Blue Water Footrpint- Industrial Water Consumption Nexus: A Case of Water Supply for Industrial Activities in Semambu Water Treatment Plant

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Abstract. Water supply and industrial activities have a common attribute of being insufficient water resources. Both are involved in water footprint and water consumption Nexus, meaning that industrial water consumption is impacting the water footprint of water treatment plants within the same area. Therefore, in order to achieve the environmental sustainability of water resource, the requirement of having effective approach in water utilisation accounting is crucial. Thus, water consumption for industrial activities and water footprint of Semambu water treatment plant has been a case study to link the nexus. As the industrial development is expanding each year, water demand for water supply also increases. Generally, heavy industrial activities consume more water than the other types of industries. In this study, heavy industrial activities of water consumption show an impact towards total water footprint of the particular water treatment plant in Kuantan river basin. In 2018, the percentage of highest industries that exist is manufacturing sector with 32% while the lowest is 1% compared to 2015, 2016 and 2017 that only scored 30% for manufacturing sector respectively. This shown that there is an increment growth in manufacturing sector in 2018 when they suddenly go up 2% higher compared to 3 years previously. The results focus on total water footprint accounting of Semambu water treatment plant (WTP) and the impact of total blue water consumptions for industrial activities. Finally, total water footprint of water treatment plants in Kuantan river basin will be sustained to cater the industrial needs except for Semambu WTP since Semambu is a gazetted area for industrial. Hence the new method of water utilisation for the industrial activities must be proposed to decrease the dependent towards WTP, especially in Semambu area.

1.0 Introduction

Water needs are increasing globally causing an increase in clean water shortages [1] . The causes of the increased concern are various aspects namely increasing of the world population, increasing capital, a

transition from fossil-based to renewable energy sources and climate change [2]. The primary causes are due to population and economic growth [3]. As the economic growth, industrial sector is increased, industrial water consumption contributes to 20% of clean water consumption [4]. Therefore, industries also need to manage water use in order to improve water supply sustainability. Hence, Water Footprint (WF) can be used to investigate total water consumption. It is also possible to determine the connections between consumption behaviours, trade practices and anthropogenic water usage [5]. Moreover, the sustainable use of water resources could only be accomplished with the aid of rational and scientific planning of the distribution of water resources among the various industrial sectors. In this study, water footprint (WF) that is a multidimensional indicator of freshwater consumption volumes by sources as well as of polluted water volumes by types of pollution. It is further analysed as blue water footprint (WF_{grey}) and grey water footprint (WF_{grey}) in Kuantan River Basin (KRB). Besides, the WF_{blue} refers to the consumption of blue water resources such as surface and groundwater along the supply chain of an industrial product. The WF_{grey} is defined as the volume of freshwater that is required to assimilate the load of pollutants, given natural background concentrations and existing ambient water quality standards [6] in KRB. Previously, WF accounting has been used in assessing focused industry such as; construction materials [7], crude palm oil [8], gaming [9], iron and steel [10], and agricultural industry [6], [11]–[13]In this study, WF were used to assess industrial water consumption according to types of industrial sector.

The industrial sector can be generally divided into the heavy industry, medium industry and the light industry. The light industry provides goods in everyday life that people consume [14]. The light industry is a sector that is usually characterized by more consumer-oriented products, such as furniture, clothes and home appliances [15]. The light industry is less energy-intensive but more labour-intensive, making substantially different substitution relationships between input factors (capital, energy, labour) and types of fuel (coal, oil, electricity, etc.) [16]. Meanwhile, a medium-sized company is often called its industry's awkward middle child because too big to get the discounts and services offered to small businesses and too small to get the weight and prestige given to big industry. Medium industry also called Small and medium-sized enterprises (SMEs) or small and medium-sized businesses (SMBs) that is stand for small to medium industry. It is more critical in medium-sized industries, where producers need to produce the components quicker and with less errors at minimal cost and deliver goods to the consumer [17].Medium-sized (SME) industries are critical contributors to any economy's economic growth and development [18]. The heavy industry manufactures machinery and products for the propagation of the economy [14]. Large and heavy products large and heavy equipment and facilities (such as large machine tools, large buildings and large infrastructure) or complicated or various processes are mainly involved in heavy industry. Heavy industries are critical contributors to any economy's economic growth and development [18]. The impact of industrial development in Kuantan river basin (KRB) towards water footprint of water supply will be assessed in this study. Hence, this study aims to achieve the overall of blue water consumption for industrial activities at Semambu water treatment plant.

