DESIKAN SEBAGAI PENYANGGA KELEMBAPAN

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Yuni K. Krisnandi is a lecturer and researcher at Department of Chemistry, Faculty of Mathematics and Natural Science, Universitas Indonesia.

She is also a member of ALMI, HKI, RSC and IZI.

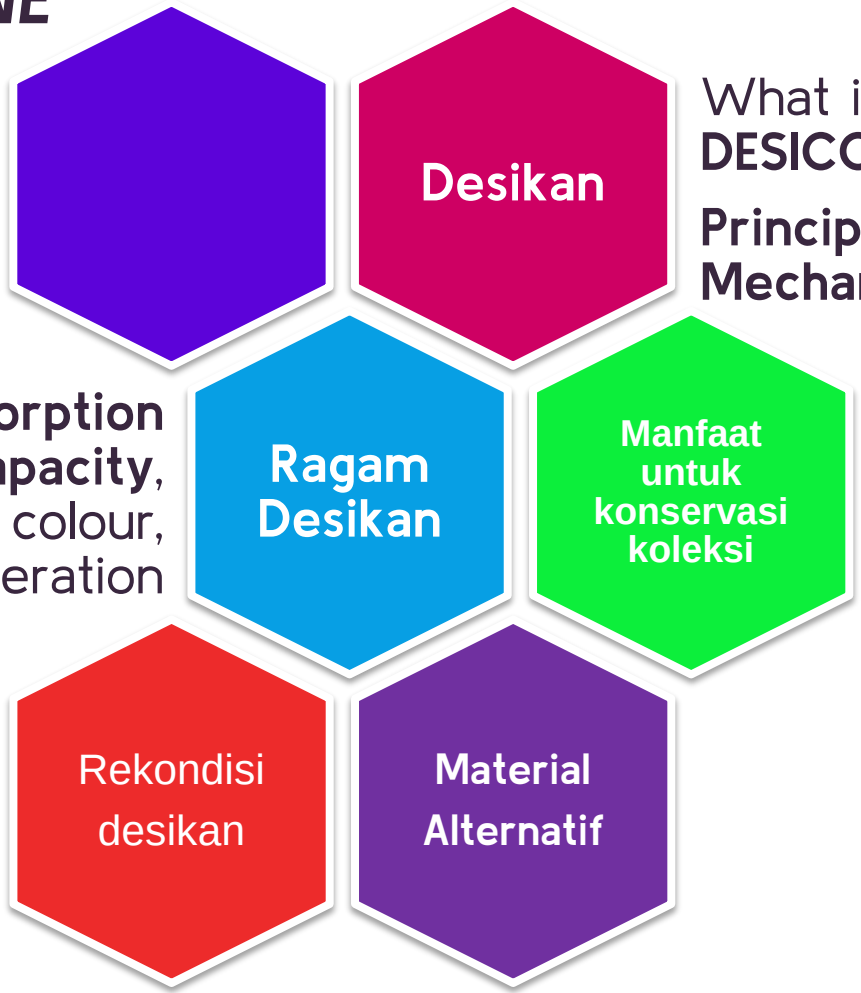
She graduated from UI (BSc. Hons., 1997),
UNSW (MSc, 2001), and Univ. Aberdeen (PhD, 2004)
then conducted Postdoc at LIKAT, Germany (2007-2009).

Her research interest is in Materials Chemistry for Energy, and the Environment: especially synthesis, modification, characterization of zeolite and other porous materials for application as catalysts, adsorbent, sensors and others.

Her recent work mainly in heterogeneous catalysts for biomass conversion to fine chemicals, mesoporous carbon, and exploration of natural minerals as sources for zeolite synthesis.

Since 2017 she has given several talks to Conservation Division at Museum Nasional.

OUTLINE



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Solid Inorganic Framework research group

1. What is DESICCANT?

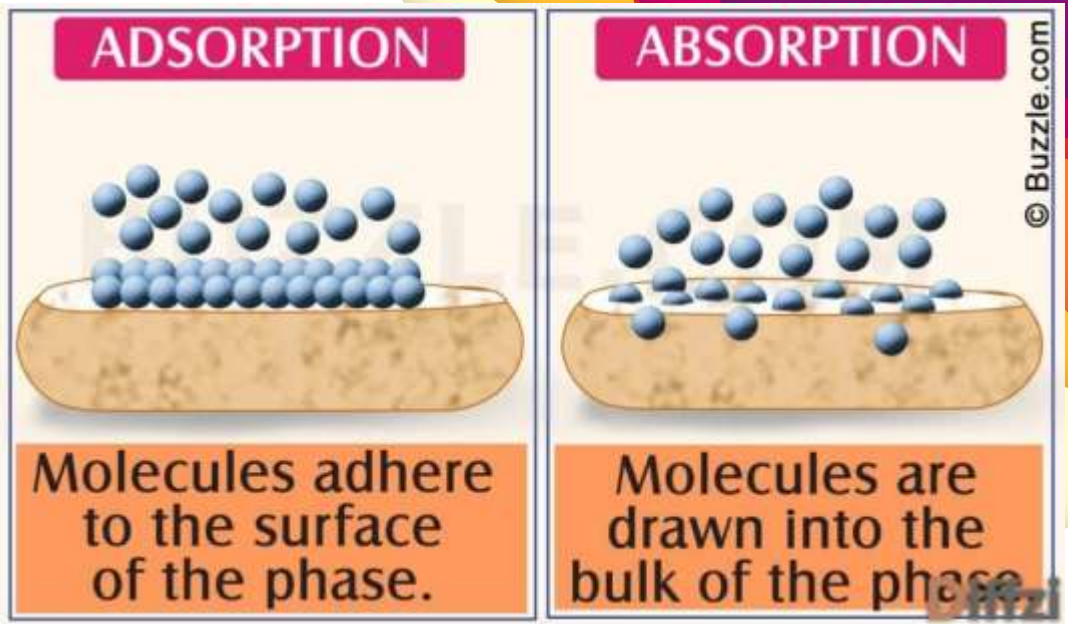
Desiccants are **compounds or agents**, such as **Montmorillonite Clay or Silica Gel**, used in **facilitating low humidity environments** by **adsorbing moisture content** from the air.

2. Principle of DESICCANT

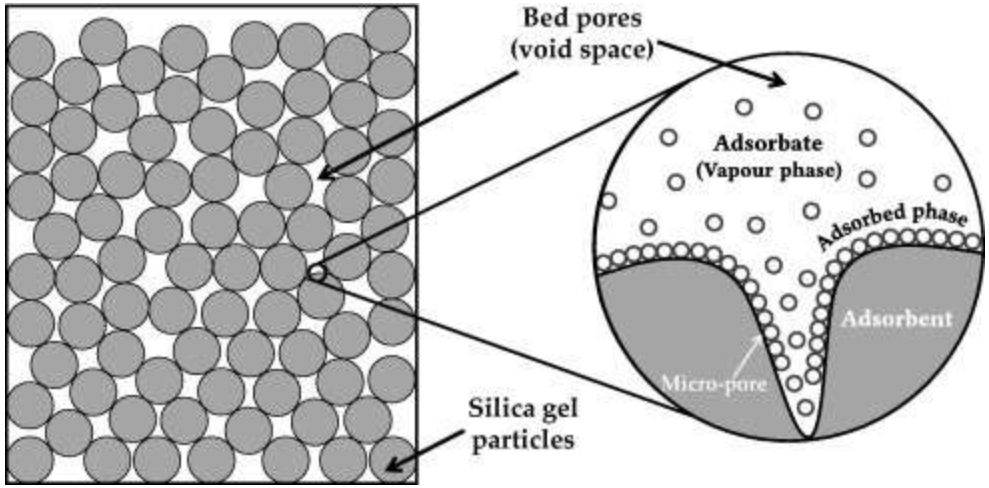
Desiccant **adsorbing moisture content** from the air with physics or chemical reaction

