

The effect size and composition of bioreactor from sand and compost to porosity purpose of bed

A Fauzan¹, Rispiandi¹

¹ Department of Chemical Engineering, Politeknik Negeri Bandung, Jalan Gegerkalong Hilir, Bandung, Indonesia

E-mail: ahmad.fauzan@polban.ac.id

Abstract. Population increase causes the need for products from plants also to increase and land is decreasing so a certain process of intensification in agriculture needed. One of them is by making a plant bioreactor that can be modelled as a fixed bed composed of compost and grains of sand. The spatial structure of the bioreactor can facilitate the presence of water, air, root system development, and life systems of various soil biota so that they are create a mechanism of production on demand for plants. The purpose of this study was to obtain the effect of bed variations on the porosity parameter (ϵ). Bed variations consist of size variations (not sifted; 4 - 2 mm; 2 - 1 mm; 1 mm - 500 μm ; 500 - 250 μm and 250 - 125 μm) and composition variations (100:0; 25:75; 50:50; 75:25 and 0:100) from compost and sand. The results showed that the addition of compost would increase the porosity of bed. The bed consisting of sand and compost with a ratio of 25:75 with a diameter of 4 - 2 mm is a good composition to increase porosity of bed with a porosity value around (ϵ) of 0.7.

1. Introduction

According to Central Statistics Agency, the population of West Java in 2018 is 48,683,775 people, and it is increase 1.89% [1]. This condition will increase the need for food from plants. Because of residential settlement and limited land, then there must be another step to increase crop productivity. One of which is by making plant bioreactors.

The transfer of nutrients needed by plants from bioreactor to the root is generally facilitated by the flow of water. If the process of transporting water on limiting rate, then the transfer of the nutrients will be slow. The presence of micro spaces formed by sand and compost will increase the surface tension of soil due to the presence of air and liquid phases. Surface tension will push water from the soil to the roots of plants faster so that the nutrients taken by the roots will increase.



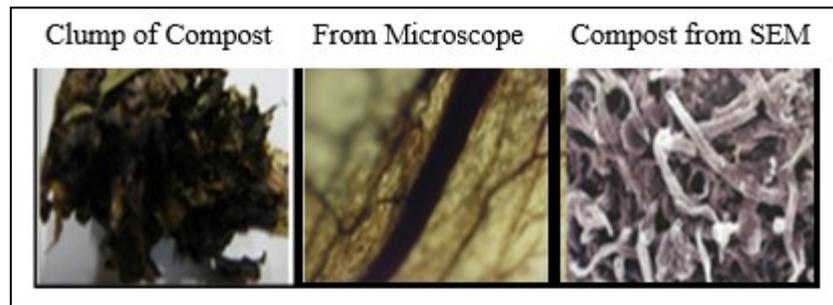


Figure 1. Compost display of various magnifications [2].

The mechanism of fluid transfer in porous and capillary media is not a new study in a displacement event. Lots of publications related to this matter [3-5] with reference to previous research about space structure [6], about characterisation fluid [7] and research about soil before [8-11]. Available data will be used to determine the parameters needed. However, it does not rule out the possibility that other data are still needed in various conditions that require to conduct experiments similar those of other researchers. The parameters obtained such as compost diameter and sand diameter can be approximated by a filter size of a certain size, the ratio of the volume of sand and compost to which water will flow through the bed to get the value of various porosity of the bed. The relationship of these parameters can show the structure of the bed that makes up the plant bioreactor.

2. Materials and methods

2.1. Materials

The compost that will be used in this study comes from the Bandung Institute of Technology and the sand that is used comes from the Geger Kalong Hilir Bandung river sand. The water used in the porosity testing process is ground water.

2.2. Methods

The experiment begins with sample preparation the determination of variations in the size of the sand and compost as well as variations in the composition of the sand and compost so that the total sample obtained is 30 samples. The variations of experiments performed are shown in Table 1.

Table 1. Variations size and composition of experiments.