2.0 Methodology

2.1 Study Area

Kuantan river basin (KRB), is an important river that surrounds the state capital of Pahang in Kuantan. Normally, during the north-east monsoon season, it receives substantial rainfall from November to March. The KRB contains several tributaries which flow along the rural, agricultural, urban, and industrial areas of Kuantan district into the Sg. Kuantan. There are 5 water treatment plants (WTP) along KRB namely Semambu WTP, Panching WTP, Bukit Ubi WTP, Sungai Lembing WTP and Bukit Sagu WTP.

2.2 Data Collection

All data used were secondary data; table 1.0 shows the data and data source.

Table 1. Source of data collection

TYPE OF DATA	SOURCE
Industrial Premises	Kuantan Municipal Council
Industrial Water Consumption	Pengurusan Air Pahang Berhad
Water Intake	Pengurusan Air Pahang Berhad
Rainfall	Jabatan Pengairan & Saliran
Temperature	Jabatan Meteorologi Malaysia

2.3 Water Footprint of water supply in Kuantan River Basin (KRB)
This study carried out by referring to water footprint manual to account total WF [19]. Total water footprint has been assessed by adding WF_{blue} and WF_{grey}. The calculate the WF_{blue} is by using the equation as follow:

$$WF_{blue} = \text{water intake} + [\text{Evaporation} \times \text{Area of open tank}] + [\text{Rainfall} \times \text{Area of open tank}] \quad \text{(Equation 1)}$$

and to calculate WF_{grey};

$$WF_{grey} = \frac{L}{C_{max} - C_{nat}} \quad [\text{volume / time}] \quad \text{(Equation 2)}$$

each contaminant of concern must be calculated separately when evaluating the WF_{grey} of an activity or process. The WF_{grey} is calculated by dividing the pollutant load that reaches a water body (L, mass / time) by the critical load (L_{crit}, mass / time) times the water body runoff (R, volume / time). The total WF was accounted according to all 5 WTPs that abstracted water from KRB.

2.4 Industrial Water Consumption
Industrial activities were categorized into 3 categories which are; light, medium and heavy industry. Then, for each category, the activities were classified according to WTP area. Monthly water consumption data based on WTP were collected for each industrial and calculated based on industrial category.

2.5 Water Footprint – Industrial Water Consumption Nexus
Total WF for all 5 WTPs were analysed and discussed with the total industrial water consumption for each particular WTP for 2015-2018.