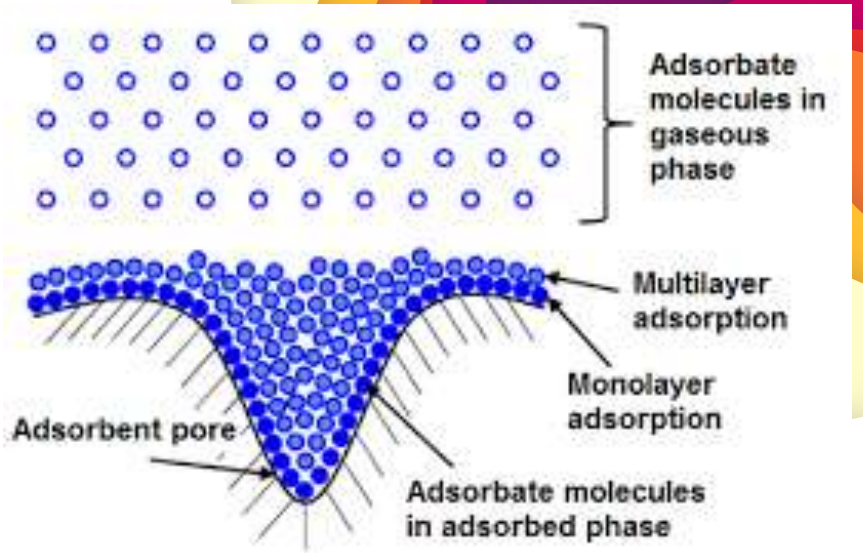
Adsorption or Absorption ???

The process of attracting and holding moisture is described as either absorption or adsorption, depending on whether the desiccant undergoes change as it takes in moisture



3. DESICCANT Mechanism





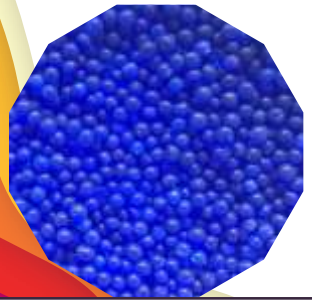
SILICA GEL

Granule that has been washed with a concentration of cobalt chloride (a heavy metal salt)

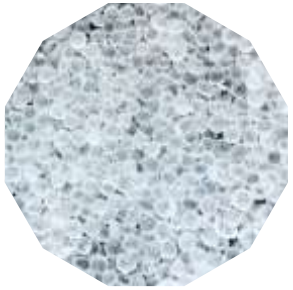
The cobalt chloride is a deep-blue color when dry and turns from blue to pink as it becomes saturated

should not be used in direct contact with products intended for consumption,

Adsorption capacity 34-40 wt%



Blue Indicating Silica Gel



Non-Indicating Silica Gel

Non-indicating desiccant forms do not provide a way to determine saturation level, resulting in added difficulty when evaluating the amount of moisture adsorbed by the desiccant

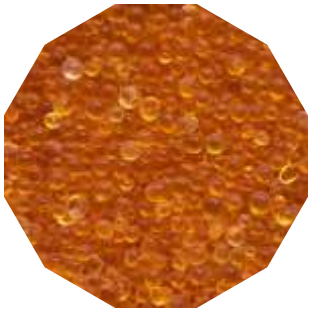
Can be used with product for consumption such as food and pharmaceutical

Adsorption capacity 35-40 wt%

Contain methyl violet as indicator

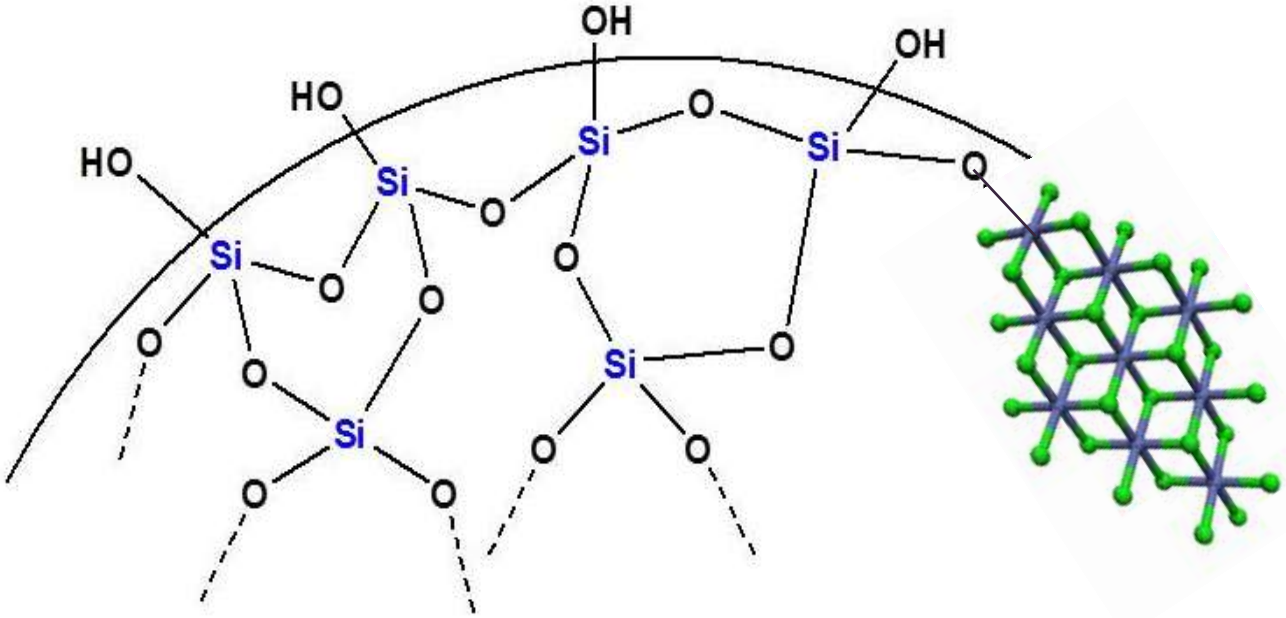
Adsorption capacity
RH 20 – 9 wt%
RH 50 – 22 wt%

Appears orange/yellow in color when dry and green after the desiccant becomes saturated with moisture



Orange Indicating Silica Gel

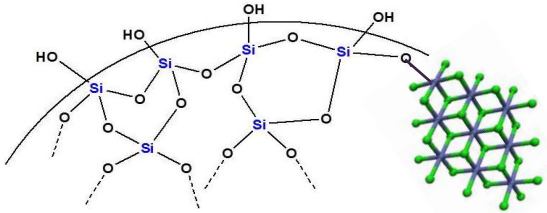
4. Silica Gel Transformation: Chemistry Explained



CoCl2 bound to silica: color indicator (deep-blue)

CoCl2.6H2O bound to silica: color indicator (pink)

4. Silica Gel Transformation: Chemistry Explained



CoCl2

Blue

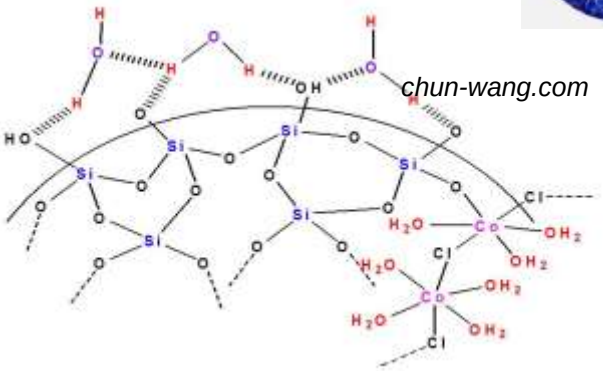
CoCl2 bound to silica: color indicator (deep-blue)

chm.bris.ac.uk

chun-wang.com

Hydrated/ damp

Heated at 120 C for 1-2 h



CoCl2.6H2O

Pink

CoCl2.6H2O bound to silica: color indicator (pink)

