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POTENTIAL OF SLUDGE WASTE UTILIZATION AS CONSTRUCTION MATERIALS VIA GEOPOLYMERIZATION

Mohd Mustafa Al Bakri ABDULLAH[1,2*], Norshahrizan NORDIN[3], Muhammad Faheem Mohd TAHIR[2], Aeslina Abdul KADIR[4,2], Andrei Victor SANDU[5,6*]

[1]Faculty of Engineering Technology, Universiti Malaysia Perlis (UniMAP), Malaysia
[2]Center of Excellence Geopolymer & Green Technology (CeGeoGTech), Universiti Malaysia Perlis (UniMAP), Malaysia.
[3]School of Business Innovation and Technopreneurship (PPIPT), Universiti Malaysia Perlis (UniMAP), Malaysia
[4]Faculty of Civil and Environment Engineering (FKAAS), Universiti Tun Hussein Onn Malaysia (UTHM), Malaysia
[5]Faculty of Materials Science and Engineering, Gheorghe Asachi Technical University of Iasi, Romania
[5]Romanian Inventors Forum, Str. Sf. P. Movila 3, Iasi, Romania

Abstract

The amount of sludge wastes produced from mining, domestic agriculture and industrial activities are about 60200 tons per year. The waste increase will have a significant impact on the energy conservation and also on the environment. Many attempts have been made to use sludge waste as construction materials such as brick; for example sewage sludge, water sludge, ceramic sludge and fly ash sludge and also advantages on the properties have been found but heavy metals leachibility will be the main concerned. Geopolymer has an ability to encapsulate heavy metals. Therefore, sludge waste is a potential alternative to convert into useful products as building materials that can alleviate the disposal problems. Therefore, in this study the potential of sludge waste to be utilize as construction materials has been studied.

Keywords: *Sludges waste; Incapsulate heavy metals; Leachibility; Geopolymer; Construction materials*

Introduction

According to Malaysia Environment Quality Report (2002), heavy metals from sludge are the second largest waste in Malaysia generated by industrial activities [1]. The amount of sludge wastes from industrial, mining and domestic agriculture activities is around 60200 tons per year. The industrial sector is facing problems when it comes to finding alternatives to deal with the sludge disposal and at the same time to meet the standards for environment preservation. In order to be able to implement disposal actions, the government needs to focus on finding a large space and cover the high cost of transportation and maintenance during the disposal operation. Inorganic sludge content from industrial waste such as heavy metals should get the specific treatment to prevent the polluting of the environment. The main issue with the sludge production industry is the fact that the sludge production increases every year and gives a negative impact on the future environment and the waste is not reused in other purposes [2].

* Corresponding author: mustafa_albakri@unimap.edu.my, sav@tuiasi.ro

Geopolymer is the cementitious material used to replace cement, obtained by adding pozzolanic compound or mineral rich alumino silicate (Si-Al) catalysts, including sodium silicate solution (Na_2OSiO_3) and sodium composition hydroxide [3]. It's a material made essentially from a mixture of sodium hydroxide and sodium silicate solution which, when combined with powdered materials such as fly ash or calcined kaolin, forms a material with properties similar to cement and in the same range as Portland cement paste [4-6]. Although these three components can vary a lot, from the concentration of sodium hydroxide and sodium silicate, to the ratio of the two solutions all the way to the composition of fly ash, there is a general consensus that producing geopolymer reaction is a form of polymerization [7-9]. Sludge waste has the potential to be used as a construction material, through geopolymerization technique due to its high silica and alumina content. The utilization of sludge waste as construction material can convert the waste into useful products, and thus resolving the sludge waste disposal problems [10]. Thus, recycling mosaic sludge waste could be one of the best alternative methods in terms of environment as well as economics. Therefore, the aim of this study was to determine the potential of sludge waste in order to be utilized as a construction material similar to concrete, mortar or brick via geopolymerization technique.

Sludge

Sludge is the semi-solid byproduct that had been produced from sewage treatment processes or industrial wastewater. Sustainable sludge handling may be defined as a socially acceptable, cost effective method that meets the requirement of efficient recycling of resources while ensuring that harmful substances are not transferred to humans or the environment [11]. Sludge handling and disposal includes collection process, transferring process, and handling process of the sludge to convert it to a form that is suitable for disposal. Figure 1 shows the final disposal of the sludge.