3. Results and Discussion

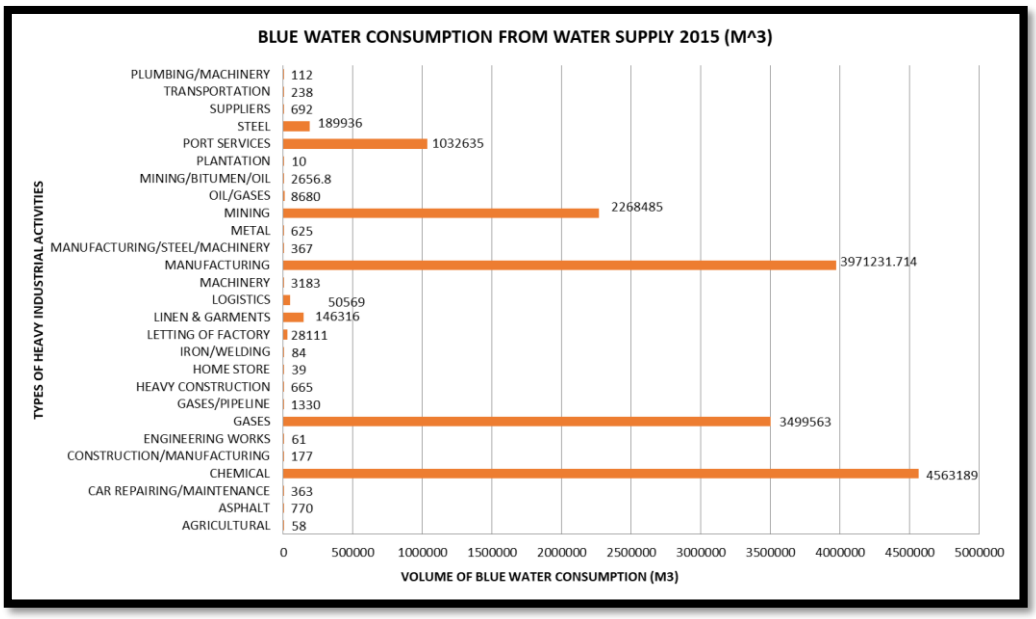

Figure 1. Water Consumption of Industrial Acitivities in Semambu for 2015

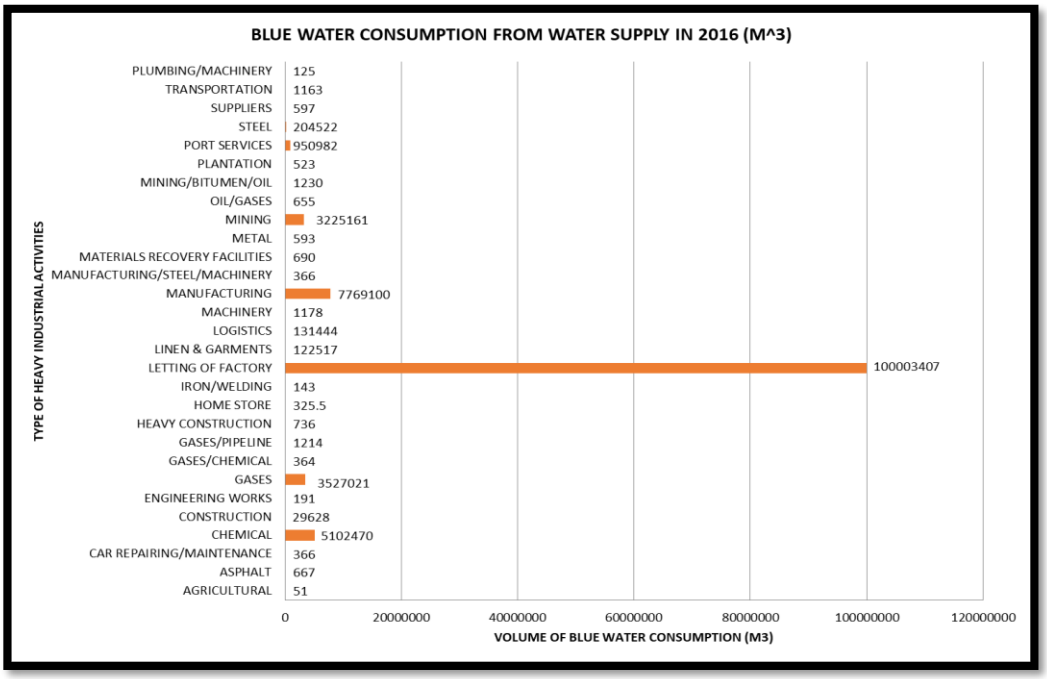

Figure 2. Water Consumption of Industrial Acitivities in Semambu for 2016

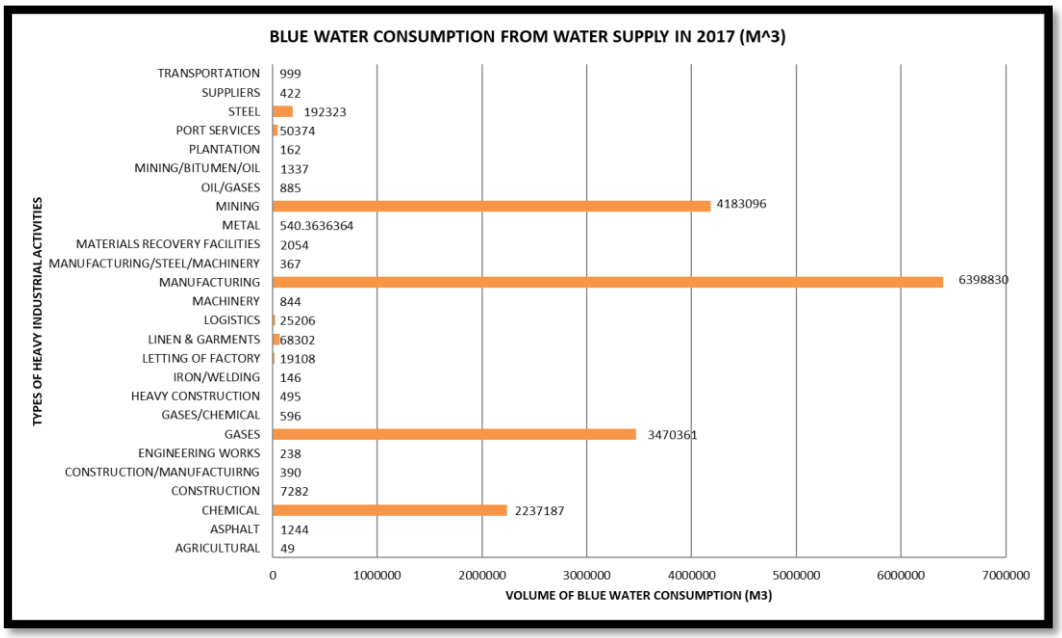

Figure 3. Water Consumption of Industrial Acitivities in Semambu for 2017