desiccant-silicagel.com

5. Penggunaan silica gel sebagai buffer kelembapan udara

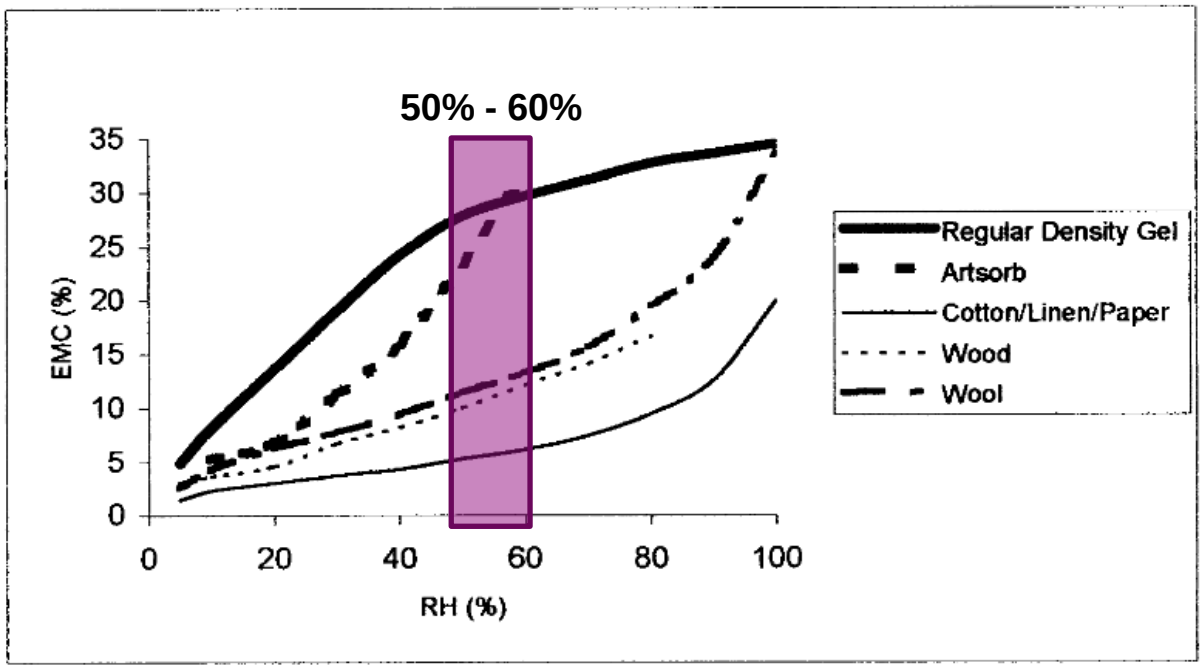
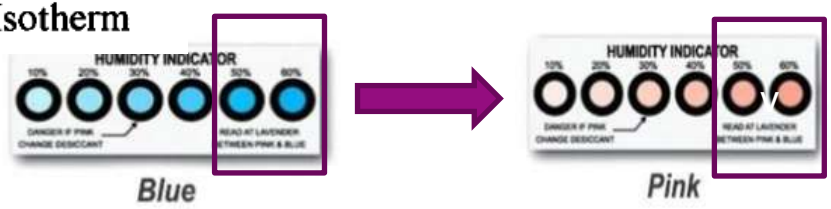


Figure 1. Equilibrium Moisture Content / Relative Humidity Isotherm

Steven Weintraub, ***Objects Specialty Group Postprints***, *Vol. Nine, 2002*, 169-194

- Silica gel dapat digunakan sebagai penyangga kelembaban lingkungan mikro pada RH 50-60% untuk menjaga kondisi koleksi
- Silica gel yang langsung dapat digunakan: Artsorb, Prosorb, dst
- **Silica gel biasa harus dikondisikan dahulu**



Buffering Capacity of Different Gels

- **A-type** - Good moisture adsorption capacity between 0-50% RH. Above 50% RH, the capacity to adsorb moisture diminishes.
- **B-type and C-type** - Low moisture adsorption capacities below 70% RH and are not appropriate for humidity buffering applications below 70% RH.
- **High-Performance Silica Gels** – Special gels with good buffering characteristics between 0-70% RH. Examples include RHapid Gel, ArtSorb and PROSorb.

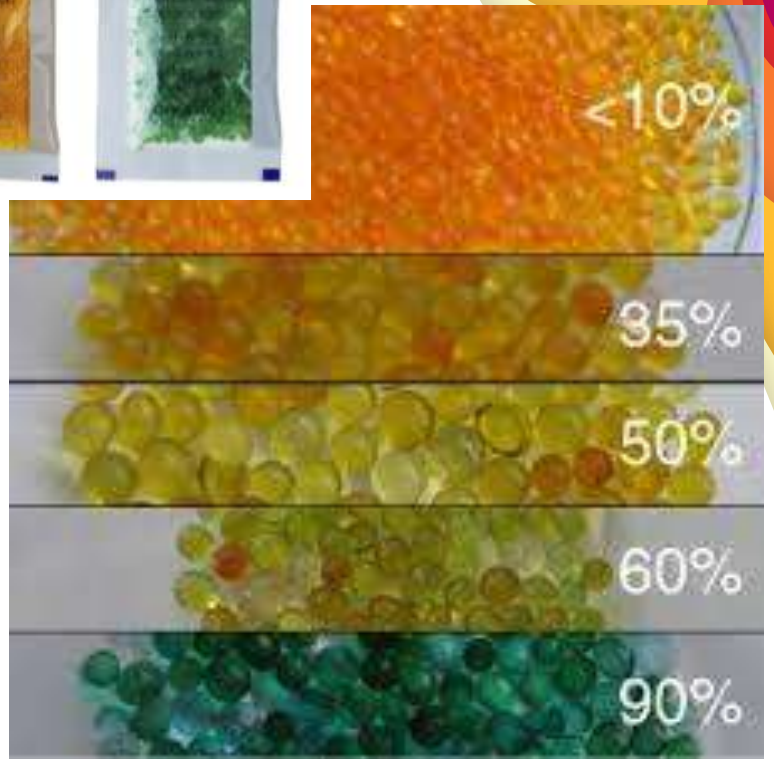
Buffering Capacity – HP versus RD

Table 1: specific moisture reservoir (g/kg for a 1% RH change) at 20°C *

Moisture sorbent	M_H 50 ± 10% RH around 50%	M 20 → 30% Keep RH low	M 60 → 50% Keep RH high
RHapid Gel	6.11 ± 2.16	4.48 ± 0.42	4.38 ± 1.40
PROSorb	5.42 ± 1.32	4.37 ± 0.10	4.25 ± 0.38
Art-Sorb	4.04 ± 0.80	2.84 ± 0.47	4.18 ± 0.49
Regular silica gel (clear, type A)	1.93 ± 0.44	5.48 ± 0.40	1.47 ± 0.16
Orange silica gel	1.16 ± 0.26	4.92 ± 0.59	0.94 ± 0.14
Bentonite clay (Desi Pak)	1.19 ± 0.07	2.25 ± 0.03	1.11 ± 0.02
Molecular sieves 4A (zeolite)	0.33 ± 0.02	0.47 ± 0.04	0.31 ± 0.01

Jean Tétreault and Paul Bégin, 2018 https://www.canada.ca/en/conservation-institute/services/conservation-preservation-publications/technical-bulletins/silica-gel-relative-humidity.html#a11b

Blue Indicating Silica Gel



Orange Indicating Silica Gel

Pre-kondisi Silica gel pada RH tertentu

Four different methods to condition silica gel:

1) **Direct Heat Application**. This technique is used when silica gel needs to be adjusted down and as much moisture removed as possible.
2) **Room or Chamber Exposure**. This method can be used to adjust gel up or down. It may take several weeks, depending on how much change in **RH is required. Use this technique when you** want to buffer your silica gel to a specific level.
3) **Exposure to Water Vapor**. This method is used for adjusting up. It will increase the gel's RH level.
4) **Gradual exposure to new gel**. This technique can be used to adjust gel up or down.

