caustic soda (NaOH) and hydrochloric acid).

GPM Nanosilica High Purity Sales

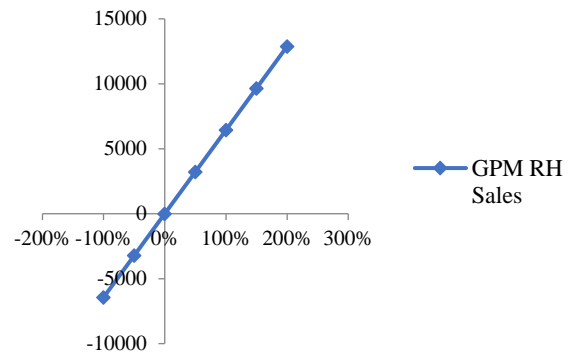


Figure 7. The effect of variable costs on sales of high purity nanosilica.

Based on calculations carried out on the processed data and the data obtained, it shows that variable costs have an effect on the CNPV value. This cost variable is used as the cost of maintaining the production process in a material production company [19]. Changes in this cost variable to -100% or percent with other negative values indicate that the costs of the process in this industry are zero, but when the cost variable is changed to 50% or percent with a positive value, it indicates that all the costs required for this production process are price value of half the original price.

From the description of the results of this cost variable analysis, its influence will have an impact on the profits obtained from this industrial project. Reducing the value of this cost variable results in a high final value of CNPV, and conversely, when increasing the value of the cost variable, the CNPV value will decrease. In this way, the CNPV value itself shows that if variable costs are low, the effectiveness of the ongoing industry will get the desired or high profits, whereas when variable costs are high or increase, this industry will be faced with decreasing profits.

However, all the fixed cost variables show that in the high purity nano silica production industry, this profit will continue to increase as seen in **Figure 8**. This is because pollution, especially ammonia, is increasing, so adsorbents with excellent capabilities will be very much needed as good materials. In the pollutant reduction tool itself or as a raw material for buildings which will become an adsorbent in itself [18]. Likewise, the profit results are similar for each cost variable, namely that you will get a profit after the third year.

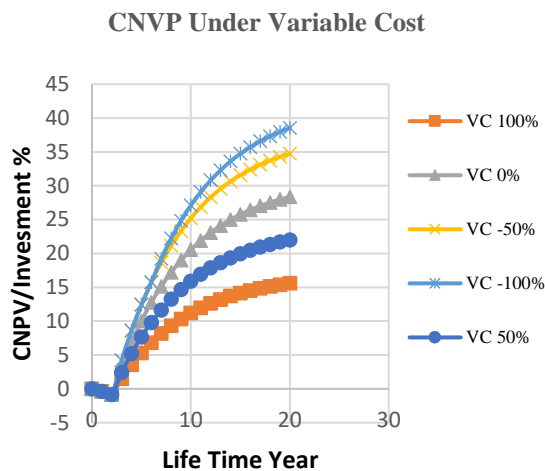


Figure 8. CNPV curve under variable cost conditions.

C. Production Capacity

This production capacity specified in minimum industrial capacity. However, this industry produces useful and sustainable production. Based on **Figure 5**. Production capacity specifications are 900 kg per day and 50 packs containing 10 kg and 80 packs containing 5 kg are calculated per day.

D. Results from an Industrial Engineering View

Based on an industrial engineering perspective, it is very possible for nanosilica production from biomass to be scaled up to industrial scale. This industry is also focused on adsorbent materials aimed at reducing pollutants. Then this nanosilica material is extracted from biomass which has large quantities and is commercially available and the equipment is not very expensive. Furthermore, with calculations of 300 cycles in one year. The scheme is made with a production process of 900 kg using the raw material rice husk ash, then 147.6 L hydrochloric acid, 2000 L sodium hydroxide or caustic soda, 5 L sulfuric acid, and 5 L ammonium hydroxide [9].

For analysis of total equipment costs, it is equal to 84037 USD. With calculations that have added the lang factor, the calculation is carried out in the total investment cost calculation. This value is economic and based on the needs of this project, less investment funds are required because it uses biomass raw materials which have long-term durability. With the project expected to last up to 20 years, the results seen from the entire project where high purity nanosilica can be produced as much as 270 tons per year are ideal conditions.

D. Results from an Industrial Engineering View

Based on the economic analysis that has been presented, this project is very possible to carry out in ideal and non-ideal conditions. Furthermore, in this consideration several variables are taken into account, namely the conditions when there is a change in the price of raw materials and this is a change that is very likely to occur. The results of these differences will result in differences which will

change other parameters of this economic evaluation [10]. A detailed description is shown in the following explanation.

1. This industrial project will benefit from increasing the price of raw materials below 100% of the estimated price of raw materials. The most significant raw materials here are sodium hydroxide and hydrochloric acid because they are the most basic ingredients in the silica extraction process from rice husk ash biomass. Meanwhile, sulfuric acid and ammonium hydroxide are not very significant because they are only used in small quantities.
2. Product sales must have a minimum of 600 kg per day with a target of 900 kg per day because the costs for maintaining and using the equipment in this project are regulated. When the selling price is reduced, the value of the product sold will increase. Otherwise, it will result in this project experiencing losses. Based on technical analysis, the product formed from this reaction is quite high due to maximization of the leaching process with hydrochloric acid itself [20].
3. Labor costs, utilities, taxes and other economic indicators remain in ideal conditions. It is also based on an analysis of the effects of changes in raw materials and product sales.

Finally, from an economic perspective, an analysis of these possible projects also needs to be carried out. In this project the GPM and CNPV values for the cost variables show promising results under ideal circumstances. This view is based on Indonesia and other countries that have similar needs, where the market, looking at PBP analysis, shows that investment will generate profits in the third year [20].

IV. CONCLUSION

Based on the results of the analysis, that nanosilica is produced from the biomass processing industry taken from agricultural waste, based on industry views and economic analysis, this project will be believed to be a profitable project provided that the cost increase of the raw material is below 100%. Then there needs to be a minimum of product sales per day, namely 600 kg per day in order to still make a profit despite the large processing costs involved.

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