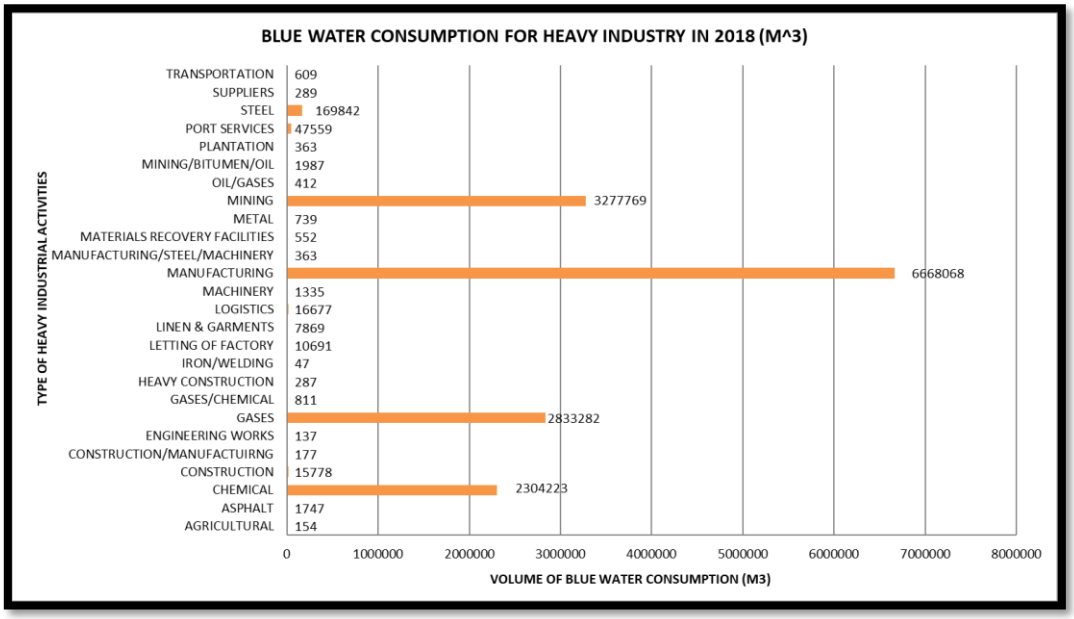

Figure 4. Water Consumption of Industrial Acitivities in Semambu for 2018

Semambu has been known as the intermediate city in Kuantan that have largest water treatment plant in Kuantan river basin. Many types of industries were found there received water supply from the same