6. Pre-kondisi Silica gel pada RH tertentu

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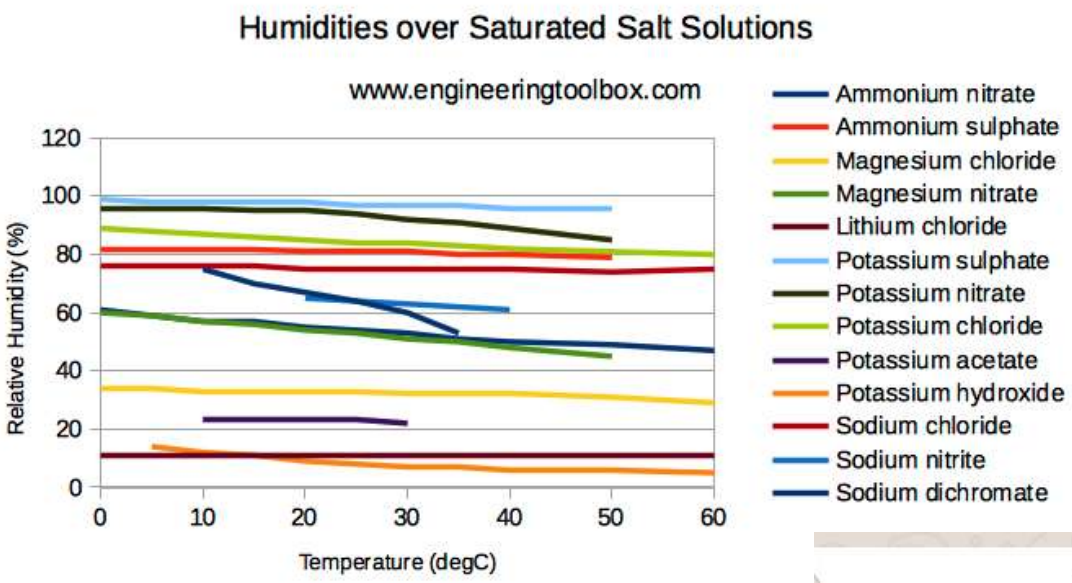
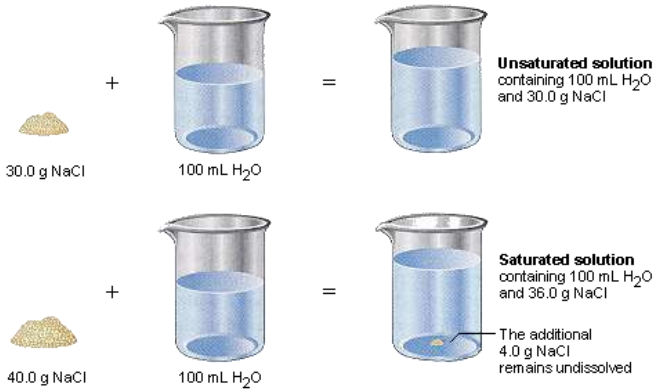




Pengkondisian silika gel melalui paparan/exposure uap air dari larutan garam jenuh ➔ ➔ ➔

Na-dikromat: RH ~50-60% pada rentang suhu yang lebar

Chemical Principles of Textile Conservation
by Agnes Timar-Balazsy and Dinah Eastop, 1998, 280

Tabel 5 Senyawa dan NIlai RH yang Dicapai[12]

Temperatur	Relative Humidity (RH) (%)					
(°C)	Litium Klorida ($LiCl.H_2O$)	Magnesium Klorida ($MgCl_2.6H_2O$)	Natrium Kromat ($Na_2Cr_2O_7.2H_2O$)	Magnesium Nitrat ($Mg(NO_3)_2.6H_2O$)	Natrium Klorida ($NaCl$)	Kalsium Nitrat $Ca(NO_3)_2.4H_2O$
10	13,3	34,2	57,9	57,8	75,2	
15	12,8	33,9	56,6	56,3	75,3	
20	12,4	33,6	55,2	54,9	75,5	55,0
25	12,0	33,2	53,8	53,4	75,8	51,0
30	11,8	32,8	52,5	52,0	75,6	

7. Reaktivasi desikan

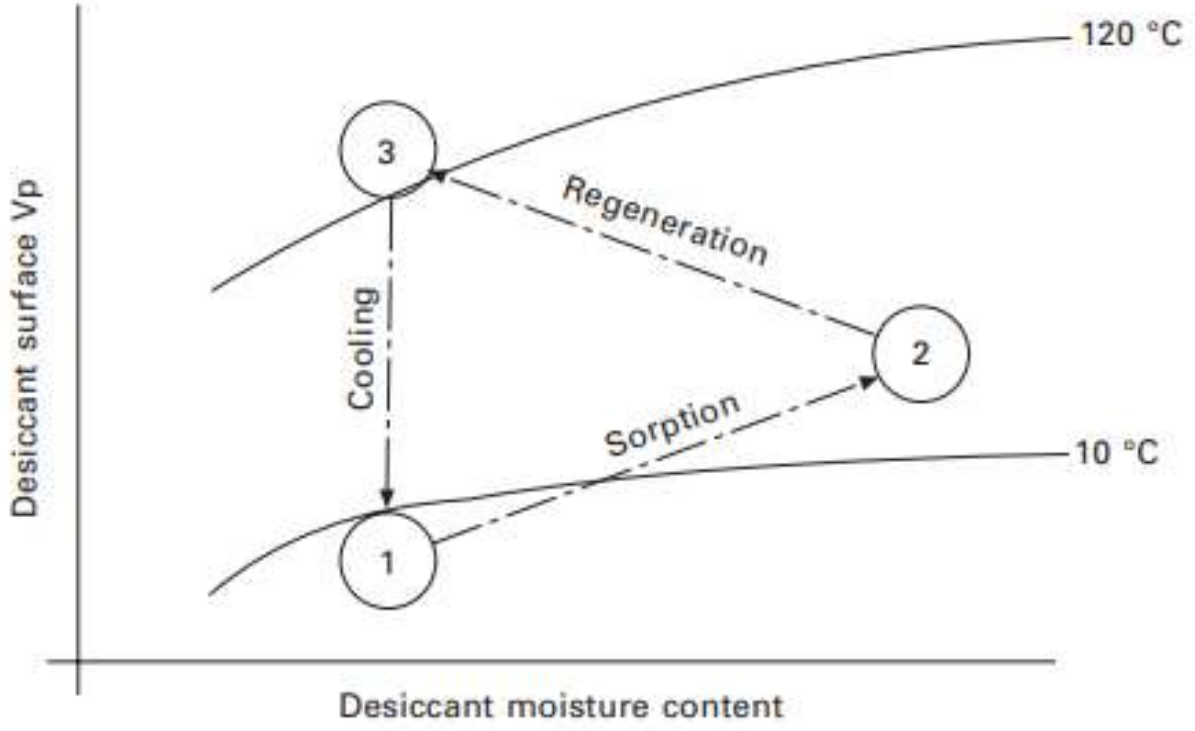
There is no limit to the number of times you can reactivate silica gel beads.

ASALKAN PROSES REKONDISI DILAKUKAN SESUAI PROSEDUR

Reaktivasi desikan

1. Spread the crystals across the bottom of a bake-safe oven dish (you can use aluminium foil if you prefer to keep it off the dish itself). Spread them evenly and less than an inch deep in the dish.
2. Place the dish in an oven and *heat it to 120° C for 1–2 hours* until they start changing colour. **If you want to avoid the risk of making your Silica Gel inactive, you could use a lower temperature and leave the Silica Gel in for a longer period of time.**
3. CAUTION: *Do not heat Silica Gel to more than 180° C* because it will lose its ability to absorb moisture.
4. The Silica Gel crystals will release the trapped water from within them and *will revert to their original blue or orange colour*. Once the colour changes fully, the Silica Gel is recharged and restored to its original capacity.
5. Note that the chemical that actually indicates the there is water in the silica gel crystals is a little more sensitive and will most likely turn blue before the Silica Gel is fully refreshed. **Therefore *it is suggested to leave the crystals in the oven for a while longer, after the crystals turn blue / orange.***
6. *Allow the crystals to cool down before you touch them*, and then restore them to their perforated containers in your cabinet.
7. *Store them in an airtight container* so that they don't absorb moisture from the atmosphere when they are not in use. Also so that **humidity doesn't come in from outside and saturate the Silica Gel crystals**.
8. *Remember to recharge your Silica* ***periodically***