Variations of experiments	
Sand and compost particle size	Not sifted, diameter 4 – 2 mm, 2 – 1mm, 1 mm – 500 μm , 500 - 250 μm and 250 μm – 125 μm
composition sand: compost in bed (% V – V)	100:0 ; 25:75 ; 50:50 ; 75:25 and 0:100

The experiment begins with preparing a bed consisting of sand and compost. The sand and compost are first dried at 90 - 110°C in the oven for two hours. This is done to ensure that all water from the bed evaporates. After drying, each sand and compost is milled with a ball mill then filtered with sizing to get the desired size. The size collected from the mesh filter is considered as a measure of the average diameter applied to capillary pipes in the compost and grains of sand. This is done because the particle diameter is one of the fixed parameters used in making the model being built. After completing the next step, the porosity test of the bed is to prepare a 250 mL measuring cup and 100 mL bed. After that, inserting the bed constituent particles into the measuring cup until it reaches a volume scale of 100 mL.

Prepare another measuring cup and fill it with 100 mL of water. Then put 100 mL of water in a measuring cup into a measuring cup containing a bed. The bed is stirred slowly until all the empty parts of the bed are filled with water. After completion, the total bed volume that has been mixed with water is obtained. Then the porosity value (ϵ) of the bed can be obtained by the formula:

$$\text{Porosity} = \text{Empty room volume} / \text{Bed volume} \quad (1)$$

Bed porosity (ϵ) is the ratio of the empty room volume to the total bed volume. So that more free space is formed on a bed, the porosity value of the bed will increase. Porosity is defined as the fraction of the bulk volume of the porous sample occupied by pore or void space [12].

3. Results and discussion

The bed being tested varies according to the size of each particle from its constituent, which is sand and compost. This bed variation (sand and compost composition) is adjusted based on volume comparison. This is done with the reason it can be applied in agricultural life in providing planting media. The process of making a sample as shown in Figure 2.

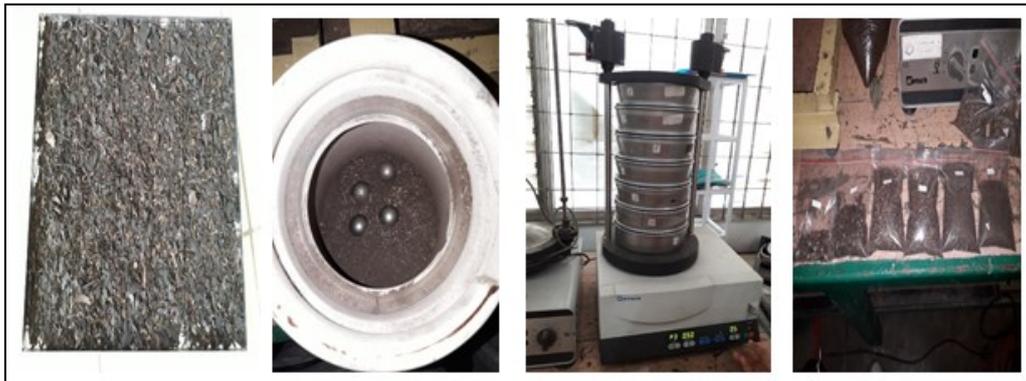


Figure 2. The process of making samples for porosity testing.

Samples that have been obtained according to the desired size are then sorted by a bed based on the expected composition so that a sample of 30 samples is obtained. After the desired sample is obtained then the bed porosity test is carried out as shown in Figure 3.

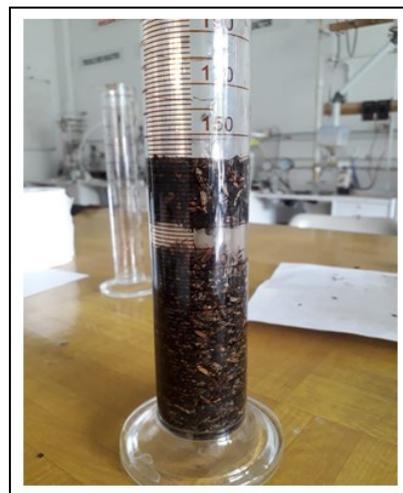


Figure 3. Test the porosity of the bed.