water treatment plant. Study stated heavy industrial activities is currently driving the attention of water enthusiast because of their heavily intake in consumption that semi-affected other industries (light and medium) and domestic usage. Based on the data of blue water consumption for every industry that was found there, the data for heavy industries is collected to identify how much water intake that heavy industries consumed for every month. Also, each of the industries is categorized under the same type of sectors that they are under for example manufacturing sector, chemical sector, steel sector and more. Result presented in figure 1.0 found that there were 69 types of premises with different activities is recorded in 2015 while in figure 2.0 shows that there were 73 premises recorded in 2016. Figure 2.0 explained about the slump in number of activities in 2017 which decrease into 67 premises from 73 premises previously and lastly in 2018, there is a slightly increasing in number of premises shown in figure 4.0 that mark it as 68 premises in total compared to the year before. The sudden growth in premises which showed an increment of 4 premises according to their respective work sectors in 2016 is the biggest findings stated amongst the year of 2015 until 2018. This skyrocket growth is due to high demand in certain areas. The owner of the premises has a definite vision about a major chance in this market which later affect the growth in industrial activities. Compared to 2016, in 2017 and 2018 heavy industrial activities was having a definite plummet in counts. It was found that, there is a changed in address or the company in previous year are closing their premises due to financial issues or they move to other place to find bigger opportunity by moving and make their existence is ceased to exist.
The total blue water consumption for each of the activities were observed in 2015 to 2018. The monthly blue water consumption form each of the activities are total together to get the total monthly blue water consumption for that year. We been known that manufacturing sector is currently leading for 4 years straight from 2015 to 2018 as the sector who has the most demand from water supply in every month compared to other sectors. This make them as the highest consumer in all heavy industries sector located in Semambu.

From the research done, the percentage of heavy industrial activities according to their sector from 2015 to 2018 is presented in the form of pie chart. In 2018, the percentage of highest industries that exist is manufacturing sector with 32% while the lowest is 1% compared to 2015, 2016 and 2017 that only scored 30% for manufacturing sector respectively. The lowest percentage for the 2015, 2016 and 2017 is recorded as 1% respectively. This shown that there is an increment growth in manufacturing sector in 2018 when they suddenly go up 2% higher compared to 3 years previously.

