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Environmental application for GIS: Assessing Iskandar Malaysia's (IM) sewage sludge for potential biomass resource

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Abstract. The low carbon scenario could be achieved through the identification of major sectors contributing to the emission of high greenhouse gases (GHG) into the atmosphere. Sewage treatment plant (STP) was ranked as one of the major sectors that emits methane gas (CH_4) during treatment processes, including sludge treatment. Sludge treatment is also capital extensive with high operational cost. Thus, sewage sludge has been accepted as a nuisance in STP. However, many has claimed that, sludge produced contain organic matter that has the potential for biomass resource. Thus, it would be such a 'waste' if sludge are directly disposed of into the landfill without utilizing them at its full potential. In order to do so, it is vital to be able to determine the amount of sludge production. This research was implemented in Iskandar Malaysia regions in the state of Johor. By using GIS tool, the regions that produced the most sewage sludge can be determined, and can be group as critical area. Result shows that Nusajaya produces the most, compared to other regions, which indicated Nusajaya as a densely populated region.

1. Introduction

In 2009, nearly 100 country leaders attend the United Nation Climate Change Conference (UNCCC) held in Copenhagen. The conference was also known as COP15. [1,2,3] The main objective of this summit is to tackle climate change issue. And to prove that Malaysia is in support of tackling climate change, the country has made a voluntary pledge in the summit that Malaysia will commit to reduce up to 40% carbon dioxide (CO_2) emission in terms of greenhouse gas (GHG) emission intensity of gross domestic product (GDP) by the year 2020, compared to 2005 levels. According to the data provided by United Nation, it could be seen that Malaysia's carbon emission in 2006 stood at 187 million tonnes, or 7.2 tonnes from each Malaysian [1]. Thus, the issue discussed for Malaysia is the concern in reducing GHG and providing financial aid from developed countries.

In line with this effort, Iskandar Regional Development Authority (IRDA) which is located in Iskandar Malaysia (IM) in the state of Johor is collaborating with a local institution, Universiti Teknologi Malaysia (UTM) and Japanese parties (Okayama University, Kyoto University, JICA, NIES,) in a joint research to reduce carbon emission. Low Carbon Scenario for Asian Region (LCSAR) project provided a number of alternatives and options in reducing energy consumption in current activities, let it be in town planning, waste management and improving technology. This will

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provide an opportunity for Malaysian to identify sectors that has the potential of emitting large amount of CO_2, and whether or not these sectors can be improvise by promoting reasonable practice suitable with local situations. [7]

One sector in particular is the sewage sludge management. It has been accepted worldwide that sludge is a nuisance in wastewater treatment, because of the waste produce during treatment is generated in order to achieve clean and treated water. [4,13,8] Fortunately, this waste has been researched into, and many claims suggested that, sludge contains organic matter that can be recovered to solve the issue with sludge management, let it be in material recovery and potential renewable energy. [13,11,8]. In doing so the biomass resource has the potential to reduce our reliability towards fossil fuel and coal as a source of energy which contribute to the rise of carbon content in the atmosphere. Thus, it is such a 'waste' to directly disposed the sludge off without able to use its full potential. This options were provided as an alternative in current sludge management.

The management of the increasing volume of domestic and industrial organic wastes has been one the prime environmental issues in Malaysia. The management of sludge produced by STP's is a difficult problem to be tackled and solved in both industrialized and developing countries. This is because sludge produce amounts to only a few percent by volume of the processed wastewater, but its handling accounts are up to 50% of total operating costs. [13] Approximately 4.2 million cubic meters of sewage sludge (pure organic waste without mixing with the industrial waste) is produced annually by Indah Water Konsortium (IWK), a national sewerage company in Malaysia and the total cost of managing is estimated at Ringgit Malaysia (RM) 1 billion (US$ 0.35 billion) [4]. Other than that, the situation concerning sludge treatment and disposal differs as population density and the percentage of inhabitants connected to a STP varies widely. Therefore, regional sludge production depends not only on the number of inhabitants, but also on the development and efficiency of the treatment. The combination of both factors results in different solutions for sludge management. Overall, the increase production of sludge can be summarized by not only the human population growth, but also the development and efficiency of the technology used.

