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The Preliminary Investigation on The Dredged Marine Sediment of Kuala Perlis as A Potential Brick Material

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Abstract. The marine sediment of estuary of Perlis River has to be dredged out of the basin to maintain the depth of ferry, boat and shipping channel. These dredged sediments were dumped back to the sea as marine disposal. However, these dump materials can come back to the river mouth depends on the wave flow where it possibly will contribute to the rapid sedimentation to the existing sediment brought by the river current. Consequently, the Marine Department which has authorities to maintain the water depth of harbour is burdened with high maintenance cost due to the frequent dredging activity. Therefore, it is important to introduce an alternative solution to manage the marine disposal other than dumping it back to the sea. Several experiments on physical and chemical properties were conducted to examine the suitability of marine sediments to be used as raw material in brick production. The investigation data showed that there are some suitable components for the brick material such as the existence of silica and alumina in the sample collected. In addition, the sediments were not hazardous as the heavy metal results were within guideline of US EPA.

Keywords: Marine sediment, Chemical properties, Physical properties.

1. Introduction

Each harbour or jetty that is involved with shipping and ferry activities have to sustain the ideal depth of ferry or shipping path by dredging out the marine sediment from the waterway basin. This dredged sediment can be classified as waste material and generally managed either by dumping back to the ocean or deposit it to the landfill. In the case of Kuala Perlis marine sediment, the dredged materials were dumped back into the sea at certain location.

Marine Department of Malaysia is the authority that manages the deepening work of the estuary of Perlis River and to maintain the depth of ferry and shipping channel. Approximately 300 000 m^3 of marine sediments have been dredged out of the basin of Perlis River mouth in two or three years time which costs about RM20 to RM30 million at each cycle of the dredging activity. The dredging cost seems to increase in the future due to the rapid sedimentation that happens lately at Kuala Perlis. There are a few factors that contribute to the rapid sedimentation such as location of Kuala Perlis that is situated at the bay area of Langkawi Island just around. This could drive the problem of dumping sediment returns to the river mouth in a short time and also depend on the wave flow. Besides, flood that happen frequently in Perlis also contributes to the rapid sedimentation where the river current brought the mud and silt to the river mouth at Kuala Perlis which placed the jetty and fishing port. Hence, the Marine Department will burden with the increment of dredging coat. Therefore, it is essential to seek for alternative strategies in marine disposal

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management such as by reusing this waste material for other purposes. In this paper, we will concentrate on the investigation of the Kuala Perlis marine sediment characteristics and to check the suitability to recycle this waste material in brick production.

The studies of marine sediment to reuse as a raw material for brick production have been done in Bremen, Germany [1] and Georgia, United States [2]. These researchers introduced the fired brick product from dredged marine sediment. However, the different location and activity of harbour or jetty could affect the characteristics and level of contaminant of the sediment that depend on the sources of the river water. In the case of Kuala Perlis, the sources of river sediment there are mostly come from agriculture activity and some come from industrial and residential waste. The different in sediment properties and contaminant level will influence the chosen types of brick making process. Thus, it is significant to examine the characteristics of the marine sediment before deciding to reuse as a raw material in brick production. Several studies also have been reported that marine sediment is possible to recycle to form other construction material such as ceramic tiles [3], light-weight aggregates [4] and pavement base material [5].

2. Material and Method

2.1. Site Description and Materials

There are two major economic activities at Kuala Perlis that give most impact on the Perlis Economy. The activities are fishing port and passenger jetty to Langkawi Island where both located at the estuary of the Perlis River. Kuala Perlis jetty is one of the major departures and return ferry terminal for Langkawi Island besides Kuala Kedah jetty. The sedimentation of jetty path disrupts the ferry schedule and might affect the Perlis economy. Another economic activity at Kuala Perlis is fishing port which load and unload small-scale cargo arriving from Thailand and Indonesia.

In order to make sure these economic activities run smoothly without interruption that might affect the Perlis economy, it is essential to control the depth of boat and ferry channel. The marine sediment has to be dredged out of the basin of Kuala Perlis in an area stretching about 2 kilometres with 40 metres wide and 4 metres depth as illustrated in the Fig. 1. This deepening work was carried out once in two or three years time or depending on how fast the sediment increases which might disrupt the ferry, boating and shipping operations.

Fig. 1: Satellite map of dredging location at Kuala Perlis.

2.2. Method

Three samples of marine sediments were collected by randomly sampling method during dredging activity. These samples were wrapped with aluminium foil and tightened in the plastic bag. The samples were characterized for physical and chemical properties.

The grain size distribution was determined using standard pipette method and Atterberg's limit was analysed in accordance with ASTM D4318 by using cone penetration apparatus. Other set of test was carried out also in accordance to ASTM to determine the pH, moisture content, specific gravity, organic content and loss of ignition.

The studied samples were sent to the Laboratory of Universiti Kebangsaan Malaysia for chemical analysis using X-ray fluorescence to determine the major oxide compositions and heavy metal concentration.

These physical and chemical properties result were compares with the previous research to check on the possibility to reuse marine sediment of Kuala Perlis in brick production.

3. Result and Discussion

3.1. Physical Properties

The result of physical properties which consist of grain size distribution, Atterberg's limit, pH, moisture content, specific gravity, organic content and loss of ignition is shown in Table 1 and compare with the marine sediment physical properties of Savannah Harbour [2].