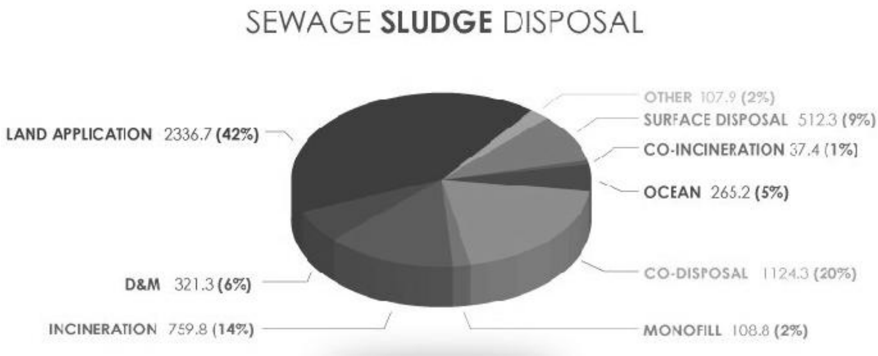


Fig. 1. Sewage Sludge Disposal [11]

Types of Sludge

The volume of liquid sludge produced at a sewage treatment plant usually represents approximately 1-2% of the total sewage flow, but treatment and disposal can account for approximately 30-50% of the running costs of the works. Sludges from conventional sewage treatment plants are derived from primary, secondary and tertiary treatment processes. Types of sludge and other solids, such as scum, grit, and screenings in a wastewater treatment plant vary depending on the type of plant and its method of operation (biological, primary and chemical treatment facilities) [12].

Wastewater sludge can be classified generally as primary and secondary, also called chemical and biological. Sludge contains settleable solids such as (depending on the source) biological flocs, food waste, silt, fibers, organic chemic compounds, fecal material, and in organics, including trace minerals and heavy metals. The sludge is raw when it has not been treated biologically or chemically for volatile solids or pathogen reduction. When the sludge is treated, the resulting biosolids can be classified by treatment, in alkaline stabilized, aerobically digested (thermophilic and mesophilic), thermally dried, and composted. The treated sludge can be only primary, secondary, or chemical or a mixture of any two or three of the sludges.

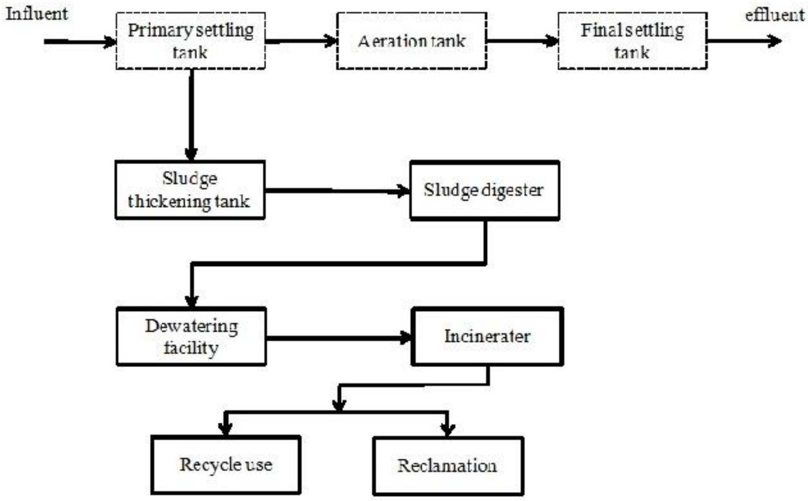


Fig. 2. Sludge Treatment [13]

Primary Sludge. Consisting largely of faecal solids, the primary sludge will also contain paper, sanitary and medical products, grit, kitchen wastes and other mineral matter. The pre-treatment, i.e., inlet screening, grit removal trap, etc., will remove the vast majority of non-biodegradable material and should always be used whenever possible. Primary sludge will also contain a variety of pathogenic micro-organisms. A typical domestic primary sludge will contain approximately 5.0-6.0% dry solids and does not normally require thickening prior to further treatment [13]. Most wastewater treatment plants use the physical process of primary settling to remove settleable solids from raw wastewater. In a typical plant with primary settling and a conventional activated sludge secondary treatment process, the dry weight of the primary sludge solids is about 50% of that of the total sludge solids. The total solids concentration in raw primary sludge can vary between 2% and 7%. Compared to biological and chemical sludges, primary sludges can be dewatered rapidly because they are comprised of discrete particles and debris and will produce a drier cake and give better solids capture with low conditioning requirements. However, primary sludge is highly putrescible and generates an unpleasant odour if it is stored without treatment [11].

Secondary Sludge. Also known as biological sludge is produced by biological treatment processes, such as activated sludge, membrane bioreactors, trickling filters, and rotating biological contractors. Plants with primary settling normally produce a fairly pure biological sludge as a result of the bacteria consuming the soluble and insoluble organics in secondary treatment system. The sludge will also contain those solids that were not readily removed by primary clarification. Secondary sludge generated in plants that lack primary settling may contain debris such as fibbers and grits. Activated sludge and trickling filter sludge generally contain solids concentrations of 0.4% to 1.5% and 1% to 4%, respectively, in dry solids weight [13]. Biological sludge is more difficult to dewater than primary sludge because of the light biological flocs inherent in biological sludge.