Technological development such as the Global Information Systems (GIS), has the capability to geo-reference the environment. Reducing the risk caused by climate change is an immense challenge. Scientist, policy makers, developers, engineers, and many others have used GIS technology to better understand a complex situation and offers some tangible solutions [6]. Technology offers a means to assess, plan, and implement sustainable programs that can affect us 10, 20 and 100 years in the future. With GIS, plotting of potential biogas sites is a made possible, specifically STP. Hence allowing for locating and observing the distribution of the STP's in IM. This assist in the estimation or forecasting sludge production in IM. In order to promote a low carbon scenario (LCS), the resource and location of potential carbon emitter must first be identified. This study focuses on the potential sources of domestic sludge. Thus, the source of such sludge will be the STP's located in IM. The use of GIS in geo-reference the environment appears to be a very useful tool. This paper will look into the use of GIS tool in mapping the STP's in IM, which acts as a stepping stone in promoting LCS through sludge management.

2. Methodology

2.1: Phase 1
Plotting sewage treatment plants (STP's) with GIS Tool

The overall approach is summarized in in Figure 1 and requires GIS tools like Arcgis Software.

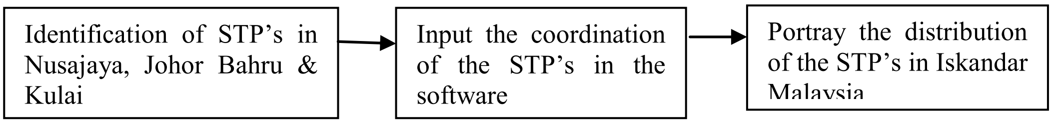

Figure 1: Flow diagram showing approaches in plotting the location of STP's

By using ArcGIS tool, the distribution of STP's can be located. The coordinates of the STP's are obtained from Google Earth (in Northing and Easting). The coordinate (which is in degree minute second) must be converted into decimal degree first before adding the points in ArcGIS software. All the information of STP's such as coordinate, name of location, treatment, population equivalent and estimated of sludge production (ESP) must be saved in Excell format. Add XY Data tool is used to locate all points which is saved in Excell format. The points must be exported into shape file data layer (named export_all) before they can be used in ArcGIS. Automatically all the information of STP points can be obtained from Attribute Table of export_all layer. Adding the layer of study area (Iskandar Malaysia region in Johor). The projection of both layers involved must be same (used Kertau_RSO_Malaysia_Meter projection). After adding both layers, we can see the distribution of STP's in Iskandar Malaysia. Map of the distribution can be produced by using the Layout View tool and Export Map tool.

Since this research was conduct in a short period of time, IWK was able to assist in providing the location of the public and private treatment plant in Nusajaya and Kulai region only. Whereas, Johor Bahru region, the location of the STP's were gathered through the Comprehensive Development Plan (CDP) report prepared for Iskandar Malaysia. Pasir Gudang region was not covered in this study. With this information, the coordination of the STP's can be placed in the software.

2.2: Phase 2
Sludge production estimation from STP's

The second map produced is about the distribution of estimated sludge production (ESP) in every STP's. The classification of the value of ESP is done by using Point Density in Spatial Analyst Tool. The Point Density calculates a magnitude per unit area from point features that fall within a neighbourhood around each cell. The Density function distributes a measured quantity of an input point layer throughout a landscape to produce a continuous surface. The classification method used is standard deviation where its interval size is 1/3 standard deviation.

The data used for this study is solely relied and revised from literature review, thesis, and reliable IWK websites since the study was conducted in a short period of time, for this phase. The aim is to quantify the amount of sludge produce individually based on the given information. In order to do so, Malaysia population generation as well as sludge generation were required. From there, the scope can be focussed towards the population in IM. According to Fakhru'l-Razi *et al*., 2002 and IWK, by the year 2005, 4.3 million cubic meters (pure organic waste without mixing with the industrial waste) of domestic sludge is produced annually. [17]. Other than that, the information on sludge treatment as well as its capacity were obtained from *2006-2025 Comprehensive Development Plan for South Johor Economic Region.* Thus, by dividing this rate to Malaysia's population, the estimate the sludge produce individually can be determined, and then can be key input in the GIS software. This will provide information in identifying which regions in IM produce the most domestic sludge and can be considered 'critical area'.

3. Result and Discussion

Since this research was carried out in a short period of time, thus the regions involved in this study were only based on the available data on hand. For this study, only three regions in IM were engaged - Nusajaya, Johor Bahru and Kulai. After gathering the information, with the aid from ArcGIS tool, Figure 2 was plotted, which portrayed the location of the STP's found within the three regions (Johor Bahru, Kulai and Nusajaya). The estimated sludge production in the STP's were determined and illustrated as in Figure 3. The ones in red colour represent the highest amount of sludge produced, which also represent the ‘critical’ area. From the figure it could be seen that, Nusajaya a highly populated region has a couple of reds as compared to the other two regions.

