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Rice husk ash as a substitute for silica gel

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ABSTRACT

Silica gel has been widely used as a dryer for food, medicine and various other purposes. Silica gel is basically a safe material, but because of its hydroscopic nature, silica gel is easily contaminated with dangerous materials. Apart from that, silica gel cannot decompose easily naturally, so using large amounts of silica gel will cause piles of silica gel waste. Therefore, efforts are being made to find replacement materials, one of which is using rice husk ash which can easily decompose naturally. This research aims to test the ability of rice husk ash as a substitute for silica gel. Tests used commercial silica gel (SG), silicon gel in non-woven geotextile bags (SG-N), and rice husk ash in non-woven geotextile bags (AS-N). In this study, AS-N was compared with SG and SG-N. The water vapor absorption test was carried out on a weight of 15 grams for 180 minutes. Each of the three samples was placed in a closed jar to avoid contamination with water vapor in the environment. The relative humidity of each jar was measured with a hygrometer. The jar lid was kept closed throughout the test. The results showed that SG, SG-N and AS-N reduced humidity by 23%, 22% and 24% respectively. Modeling with the Avrami equation is used to extrapolate the absorption results. The research results showed that 15 gram non-woven geotextile rice husk ash had superior water vapor absorption capabilities compared to silica gel and silica gel non-woven geotextiles. So it can be concluded that dryers with rice husk ash as the basic material can be used for needs such as clothes dryers, food dryers and other needs.

Keywords: Dryer; rice husk ash; silica gel.

1. INTRODUCTION

Silica is widely used in various industries such as ceramics, rubber, plastics, microelectronics, food, pharmaceuticals, cosmetics and structural materials [1], [2]. Silica that has been used becomes waste, especially silica gel. Silica gel is produced through condensation polymerization of silicic acid (Si(OH)4) [3]–[5] which can be used as an absorbent. Although some of the silica gel is reused, much more is an environmental problem. Basically, silica gel itself is not toxic, but it becomes dangerous after it binds to toxic compounds [2]. Therefore, to avoid health and environmental problems, it is necessary to consider replacing silica gel with other adsorbent materials, for example using rice husk ash.

Rice husks are often found in countries where farmers make a living, apart from being cheap and abundant in quantity, rice husks contain around 90% silica by dry weight after complete combustion [4]. Burning at high temperatures to remove the organic fraction, so that only the inorganic fraction remains [6]. Amorphous silica which is an inorganic material is dissolved and continued with precipitation using HCl. Amino-silica hybrid adsorbent was successfully synthesized through a sol gel process using sodium silica derived from rice husk ash [7]–[9]. The elements in silica gel contain various elements, including silica with a concentration of 42319 ppm as seen in Table 1. Meanwhile, rice husk ash contains 2333350 ppm or 96.97% as seen in Table 2. Based on this table, it can be seen that the silica content in rice husk ash is much higher than in silica gel. This shows that rice husk ash has potential as a substitute for silica gel in various applications involving humidity control.

This research specifically compares the water absorption capabilities of silica gel in original packaging (SG), silica gel in non-woven geotextile packaging (SG-N) and husk ash in non-woven geotextile packaging (AS-N). As far as is known, there have been no publications comparing rice husk ash and silica gel in packaging.

Table 1. Silica gel content

Sample Code	As ppm	Ca ppm	Cd ppm	Cu ppm	Fe ppm	Ga ppm	K ppm	Mn ppm
Silica gel	1.5	35453	7.1	15.2	17910	9.0	667	96.9
	Pb ppm	Rp ppm	Sb ppm	Se ppm	Si ppm	Sr ppm	Ti ppm	Zn ppm
	4.7	11.7	39.6	1.3	42319	148	856	31.4

Table 2. Ash content of rice husks

Sample Code	Ca ppm	Cu ppm	Fe ppm	K ppm	Mn ppm
Rice husk ash	1612	2.4	2.4	624738	488
	Rb ppm	Si ppm	Sr ppm	Zn ppm	
	26.4	233350	10.1	40.6	

2. METHOD

In this experiment, rice husk ash was put into a non-woven bag (AS-N) and compared with commercial silica gel which was still in its original packaging (SG) and repackaged into a non-woven bag (SG-N). Husk ash and silica gel were tested with the same weight, namely 15 grams. Each type of packaging is placed in a 350 ml glass bottle and measured using the tool in Table 3.

