

Potential Utilization of Sewage Sludge from Water Treatment Plant as Brick Material

Budi Prasetyo Samadikun^{1*}, Siti Rukayah², Ika Bagus Priyambada¹, Sry T. Romaito Lumbantobing¹ and Mochamad Arief Budihardjo¹

¹Department of Environmental Engineering, Faculty of Engineering, Diponegoro University, Semarang – Indonesia

²Department of Architecture Engineering, Faculty of Engineering, Diponegoro University, Semarang - Indonesia

Abstract. One of the results of the water treatment process is the sludge. Generally, the processed sludge from the water treatment is collected and delivered to a landfill. With the delivery of sludge waste, it requires additional cost as a levy in handling sludge waste. Therefore, it is needed to innovate on the recycling of sludge. The waste recycling process is expected to minimize the residual impact of the Water Treatment Plant. The process of waste recycling can be done by utilizing sludge from water treatment, which is brick making process. The benefits can eliminate environmental problems and also some economic problems. This study aims to determine the potential of sludge from water treatment plant to be added for brick making by investigating the physical and characteristics of sludge. The research findings show that sludge waste has the potential to become a brick raw material depending on the nature and clay microstructure

Keywords: **recycling; sludge ; brick.**

1 Introduction

The drinking water treatment plant that processes raw water is a system that combines various process to obtain drinking water proper for consumption according to regulation of quality requirements of drinking water. The process of raw water treatment at the water treatment plant will produce a main waste that is sludge from various production units which will be discharged directly into the water body without processing. The sludge disposal activity directly to water body is certainly an environmental pollution action. The sludge generated from water treatment plant has a large quantity with high aluminium concentration that can lead to aluminium accumulation in aquatic organisms and human body if it directly discharges into water bodies. The accumulation of aluminium on human body can lead to Alzheimer's disease and mental retardation [1].

Utilization of sludge needs to be conducted to reduce the disposal of sludge directly to water bodies. The mineral composition found in sludge is similar to that of clay [2]. Clay and water are the raw materials for making bricks [3]. The clay used in the manufacture of bricks comes from the land surrounding the settlements. Continuous clay excavation causes landscape changes that can alter the structure of the soil due to loss of cover vegetation which also leads to reduced oxygen content in the air so that the temperature in the region becomes higher and causes the soil to become more volatile [4].

Therefore, sludge has the potential to be used in brick making [4]. Bench-scale experiments [5] showed that conventional clay and industrial sludge mixtures can be used as materials for brick making. The clay product is called "biobrick". Utilization of sludge in brick making can reduce environmental problems and some economic problems associated with substitution of natural raw materials of clay so that brick making can be more environmentally friendly [6]. However, high aluminum concentrations in the sludge may affect the nature of the sludge. A study is needed to know the characteristic of sludge waste from water treatment plant and compare it with clay that is used as material for brick making.

The result of this study will be useful for the authorities to handling sludge waste and reducing the use of natural clay in order to support low carbon society.



(a)

* Corresponding author: budisamadikun@gmail.com



(b)

Fig. 1. (a) Location of PDAM Tirta Moedal Semarang; (b) Location of brick industry of Penggaron Kidul Semarang

2 Materials and methods

2.1 Material

2.1.1 Sludge

Sludge used was derived from 2nd and 4th outlets of Water Treatment Plant (WTP) PDAM Tirta Moedal Semarang City.

2.2.2 Clay

Clay used was derived from clay around the brick industry in the village of Penggaron Kidul Semarang

2.2 Method

2.2.1 Sampling Method

Sludge collection was conducted using disturbed sample of soil sampling method by taking sufficient sample quantities to perform characteristic testing. The recommended number of samples according to ATSM: D 420 - 98 is 50 - 500 g, and the number of samples for

the analysis of grain size on non-gravel soil is 500 g - 2.5 kg.

2.2.2 Soil Classification

ASTM D 2487 is used as reference for soil classification which classify the soil based on particle size analysis, liquid limit, and plasticity index.

2.2.3 Atterberg Limit

Atterberg limit testing was conducted based on ASTM D 4318. The liquid limit was determined by flattening the sample into a yellow cup (cassagrande) and dividing it to two using grooving tools. Then the yellow cup was dropped repeatedly in a standard mechanical device. The liquid limit experiments required 3 or more experiments of various amounts of water mixed. Then the data was plotted on the graph to get the liquid limit relationship.