Table 1: Physical properties of dredged marine sediment of Kuala Perlis and Savannah Harbor [2]

Grain Size Distribution (%)			
Item	**Range**	**Average**	**Savannah Harbor [2]**
Clay	16.2 – 27.2	20.53	40
Silt	32.3 – 38.6	34.67	46
Fine sand	39.3 – 51.4	44.53	15
Coarse sand	0.1 – 0.4	0.27	
Atterberg's Limit (%)			
Liquid limit	70.5 – 71.6	71.05	80
Plastic limit	38.32 – 40.11	39.13	45
Plasticity index	31.49 - 32.18	31.77	35
Other Properties (%)			
pH	6.5 – 6.8	6.7	nr
Moisture content	62.6 – 70.2	66.13	nr
Spesific gravity	2.08 – 2.22	2.15	nr
Organic content	2.75 – 3.63	3.26	3.07
LOI	11.95 – 12.03	11.98	nr

nr = not reported

The result of grain size distribution and Atterberg's limit showed that the Kuala Perlis marine sediments is classified as sandy silt with high plasticity. The sediment has roughly 70 per cent moisture content. The existence of clay, silt and sand in the studied material is slightly similar with the content of raw material for some common brick product. Normally in practice, brick product should have clay fraction about 10 to 50 per cent with some presence of silt and sand [6]. The larger the proportion of sand will cause the brick more shapely, uniform in texture [7] and increase in strength. Therefore, marine sediment of Kuala Perlis have a possibility to be reuse as a raw material for brick product base on the physical properties data that almost similar to the existing brick product. In addition, based on the comparison data in between Kuala Perlis marine sediment and Savannah harbour marine sediment, the physical properties of studied marine sediment are quiet similar with the marine sediment properties of Savannah harbour except the sand content of studied sediment is higher than Savannah harbour marine sediment.

3.2. Chemical Properties

Chemical composition

The obtained data of chemical composition analysis for dredged marine sediment of Kuala Perlis are presented in Table 2. The results of studied sediment are also compared with the previous research. The major oxide components that contain in the studied sediments are silica, alumina, iron oxide, magnesia, potassium oxide and sodium oxide which some of these components are the major constituent of clay brick particularly silica and alumina component. Proportion of silica and alumina in brick material are necessary to form a strong durable brick product [6, 8]. The presence of iron oxide in the studied sediment is also significance to support the use of this sediment in brick making. The existence of iron oxide also will contribute to the hardness and strength of brick [7].

Table2: Comparison of chemical composition (%)

Component	Kuala Perlis, Malaysia	Bremen Harbour, Germany [1]	Savannah Harbor, US [2]
SiO_2	57.88	63	52.17
TiO_2	0.79	nr	0.89
Al_2O_3	17.40	11	17.16
Fe_2O_3	5.26	8.3	8.41
MnO	0.05	nr	0.23
MgO	2.48	0.9	1.56
CaO	0.77	1.8	1.76
Na_2O	1.44	1.9	0.5
K_2O	2.08	1.6	1.34
P_2O_5	0.16	nr	0.24
LOI	11.98	10	nr

nr = not reported

Based on the comparison results of chemical composition, the dredged marine sediment of Kuala Perlis is more or less the same with the two previous reported researches which had successfully reused the dredged sediment for fired brick product. The significant different of the comparison data appear at the component of iron oxide and potassium oxide. The value of iron oxide is lesser but the value of potassium is slightly higher compared to the previous studies.

On average, the chemical composition of studied sediment is much similar to the dredged marine sediment properties from Savannah harbour. Thus, it is proven that the studied marine sediment is highly potential to be reused in brick making industries.

Table 3: Comparison of heavy metal concentration (mg/kg)

Composition	Kuala Perlis, Malaysia	Bremen Harbour, Germany [1]	Savannah Harbor, US [2]	EPA[a]
As	11. 67	15	22.67	41
Cr	85.33	131	71.33	1200
Cu	23	87	17.3	1500
Ni	49.33	60	18.87	420
Pb	73.67	122	25.7	300
Zn	109.67	790	104.07	2800

[a]US EPA pollutant concentration limit (PCL) for biosolids productively reused

Heavy metal concentration

Table 3 shows heavy metal concentration for the Kuala Perlis marine sediment with comparison data from the two previous studies and guidelines by US EPA pollutant concentration limit (PCL) for biosolids productivity reused [10].

The recycling of waste material into a new product can be problematic if the level of contaminant in the material is high and harmful to human and environment. Therefore, it is essential to examine the heavy metal concentration to ensure the reuse material is no danger due to the environmental impact. The comparison result shown in Table 3 indicates that dredged marine sediment of Kuala Perlis results were approximately similar to the result of Savannah Harbor for most parameters except for lead and nickel but for Bremen Harbour, all parameter concentrations were higher than Kuala Perlis. However, the Kuala Perlis results are comply with the US EPA guideline since it is lower than the limit value stated in the guideline.

4. Conclusion

The study was conducted to evaluate the physical and chemical properties in the dredged marine sediment of Kuala Perlis and to investigate its feasibility to be used as a feedstock in brick production. Based on the obtained data, it is clearly shown that studied marine sediment is compatible with the previous research which had successfully produced fired brick product from dredged marine sediment. In addition, the level of heavy metal concentration is also acceptable since it is under the limit of US EPA guideline. These data also showed that no inconsistencies that could affect the possibility of using the dredged marine sediment as a raw material in brick production. However, further study will focus on the producing of unfired brick using marine sediment in order to reduce the brick making cost.

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