Desiccant Cycle



8. Alternative Materials

BENTONITE

B. Bananezhad et al./Polyhedron 162 (2019) 192–200

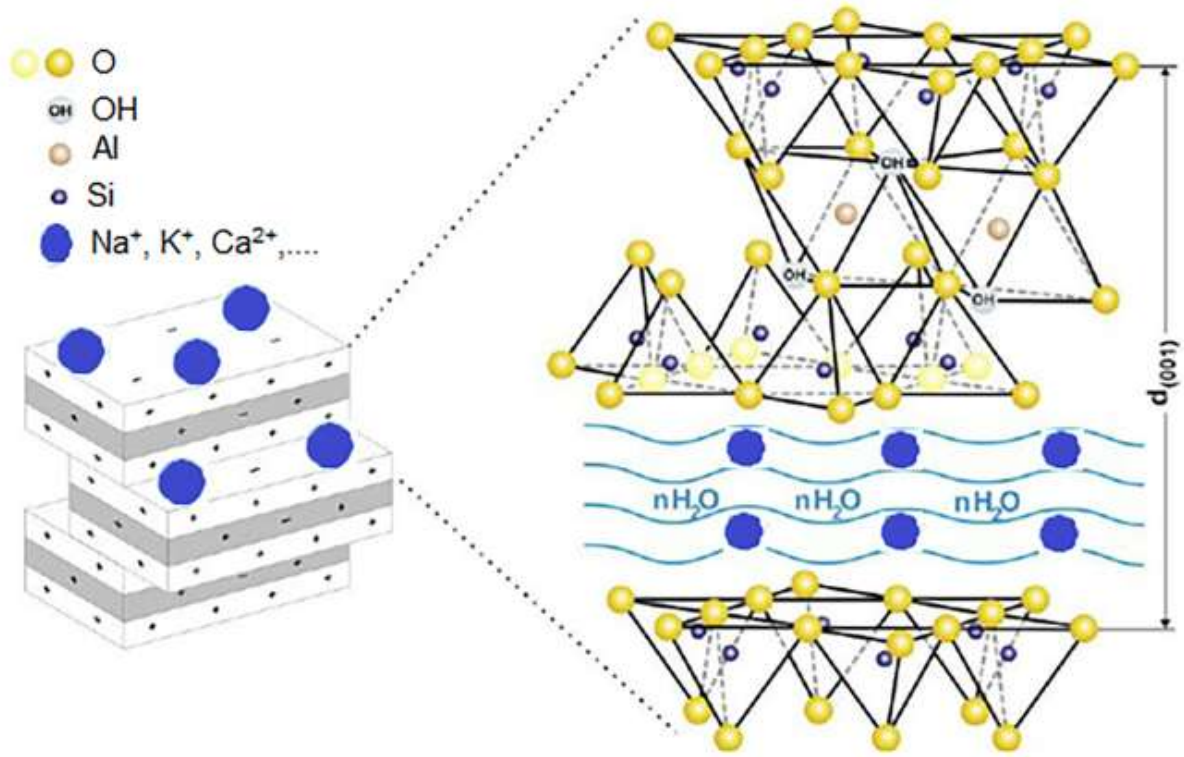
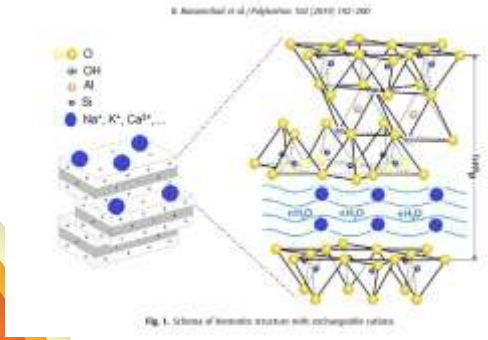
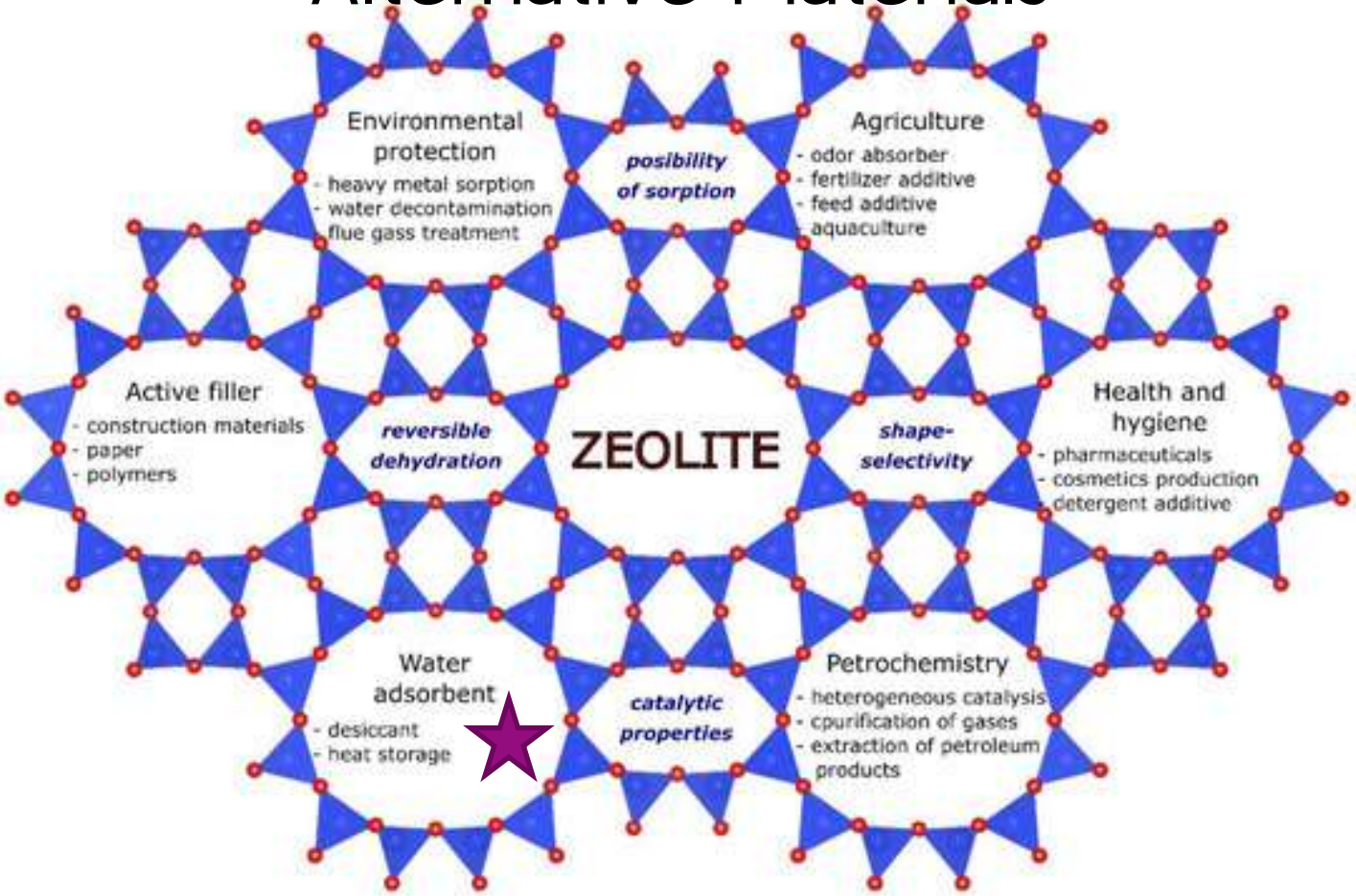


Fig. 1. Schema of bentonite structure with exchangeable cations.