The plastic limit was determined by twisting the sample until a crack appeared due to the reduced moisture content at 3.2 mm in diameter. The water content at that point was the value of the plastic limit.

3 Results and discussions

The water treatment system to generate clean water required by the community involves a series of processes, namely the first raw water coming from the river is accommodated in the intake, then discharged through the pump to the coagulation unit. In the coagulation unit, the addition of coagulant in the form of alum / PAC to bind the sludge is conducted. Coagulated water is discharged into the flocculation unit and sedimentation unit. In the sedimentation unit, the floccled sludge from the coagulation and flocculation unit is deposited. Afterwards, water is discharged to the filtration and reservoir units. In reservoir unit the disinfectant in the form of Cl is added. From the reservoir, water is ready to be distributed through transport pipes. The sludge from the sedimentation unit containing the alum / PAC is returned to the river.

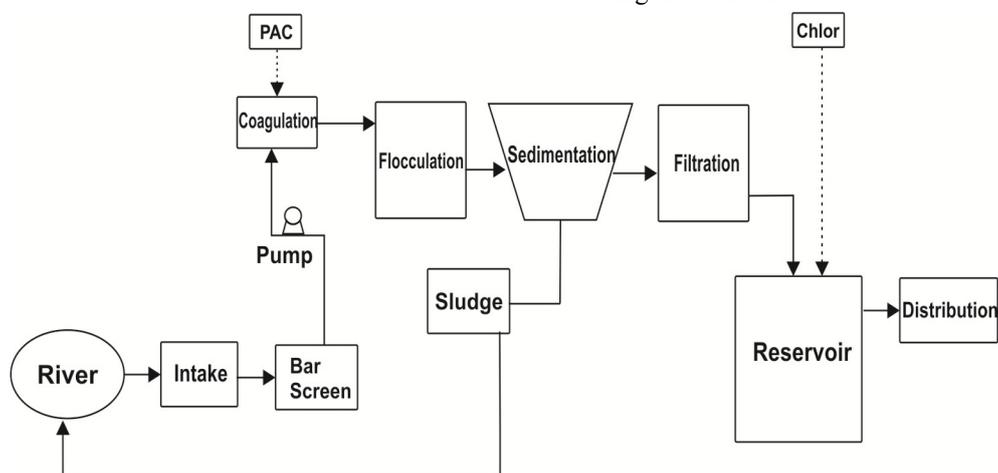


Fig. 2. WTP process

The sludge from water treatment plant and the clay from Penggaron Kidul were taken and then tested to reveal their physical characteristics.

Table 1. Atterberg

Sample	Plastic Limit	Liquid Limit	Plasticity index
Clay	35	277	242
Sludge	45	154	109

Table 2. Moisture

Sample	Optimum Moisture Content (%)	Natural moisture content	Maximum Dry Density (gr/cc)
Clay	27.5	13%	1.75

Sludge	26.65	10 %	1.71
--------	-------	------	------

Table 3. Specific Gravity, shrinkage and cohesion

Sample	Specific Gravity	Shrinkage Limit (%)	Cohesion (kg/cm ²)
Clay	2.42	37.15	0.22
Sludge	2.12	35.15	0.21

The test result of particle size distribution of natural clay from the above graph was obtained as much as 74% natural clay grain which passed on filter No.200 (0,075mm), and for sludge was obtained as much as 62%. The results were adjusted according to ASTM D 2487 and it was obtained that natural clay and sludge belonged to "fine-grained soil" consisting of 2 types of silt and clay.