Table 3. Research tools

No	Tools	Specifications
1	Hygrometer Digital	range 0 – 100%
2	Glass Bottles	350 ml
3	Analytical scales	0 – 1000 gr (0,0001 g)
4	Styrofoam box	39 cm x 26 cm x 17,5 cm
5	Filter	Maximum pore size 20-25 mm
6	Measuring cup	20 ml

Data collection was carried out in the materials laboratory of the Faculty of Industrial Technology and Informatics, UHAMKA using a research scheme as in Figure 1. The control bottle is an empty bottle which is used to compare the decrease in humidity if no material is added. Data collection was carried out using three samples [10] for 180 minutes, and recorded every 5 minutes. The results of data collection will be processed using the Avrami equation. The results of data collection will be processed using the Avrami equation. Avrami's equation is usually used in metal casting processes to determine the kinetics of phase changes, but some researchers have extended its use to absorption processes [11], [12] and even to analyze solar still results [13].

The Avrami equation is a mathematical equation used to describe the way a material changes shape in various situations. This equation is similar to a simple mathematical function used to describe the change process as written in equation 1 and equation 2.

$$Y = 1 - Exp(-Kt^n) \tag{1}$$

$$\ln\left[\ln\left(\frac{1}{1-Y}\right)\right] = n \ln nt + \ln K \tag{2}$$

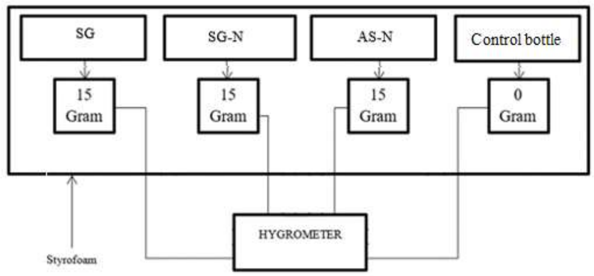

Figure 1. Research scheme

3. RESULTS AND DISCUSSION

The humidity test results were measured using 3 variations which were tested on empty bottles producing several data in the form of the Rh (Relative Humidity) value and temperature shown by the hygrometer. Each variation has a different Rh value and temperature depending on the sample variations used within the specified time interval. The measurement results can be seen in Table 4

Table 4. Research data 15 gr

No	t, second	SG Rh (%)	SG-N Rh (%)	AS-N Rh (%)	No	t, second	SG Rh (%)	SG-N Rh (%)	AS-N Rh (%)
1	300	84	84	84	19	5700	65	66	64
2	600	83	80	78	20	6000	64	66	64
3	900	82	79	70	21	6300	63	66	64
4	1200	80	78	69	22	6600	62	65	63
5	1500	78	78	68	23	6900	62	65	63
6	1800	77	74	68	24	7200	62	65	62
7	2100	76	73	68	25	7500	69	64	62
8	2400	76	70	66	26	7800	68	64	62
9	2700	76	68	65	27	8100	68	64	62
10	3000	76	68	65	28	8400	68	64	62
11	3300	75	68	64	29	8700	67	64	62
12	3600	75	68	64	30	9000	67	63	62
13	3900	66	65	64	31	9300	66	63	62
14	4200	65	66	64	32	9600	66	63	61
15	4500	65	66	64	33	9900	66	62	61
16	4800	65	66	64	34	10200	66	62	61
17	5100	65	66	64	35	10500	66	62	60
18	5400	65	66	64	36	10800	66	62	60

Using equation (2), the experimental data Table 4 is linearized. Time t is linearized to Ln t while humidity is linearized to Ln[Ln(1/1(1-Y)] then entered into **Error! Reference source not found.**.