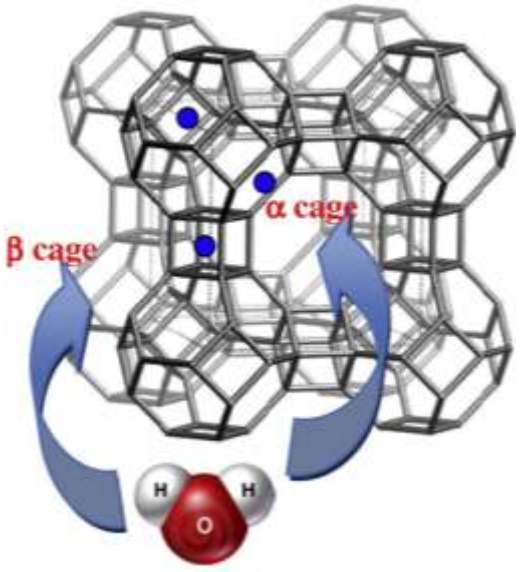
Alternative Materials

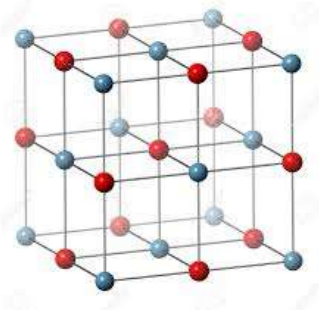
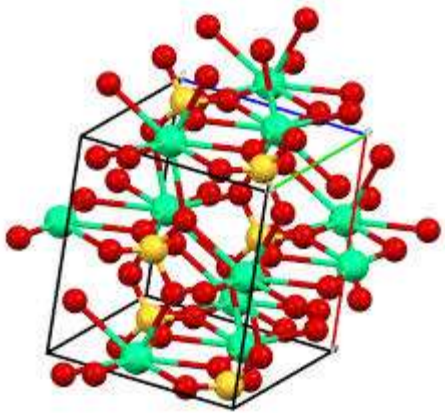
BENTONITE/ CLAY/ TANAH LEMPUNG		Explanation
	   	**Montmorillonite Clay** is a naturally occurring porous adsorbent. This clay will successfully regenerate for repeated use at very low temperatures without substantial deterioration or swelling. However, this property causes clay to give up moisture readily back into the container as temperatures rise. **Clay is inexpensive and effective within normal temperature and relative humidity ranges**

Alternative Materials

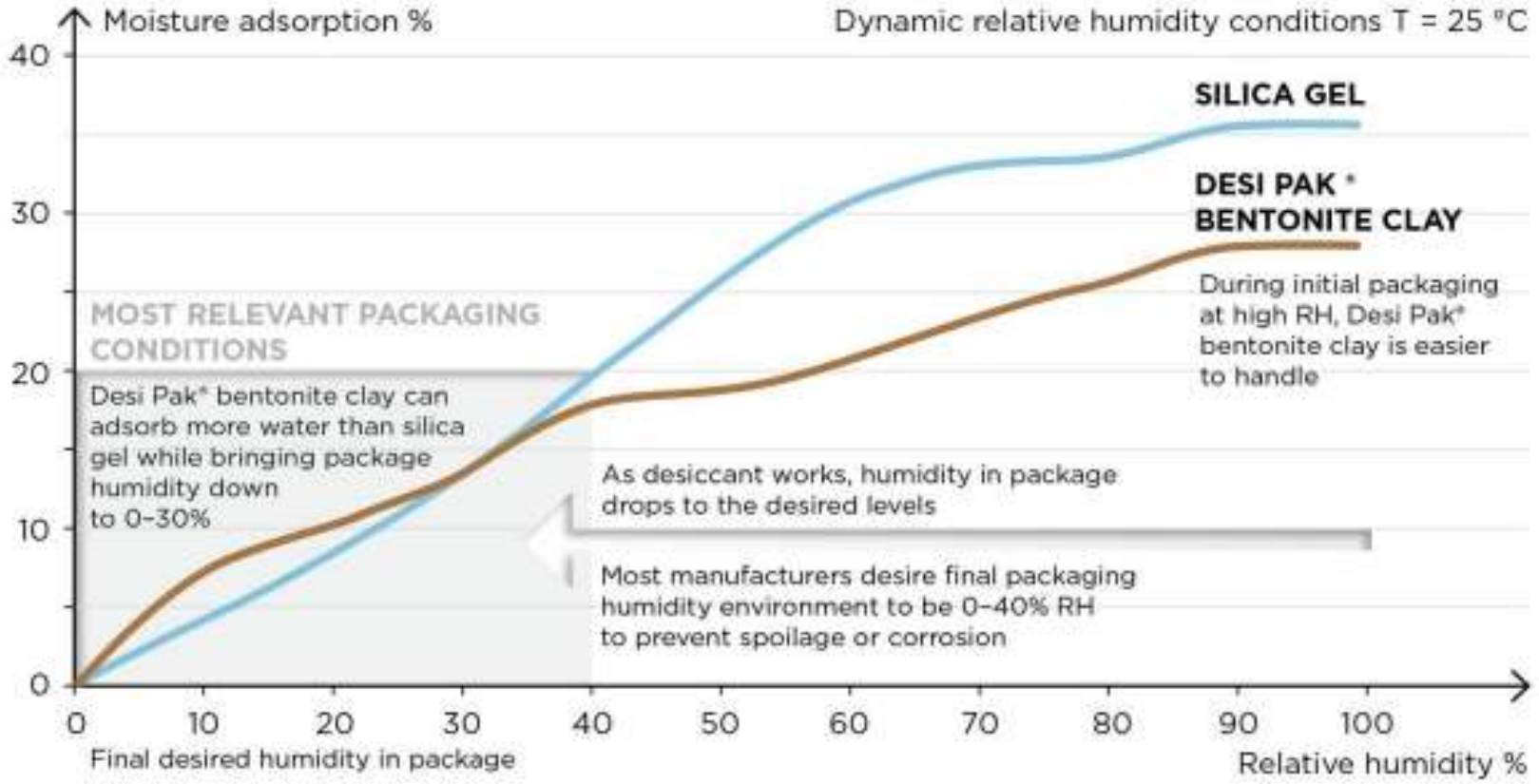


Alternative Materials

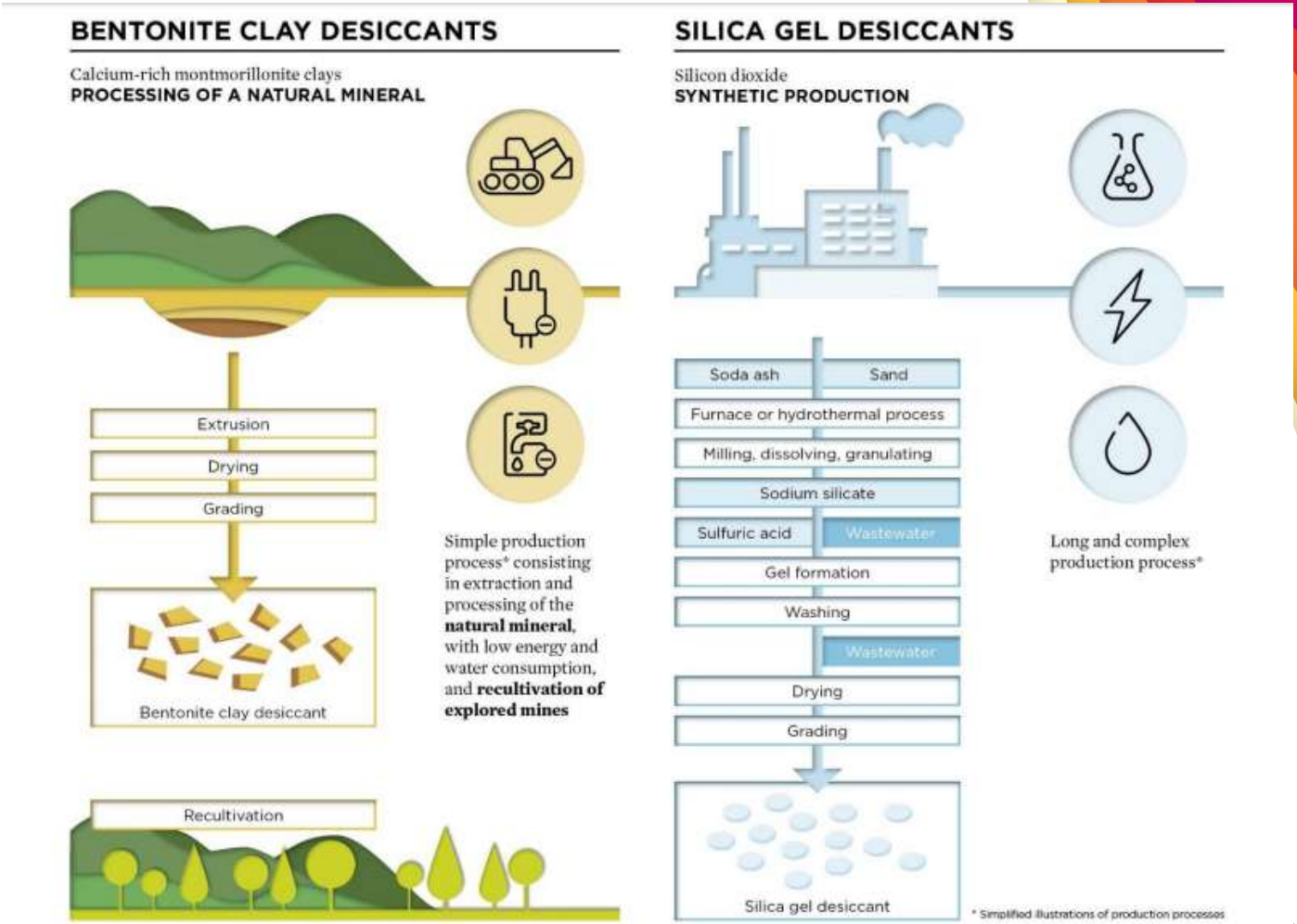
NATURAL ZEOLITE/ZEOLIT ALAM/PASIR KUCING		Explanation
	  	**Molecular sieves (also known as Zeolite)** adsorb moisture more strongly than either silica gel or clay. Where a very low relative humidity is required, molecular sieves are often the most economic desiccant because of their high adsorption capacity at low relative humidity. Also, molecular sieves will not give up moisture into the package as readily as silica gel or clay as temperatures rise