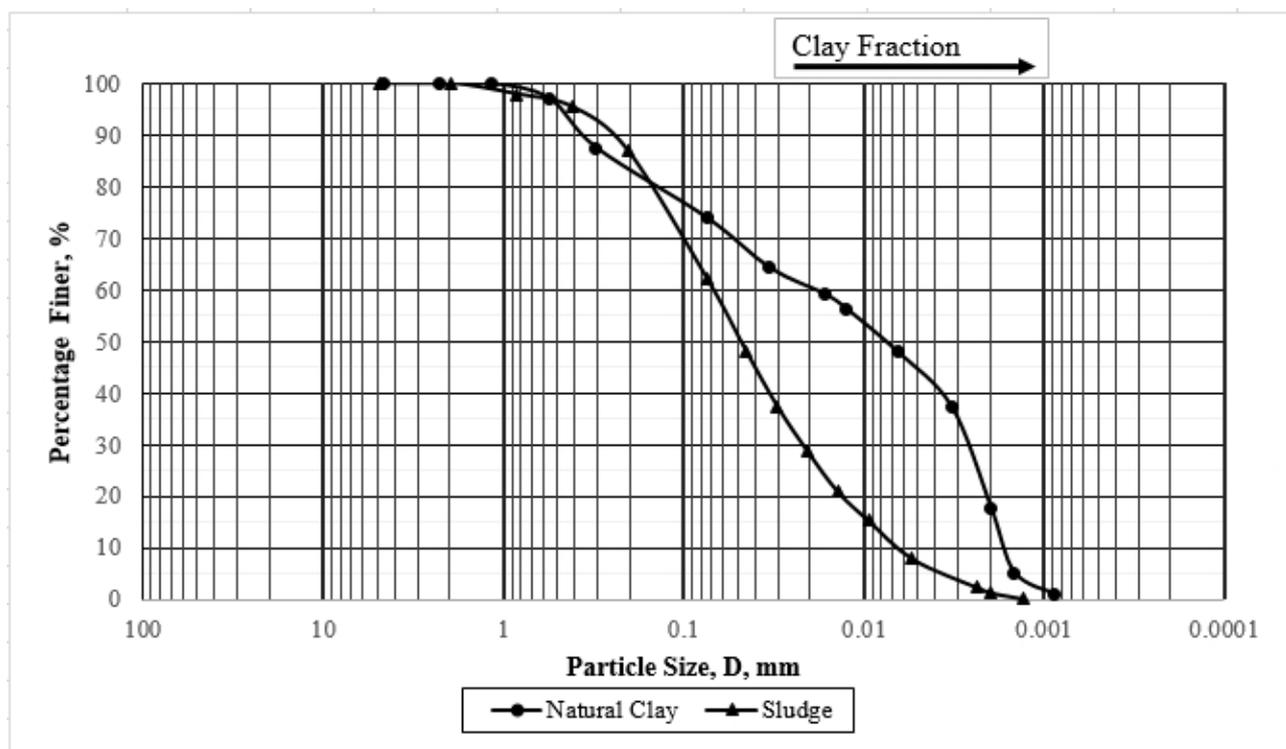


Fig. 3. Particle-size distribution of Natural Clay and Sludge

To obtain the specific characteristics of natural clay and sludge, the analysis of atterberg limit was conducted. Atterberg test results of natural clay obtained a result of 277 for clay liquid limit and plasticity index of 109 which indicating that the natural clay was belonged to the category of CH (Clay High Plasticity) [7]. While atterberg sludge test results obtained a result of plasticity index of 242 and 154 for liquid limit indicating that sludge was belonged to the category of OH (Organic Clay High Plasticity). Atterberg test results also resulted in a correlation of mineral characteristics showing that natural clay belonged to smectitic clays and sludge belonged to kaolinitic clay, in accordance with previous study [5] that the smectitic clays had a liquid limit up to 680% and kaolinitic clay had a liquid limit up to 85%.

4 Conclusion

Natural clay derived from Penggaron industry with sludge from Tirta Moedal PDAM WTP has physical characteristics that are almost the same with the classification of "clay high plasticity". Judging from the characteristics of mineralogy which is the correlation of atterberg limit value, natural clay and sludge belong to class of smectitic clay.

This research was financially supported by The Faculty of Engineering, Diponegoro University, Indonesia through Strategic Research Grant 2018.

References

1. Lai, J.Y. and Liu, J.C., 2004. *Water Science and Technology*, 50(9), p.41.
2. Algamal, Y., Khalil, N.M. and Saleem, Q.M., 2018. *Journal of Chemical Technology & Metallurgy*, 53(3).
3. Dalkılıç, Neslihan, and Adnan Nabikoğlu. *Frontiers of Architectural Research* 6, no. 3 (2017): 346-359.
4. Benlalla, A., M. Elmoussaouiti, M. Dahhou, and M. Assafi. *Applied Clay Science* 118 (2015): 171-177.
5. Hasan, U., Chegenizadeh, A., Budihardjo, M.A. and Nikraz, H., 2016.. *Journal of GeoEngineering*, 11(2), pp.59-73.
6. Spagnoli, G., Sridharan, A., Oreste, P., Bellato, D. and Di Matteo, L., 2018.. *Applied Clay Science*, 156, pp.152-159.
7. Hasan, U., Chegenizadeh, A., Budihardjo, M.A. and Nikraz, H., 2016. *Geotechnical and Geological Engineering*, 34(6), pp.1707-1722.