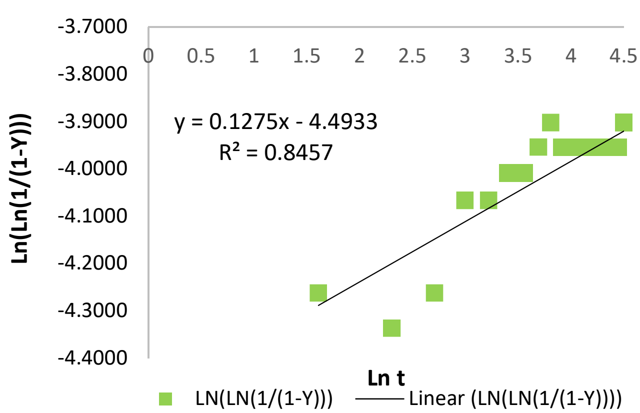

Figure 2. Linearization of humidity data

Error! Reference source not found. you can see Ln t plotted on the x-axis and Ln[Ln(1/(1-Y))] plotted on the Y-axis. Using linearized data, the trend formed from the experiment was analyzed using linear regression and a straight line was obtained with the equation y = 0.1275x - 4.4933 with a coefficient of determination of 0.8457. The coefficient of determination (R2) is calculated to determine the effect of the independent variable on the dependent variable [14] or suitability of data with regression [15], [16]. Generally a goodness-of-fit above 0.8 is considered representative of the data.

By using the equation Y=0.1275x – 4.4933, the values of K and n can be obtained in equation (2). Because n Ln t is equal to 0.1275x, then x can be considered as Ln t, so the value of n is 0.1275x. Furthermore, the K value can be obtained because Ln K is -4.4933. By calculating the exponential value (-4.4933), we obtain a K value of 0.011184. With a similar approach, we can determine the K and n values of SG, SG-N and AS-N absorption. as shown in Table 5. Next, the K and n values are used in equation 1, the results of which are shown in Figure 3.

Table 5. K and n values

No.	Adsorpbent	K	n
1	SG 15 grams	0.000523	0.75
2	SG-N 15 grams	0.001986	0.49
3	RH-N 15 grams	0.006729	0.25

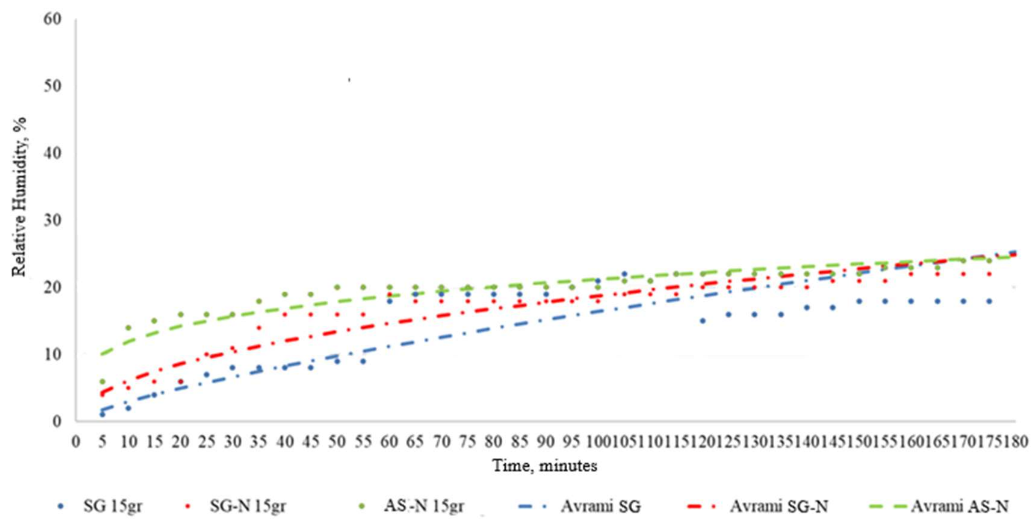

Figure 3. Research data and Avrami modeling results

Figure 3 depicts absorption (Rh) in three different variations using three different types of absorbent materials, namely SG, SG-N and AS-N. It can be seen that AS-N has more dominant water vapor absorption than the other two samples. This shows that rice husk ash has better absorption potential at the beginning of the absorption process, and the results are in accordance with the Avrami equation. The results of experiments and calculations show that non-woven geotextile rice husk ash has better water vapor absorption capabilities compared to silica gel and silica gel non-woven geotextiles at a weight variation of 15 grams with a capacity of 24% with absorption measured at maximum absorption. the percentage that an absorbent material can reach at a given time. The ash capacity of non-woven geotextile rice husks tends to increase with increasing weight variations.

4. CONCLUSION.

Based on the test results, it was found that non-woven geotextile rice husk ash had better water vapor absorption capabilities than silica gel with original packaging and silica gel with non-woven geotextile packaging. Especially with a weight of 15 grams. These results show that non-woven geotextile rice husk ash has better water vapor absorption capacity compared to silica gel. The difference in the range of absorption values also reflects the absorption characteristics of each absorbent material. Thus, non-woven geotextile rice husk ash can replace silica.

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