	**Calcium oxide (CaO)** is calcinated or recalcinated lime having a moisture adsorptive capacity of not less than 28.5% by weight. It will adsorb a much greater amount of water at low relative humidity than other materials ; it is effective in retaining moisture at high temperatures; and it is relatively inexpensive as compared to many other desiccants
	**Calcium sulfate ($CaSO_4$),** is an inexpensive alternative available in suitable packaging forms. Calcium sulfate is created by the controlled dehydration of gypsum, acting as a general-purpose desiccant geared mainly toward laboratory use. It is chemically stable, non-disintegrating, nontoxic, non-corrosive, and does not release its adsorbed water when exposed to higher ambient temperatures.

Silica Gel vs Bentonit Performance



How to Get Silica Gel and Bentonite Dessicant?



Which is Better ?

Both bentonite clay and **silica gel** packs **are effective** means of moisture prevention for electronics, food, medicine, etc.

Because **bentonite packs tend to be less costly** and **more cost-effective while still having the moisture level measuring property**, in most cases, they are the **preferable option** between the two

Sedangkan zeolite alam masih perlu diuji apakah kemampuan adsorpsi uap air nya sudah memenuhi persyaratan.

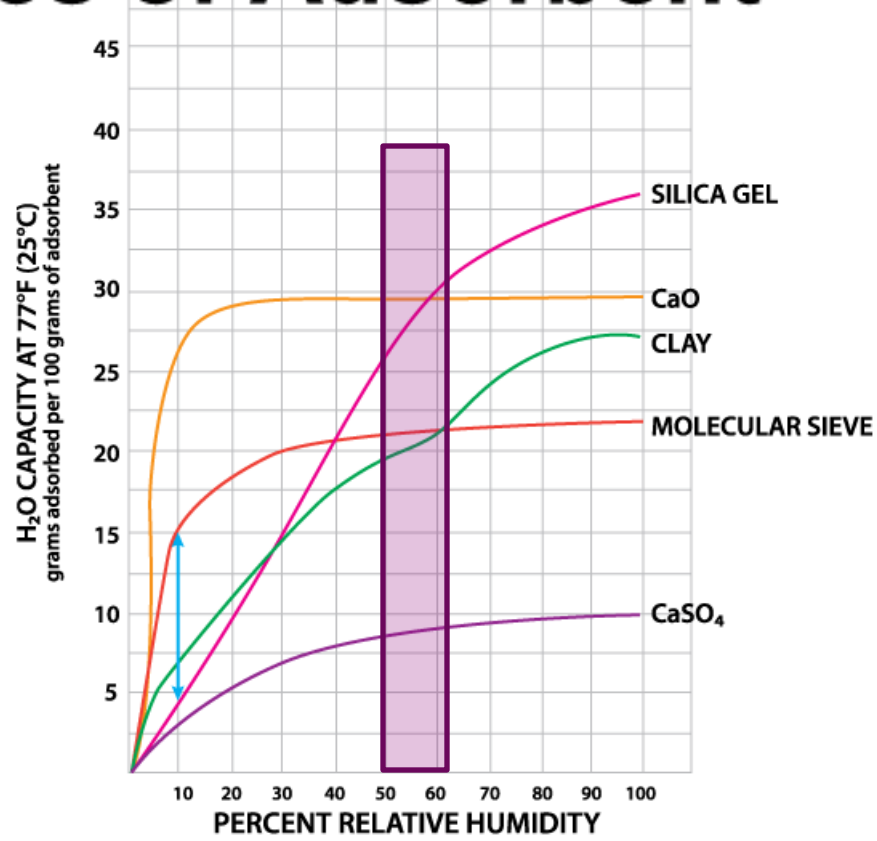
Properties of Adsorbent

Property	Molecular Sieve	Silica Gel	Montmorillonite Clay	CaO	CaSO4
Adsorptive Capacity at low H20 Concentrations	Excellent	Poor	Fair	Excellent	Good
Rate of Adsorption	Excellent	Good	Good	Poor	Good
Capacity for Water @77° F, 40% RH	High	High	Medium	High	Low
Separation by Molecular Sizes	Yes	No	No	No	No
Adsorptive Capacity at Elevated Temperatures	Excellent	Poor	Poor	Good	Good

Tanah lempung

Zeolite alam??

Properties of Adsorbent



Tanah lempung

Zeolite alam??