The porosity test results of various beds composed of various sizes and compositions of the tested sand and compost are shown in Table 2.

Table 2. Porosity values (ϵ) of various of beds.

Size (Bed diameter)	Composition		Volume (ml)			Porosity
	Sand	Compost	Water	Bed	Total	
Not sifted	100	0			145	0.55
	75	25			147	0.53
	50	50	100	100	138	0.62
	25	75			135	0.65
	0	100			128	0.72
4 mm – 2 mm	100	0			144	0.56
	75	25			144	0.56
	50	50	100	100	140	0.60
	25	75			124	0.76
	0	100			128	0.72
2 mm – 1mm	100	0			140	0.60
	75	25			145	0.55
	50	50	100	100	144	0.56
	25	75			128	0.72
	0	100			131	0.69
1 mm – 500 μm	100	0			142	0.58
	75	25			143	0.57
	50	50	100	100	137	0.63
	25	75			130	0.70
	0	100			130	0.70
500 μm – 250 μm	100	0			144	0.56
	75	25			145	0.55
	50	50	100	100	142	0.58
	25	75			128	0.72
	0	100			137	0.63
250 μm – 125 μm	100	0			150	0.50
	75	25			148	0.52
	50	50	100	100	142	0.58
	25	75			138	0.62
	0	100			136	0.64

Compost has higher porosity value than sand. This is due to the diverse shapes and sizes of compost causing the irregularity of the bed to become more irregular and allowing more free space between the particles in the bed. However, the table also shows the porosity test results in the mixture of compost and sand, showing that the addition of compost to the sand results in increased porosity, this is due to the addition of compost, the density, size distribution increases and the shape of the particles becomes more diverse so there will be empty space formed will be more and more. After the porosity test is obtained the porosity graph of various sizes as shown in Figure 4.