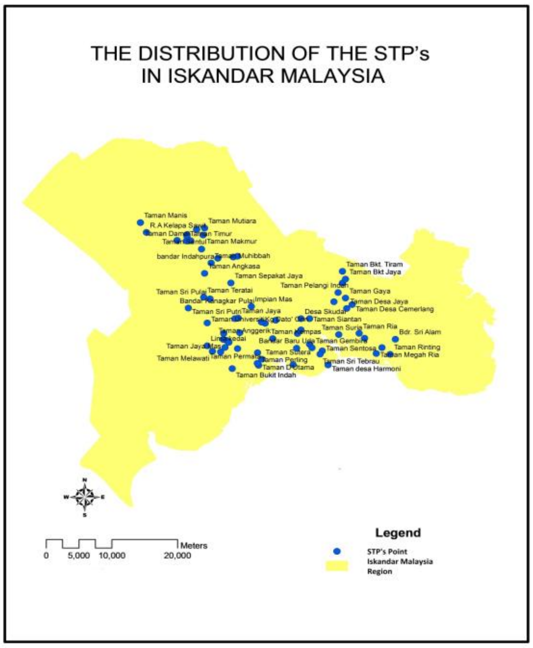

Figure 2: The distribution o the STP’s in Iskandar Malaysia

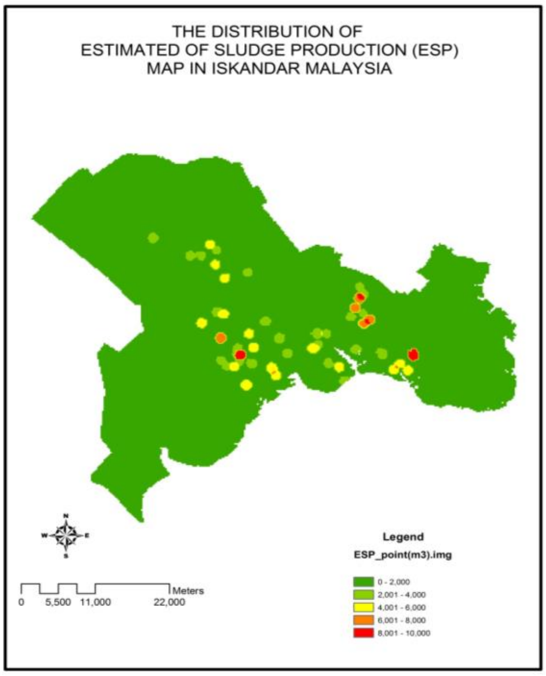

Figure 3: The distribution of ESP in Iskandar Malaysia

Table 1 summarized the vital information needed for this study. From the table, Johor Bahru has the highest number of treatment compared to the other two. This treatment includes Imhoff Tank, oxidation pond, extended aeration, rotating biological contactors, communal septic tanks and oxidation ditch. The sludge quantities produced are directly linked to the volume and characteristic of wastewater treated which is dependent on the rate of wastewater collection, type of treatment, size of population connected and type of industrial connected. In other words, the sludge produced thus not rely solely on the population, but also dependent towards the efficiency and the level (primary, secondary, tertiary) of the treatment, as well as number of treatments.

Table 1. Treatment plants in in Iskandar Malaysia.

Region	Number of treatment plants based on location	Number of treatments	Population equivalent
Johor Bahru	25	797	123,050
Nusajaya	39	163	449,459
Kulai	20	40	60,727

Based on Table 1, it could be seen that Johor Bahru has 797 treatments within those 25 treatment plants, but Nusajaya has only 163 treatments in its 39 treatment plants. It can be assumed that the treatments in Nusajaya region is not as efficient as in Johor Bahru. This might be due to the existing facilities in Nusajaya has not been upgraded to improve their performances. Thus, measures need to be taken to resolve this issue.

4. Conclusion

A significant proportion of the studied area is locating the STP's in order to estimate the sludge produced in the area of the STP's. To achieve this, an understanding of the sludge production is necessary. It is advantageous to adopt a holistic or systematic approach in solving this issue. All these can be achieved only through the collection of accurate, reliable and comprehensive set of scientific data. Remote sensing technology in recent years has proven to be of great importance in acquiring data for effective resources management and hence could also be applied to coastal environment monitoring and management. Further, the application of GIS (Geographical Information System) in analysing the trends and estimating the changes that have occurred in different themes helps in management decision making process. The study uses GIS to determine STP's sites and sludge production. By doing so, this help in portraying the distribution of the STP in the region. And with the help of GIS tool, estimation of sludge production is made possible, based on the population equivalent of the treatment. The critical area were also determined.

5. Acknowledgement

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