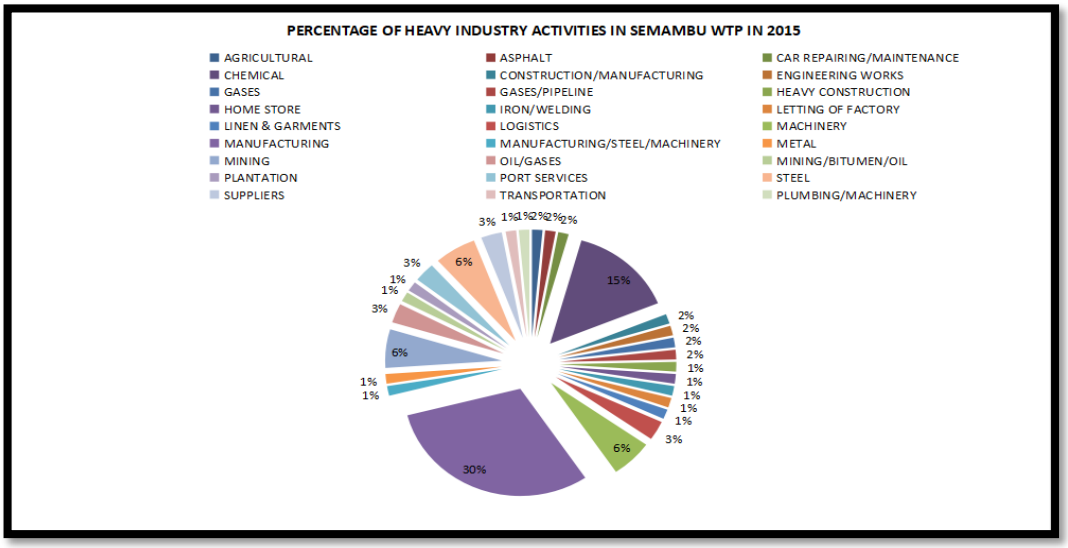

Figure 5. Percentage of heavy industrial activities for Semambu in 2015

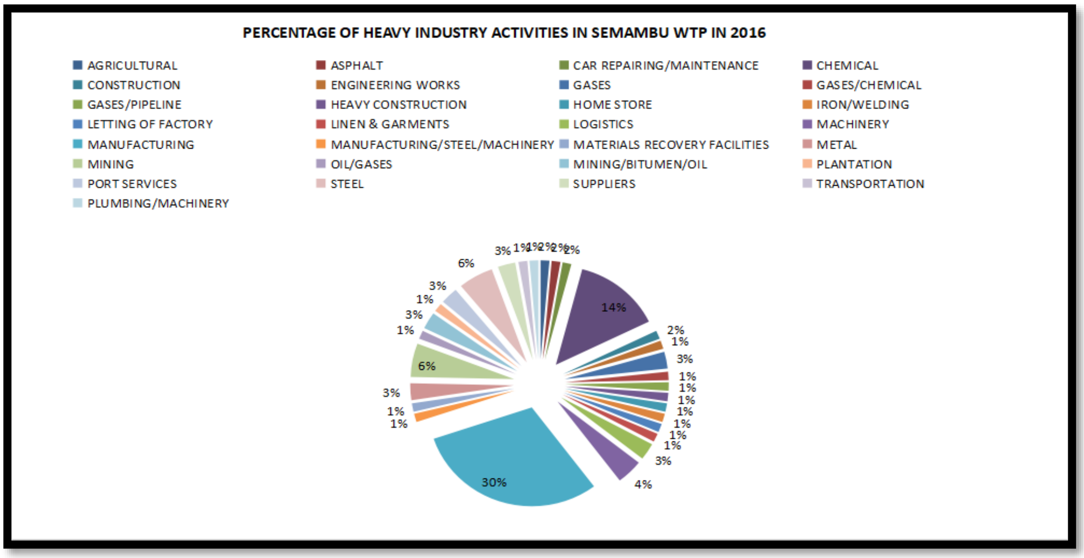

Figure 6. Percentage of heavy industrial activities for Semambu in 2016

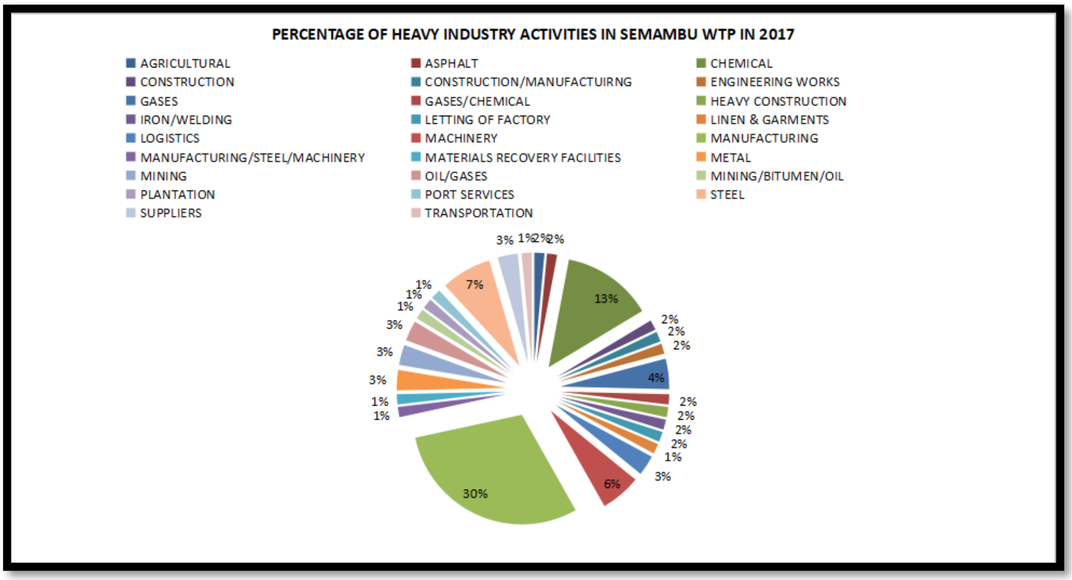

Figure 7. Percentage of heavy industrial activities for Semambu in 2017

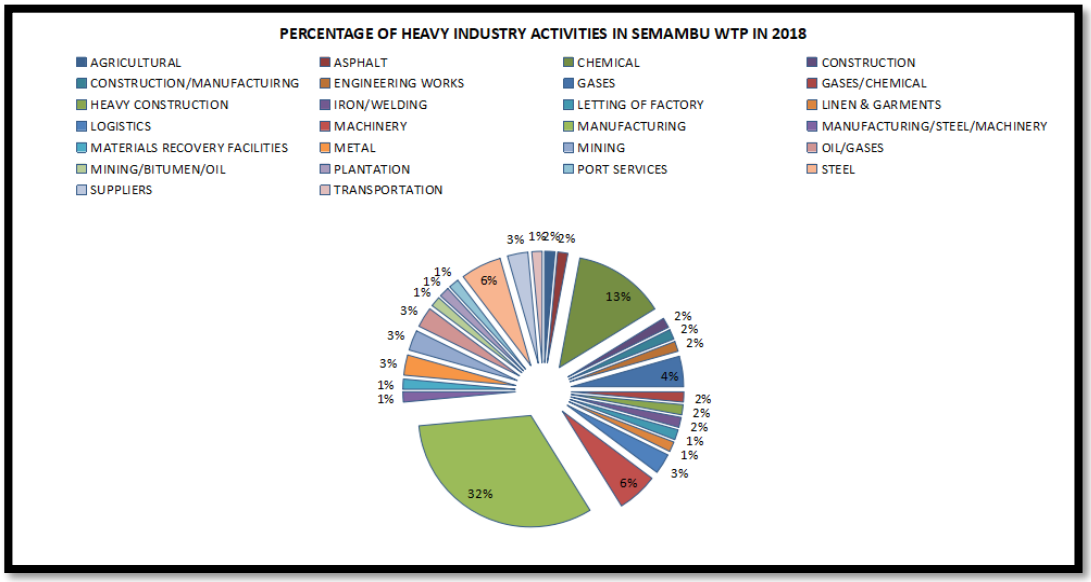

Figure 8. Percentage of heavy industrial activities for Semambu in 2018

4. Conclusion

In recent findings, a detailed result for the pattern in 4 previous years can be seen based on their changes in total blue water footprint obtained. The types of activities for heavy industrial that exist and also which type of activities are monopolizing as the highest consumers for every year from 2015 to 2018. Since there is an increment is growth of heavy industry, the demand for water consumption also increase for monthly consumption. For examples in Semambu, Manufacturing industry is widely known as the biggest consumer of blue water consumption which was supplied by Semambu Water treatment plant. Total blue water footprint for all types of activities is calculated based on a few parameters like rainfall, evaporation, water intake and temperature as were required in blue water footprint network formula.

The conclusion that can be draw from this study are firstly, the heavy industrial activities within Kuantan river basin in 2015-2018 is inventoried. The total number for each of the year is shown as in table until table 4.4 for all types of heavy activities there. Next is blue water footprint of heavy industrial activities within Kuantan river basin in 2015-2018 is determined. Based on the blue water footprint network formula and the parameters available, all the final data for blue water footprint can be established based on their location of water treatment plants.

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Acknowledgement
Special Thanks to Allah S.W.T for His willing to give me the opportunity for completing this type of paper. I would like to express my deepest appreciation to all those who provided me the possibility to conduct this paper. A special gratitude I give to my supervisor, Prof. Madya. Ts. Dr. Edriyana binti A.Aziz, whose contribution in stimulating suggestions and encouragement, helped me to coordinate my research study especially in writing this report. Besides to corresponding author, who have helped and guided me for doing his review of this paper before submitting. The authors are grateful for financial support by the Ministry of Education, Malaysia, from the Fundamental Research Grants Scheme (FRGS) under grant no. FRGS/1/2019/TK01/UMP/02/3. Lastly, I would like to thank to whoever that involved directly or indirectly in this peer-reviewed completion.