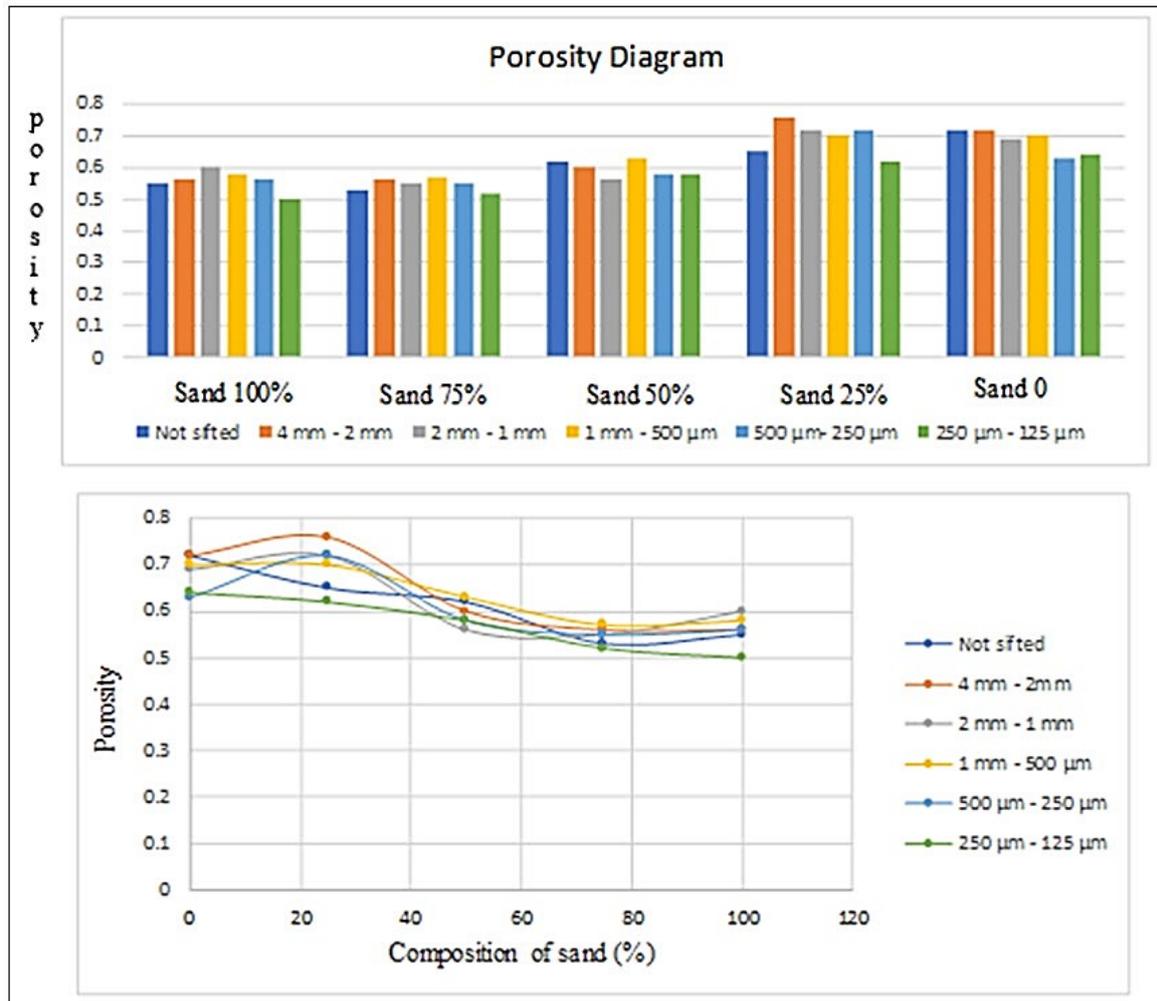


Figure 4. Graph of porosity of various beds.

From this research a porosity test of various beds of various sizes and compositions was successfully carried out. From the above data it can be concluded that the bed consisting of sand with a diameter of 4 mm - 2 mm with a ratio of sand and compost 25:75 has a good porosity of 0.76 compared to other beds.

4. Conclusions

The process of making beds with variations in the composition of sand and compost 25:75 is good in providing porosity for plant bioreactors of various sizes compared to other beds. Meanwhile, the best particle size in porosity is 4 - 2 mm. Overall the porosity value can be concluded that the ratio of sand and compost 25:75 is effective, and the best diameter size is 4 - 2 mm.

5. References

- [1] Herlando D 2018 *Jawa Barat Province in Figure* (Jawa Barat: BPS Statistics of Jawa Barat Province)
- [2] Purwasmita M and Sutaryat A 2012 *Padi SRI Organik Indonesia* (Jakarta: Penebar Swadaya) 17 – 18
- [3] Bish M 1987 *International Journal of Mine Water* **6** 1-24
- [4] Xu P and Yu B 2007 *Advances in Water Resources* **31** 74-81

- [5] Teng H and Zhao T S 2000 *Chemical Engineering Science* **55** 2727-2735
- [6] Masrofah I 2014 *Struktur Ruang dan Hidrodinamika Bioreaktor Tanaman* (Bandung: Institut Teknologi Bandung) 36-43
- [7] Ichsan F and Ridwan P P 2015 *Karakteristik Aliran Fluida dalam Model Unggun Bioreaktor Tanaman Berbentuk Butiran dan Pipa Berukuran Mikro* (Bandung: Teknik Kimia ITB)
- [8] Herris S Z, Mosavian M T H and White E T 2009 *Brazilian Journal of Chemical Engineering* **26** 695-704
- [9] Hopkins W G and Hüner N P A 2008 *Introduction to Plant Physiology* (United States: John Wiley and Son, Inc) 7-37
- [10] Fries N 2010 *Capillary transport processes in porous materials-experiment and model* (Germany: Cuvillier Verlag)
- [11] Chapuis R P and Aubertin M 2003 *Predicting the Coefficient of Permeability of Soils Using the Kozeny-Carman Equation* (Canada: Ecole Polytechnique de Montreal)
- [12] Dullien F A 1991 *Porous media: fluid transport and pore structure* (United States: Academic press)

Acknowledgments

This research work has been financially supported by DIPA Politeknik Negeri Bandung.