Tertiary Sludge. Tertiary sludge is derived from tertiary treatment processes and comprises the fraction of secondary sludge that remains in the effluent from the secondary clarifier that is removed by the tertiary treatment filters. Tertiary sludge forms a very small part of the total sludge production of a plant and is normally returned for further treatment or co-settlement. Sludge produced during physico-chemical treatment for nutrient removal of secondary effluents such as phosphorous precipitation, is included in this category. Tertiary sludge rarely contains more than 1.0% dry solids [11].

Attached Growth System Sludge. The microorganisms in attached growth secondary treatment systems such as trickling filters and rotating biological contactors (RBCs) are biochemically similar to the microorganisms that predominate in activated sludge systems. Consequently, the biomass production from attached growth systems and activated sludge systems is roughly similar when compared on the basis of a kilogram of biomass produced per kilogram of substrate removed.

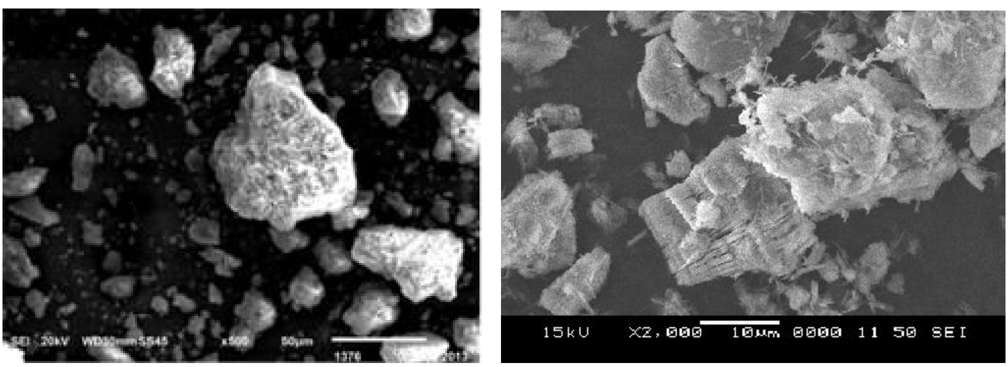
Chemical Sludge. Chemicals are widely used in wastewater treatments to precipitate and remove phosphorus and in some cases to improve the efficiency of suspended solids removal. Chemicals can be added in raw wastewater, to a secondary biological process, or to secondary effluent, in which case tertiary filters or tertiary clarifiers are used to remove the chemical precipitates [11]. Although theoretical rates of chemical sludge production can be estimated from the anticipated chemical reactions, competing reactions can make the estimation difficult. The quantities of precipitates in chemical sludge are influenced by such conditions as pH, mixing, reaction time, and opportunity for flocculation.

Humus Sludge. Humus sludge is the product of settlement of effluents from biological filters, submerged aerated filters, etc. and is mainly bacterial and fungal material sloughed from the filter media. Typical humus sludge contains 0.5-2.0% dry solids and is not easily thickened/dewatered alone.

Surplus Activated Sludge. In an activated sludge plant, polluting matter is transferred to the mixed liquor suspended solids thus increasing its mass. To maintain an optimum level of mixed liquor suspended solids, a portion of sludge is removed at regular intervals and is known as surplus activated sludge. The sludge will consist mainly of flocculated and synthesised solids and micro-organisms. Surplus activated sludge rarely contains more than 1.0% dry solids and requires thickening prior to further treatment [11].

Sludge in Geopolymer

Previous research shows a potential of sludge to be used as geopolymer raw materials due to its characterization which is quite similar to the properties of kaolin [14, 15]. Kaolin widely being used as geopolymer raw material. Based on Cherdsak, the particles of sludge are irregular in shape which is similar to kaolin as shown in Figure 3. The geopolymer made with sludge waste can give a compressive strength up to 20 MPa for 7 days compressive strength [16]. This shows that sludge waste is a potential geopolymer raw material.



(a) (b)

Fig. 3. Scanning Electron Microscopy (SEM) images of: sludge [10] and kaolin [11]

Conclusion

The findings from the reviews show that the waste sludge has great potential as a raw material, in producing construction materials such as concrete, brick or aggregate with desirable strength instead of cost effective construction material. This can also be a solution for the sludge waste management. Therefore, sludge could be an alternative low cost material in construction materials manufacturing via geopolymerization technique and can also provide a disposal method for the sludge waste.

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