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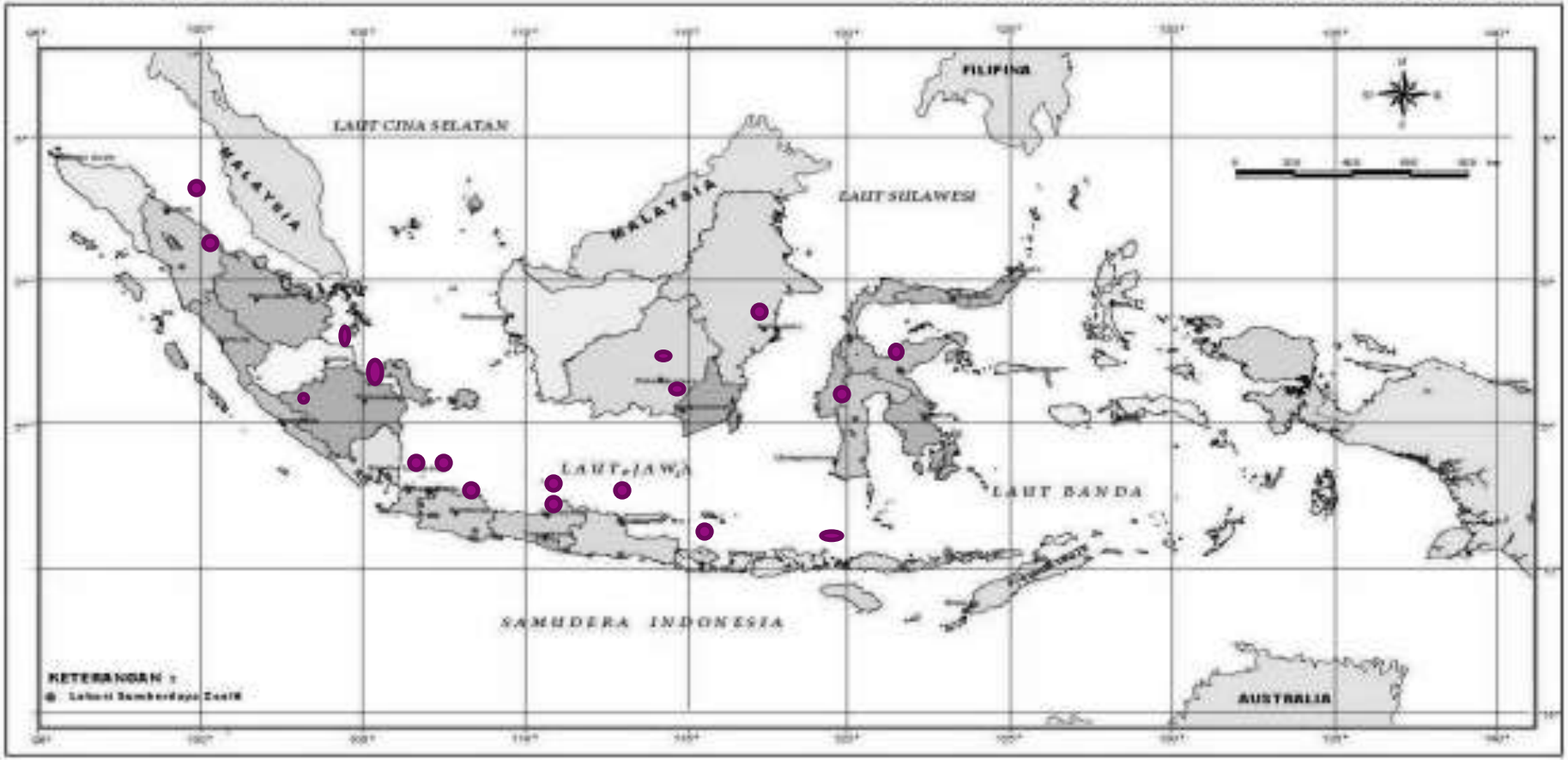
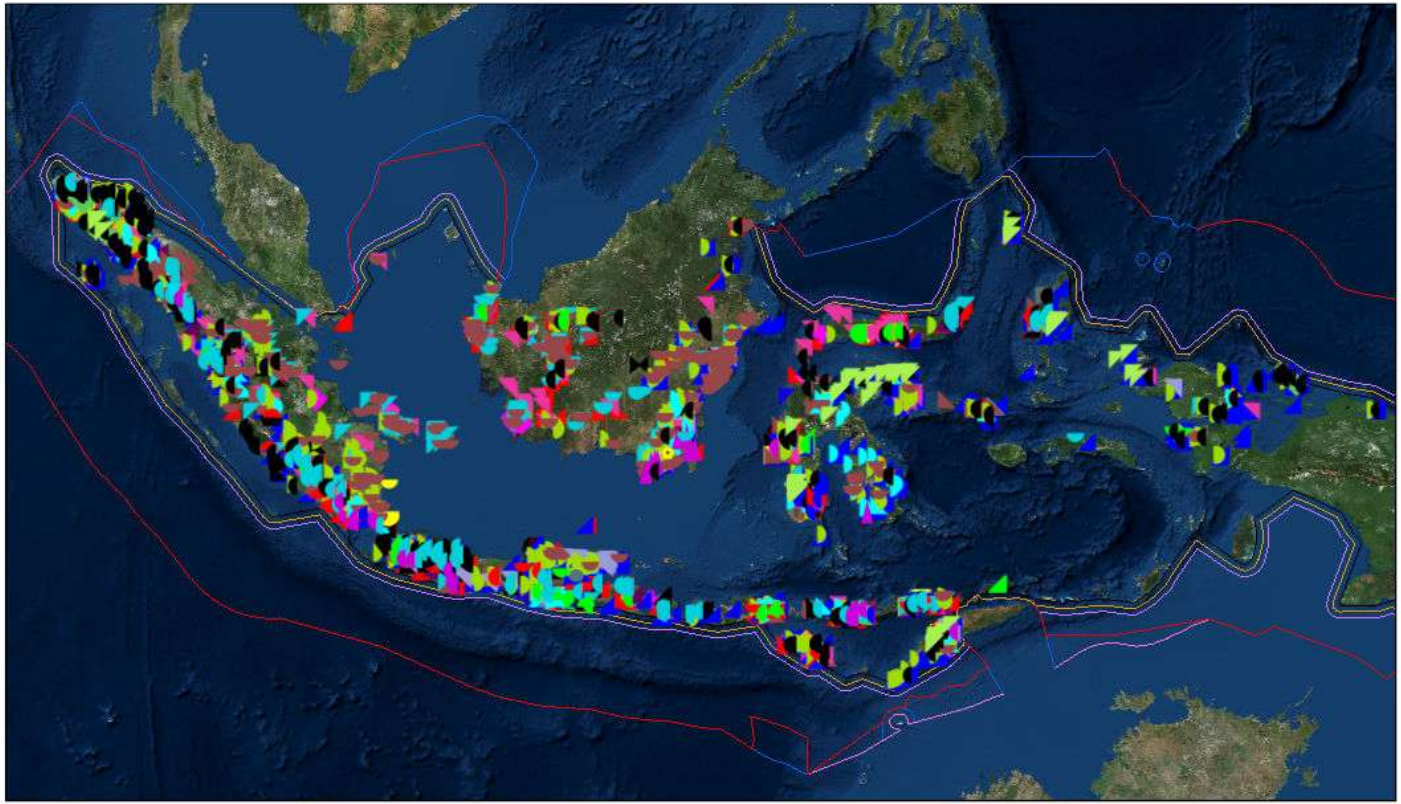


Kementerian ESDM



24/8/2020 16.05.22

Potensi Mineral Bukan Logam

- Ametis
- Andesit
- Ball / Bond Clay
- Barit
- Basal
- Batu Hias
- Batu Kuarsa
- Batuan Pembawa Kalium
- Batuapung
- Batugamping
- Batusabak
- Belerang
- Bentonit
- Dasit
- Diabas
- Diatomea
- Diorit
- Dolomit
- Felspar
- Fosfat
- Gick
- Gipsum
- Grafit
- Granit
- Granodiorit
- Intan
- Jasper

1:18,489,298

0 160 320 640 mi

0 245 490 980 km

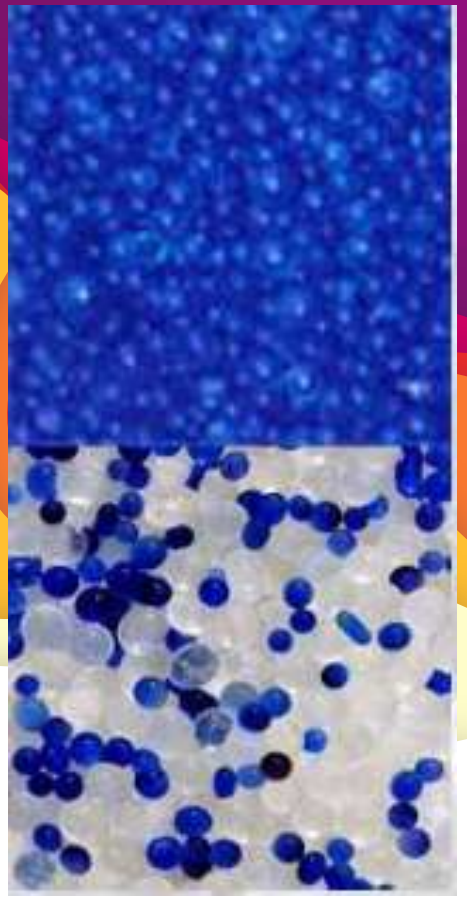
Kebijakan Satu Peta. Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Pusdatin ESDM

Pusdatin ESDM

9. TIPS HEMAT PENGGUNAAN DESIKAN

- GUNAKAN DESIKAN TAK BERWARNA, SEPERTI SILIKA GEL PUTIH, BENTONITE ATAU ZEOLITE YANG DITAMBAHKAN SEDIKIT SILIKA GEL BIRU
- BILA WARNA SILIKA GEL BERUBAH DARI **BIRU** KE **MERAH MUDA**, BERARTI SILIKA GEL PUTIH ATAUPUN DESIKAN LAINNYA **SUDAH MENYERAP UAP AIR DENGAN KADAR YANG SAMA**.
- REAKTIVASI PADA SUHU 100-120°C DAN WAKTU YANG LEBIH LAMA



10. Conclusion

- The silica gel adsorbs moisture from the air, preventing damage at the point of use of the compressed air due to condensation or moisture
- Pre-conditioned Silica gels can be used as buffer to maintain desired RH in micro-environment that prevent damage in collection caused by fluctuated RH
- Appropriate reactivation and recondition of silica gel will preserve the adsorption capacity of silica gel
- Bentonite and Zeolite are natural resources that has similar properties with silica gel can be used as desiccant and RH buffer that more eco-friendly and can be easily obtained in Indonesia

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Terimakasih

Any questions?

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Faculty of Mathematics and Natural Science
Universitas Indonesia

Solid Inorganic Framework research group

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