Mapping and analysis of illegal solid waste heap point at segment 6 Ciliwung riverbanks

L A Saska, P P P Riatno and D Indrawati*
Environmental Engineering Department, Faculty of Landscape Architecture and Environmental Technology, Trisakti University, Jakarta, Indonesia
*dindrawati@trisakti.ac.id

Abstract. The research about illegal heap point of solid waste was conducted to identify the quantity, measure the volume and compositions of solid waste heap point as a response to river pollution caused by solid waste along Segment 6 Ciliwung Riverbanks. Calculations of the volume and compositions of solid waste were carried out for three days in five locations are riverbank in area of Manggarai (Location 1), Kebon Manggis (Location 2), Menteng (Location 3), Kwitang (Location 4), and Kebon Sirih (Location 5). The research shows that there are 22 illegal heap points consisting of 93.38 m³ solid waste volume. The highest volume of the illegal heap point of solid waste was located in Kebon Manggis Area with 34.64 m³ and the lowest volume was located in Kebon Sirih Area with 1.53 m³. The average compositions of solid waste consisting of 45.56% organic waste and 54.44% non-organic waste with the highest percentage are the plastic waste 18.6% and the lowest percentage is rubber/leather waste 2.01%. The existence of the illegal heap point of solid waste in riverbank has the potential to cause a high value of Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), and cause low levels of Dissolved Oxygen (DO).

1. Introduction
The high change of populations from village areas to urban areas has increased the availability of land for urban settlements. Increasing development in the urban areas has caused most of the areas to change function becomes residential areas and cause the problems to the environment [1]. One of the lands has been changed function into the residential areas is riverbanks. The availability of land for settlements areas is very difficult that causing riverbanks to become an option for settlements areas. The function of the riverbank is the place where some of the river discharge flows during a flood. The appearance of the settlements in riverbank will also contribute to problems with the river.

The river has a function as a source of raw water, irrigation, flood control, and urban macro channels. Therefore, in the riverbank area, there is a prohibition to throw the waste and build the settlement [2]. At this time the river has decreased the function to large trash. This is caused by increasing of settlements on the riverbanks. Watershed (DAS) Ciliwung has a social and economic function. Development activities in the downstream part of the Ciliwung watershed occur continuously along with the population increase. Changes in land use and increasing settlements areas in downstream Ciliwung have the potential to infuse pollutants into the Ciliwung watershed [3].

In general, people living in the riverbanks has the potential to throw their household waste into the riverbank, that cause river pollution. This happened in the downstream part of the Ciliwung River in
DKI Jakarta [4]. Ciliwung riverbanks in DKI Jakarta known as the riverbank with many illegal settlements and susceptible to the risk of flooding [5].

Ciliwung watershed located between 106 ° 42'12" - 106 ° 55' 20" BT and 6 ° 11' 54" - 7 ° 01' 27" LS approximately has 347 Km2 in area and the length of the main river is 117 Km [6]. Ciliwung watershed covers areas ranging from the Bogor Regency, Bogor City, Depok City, to DKI Jakarta Province which is divided into 6 segments [7]. Ciliwung River Segment 6 is a river that passes 4 administrative areas of DKI Jakarta, 16 sub districts starting from Manggarai and empties into Ancol. Based on this description, this study was conducted to determine the point of the illegal solid waste heap, the volume, and the compositions of the illegal solid waste heap in Segments 6 Ciliwung riverbanks as a mitigation effort related to exposure to river water due to the presence of garbage.

2. Method

2.1. Sampling locations

This research was conducted in five sampling locations namely, Manggarai Village (Location 1), Kebon Manggis Village (Location 2), Menteng Village (Location 3), Kwitang Village (Location 4), and Kebon Sirih Village (Location 5) along the downstream of Segment 6 Ciliwung Riverbanks in DKI Jakarta. Determining sampling locations were selected based on the amount of spot solid waste were obtained from a preliminary survey, the site makes it possible to do sampling and at the Segment 6 Ciliwung Riverbanks many of the inhabitants.

2.2. Data analysis

2.2.1. Analysis of illegal solid waste volume. Measurement of the volume of the illegal solid waste heap was carried out for three days in sampling locations. Determination of illegal solid waste volume is done by the following formula:

\[ V = L_t \times T_r \]  

Where:
- \( V \): Illegal solid waste volume (m3)
- \( L_t \): Illegal solid waste heap area (m2)
- \( T_r \): Illegal solid waste heap average height (m)

2.2.2. Analysis of illegal solid waste compositions. Measurement of the compositions of the illegal solid waste heap was conducted to find out physical components in illegal solid waste heaps such as organic, papers, wood, textile, rubber-leather, plastics, ferrous metals, glass and others [8]. Determination of percentage of illegal solid waste compositions is done by the following formula:

\[ \%K_s = \frac{\text{Component Weight (kg)}}{\text{Total Solid Waste Weight (kg)}} \times 100\% \]  

Where:
- \( \%K_s \): Percentage components of solid waste

3. Results and discussion

3.1. Solid waste volume

The volume of solid waste in Segment 6 Ciliwung Riverbank is 34,352 kg/day, assuming the population of the Ciliwung Segment 6 Riverbank is 41,457 people with the generation rate of solid waste is 0.7 kg/people/day [9]. The point of illegal solid waste heap consists of 22 points and of a various volume of the solid waste, can be seen in Table 1.
Table 1. Estimates of solid waste volume.

| Research Location | Illegal Solid Waste Heap Point | Longitude | Latitude | District Area | Estimates of Solid Waste Volume (m³) | Sub Total (m³) |
|-------------------|--------------------------------|-----------|----------|---------------|--------------------------------------|----------------|
| I                 | 1 106°51'27.61" 6°12'45.132" | Manggarai |          | 4.52          |                                      |                |
|                   | 2 106°51'27.22" 6°12'44.66" | Manggarai |          | 4.41          |                                      |                |
|                   | 3 106°51'27.02" 6°12'44.35" | Manggarai |          | 4.30          |                                      |                |
|                   | 4 106°51'25.95" 6°12'43.57" | Manggarai |          | 6.89          |                                      |                |
|                   | 5 106°51'25.44" 6°12'43.24" | Manggarai |          | 7.47          |                                      |                |
| II                | 6 106°51'28.57" 6°12'45.11" | Kebon Manggis |      | 3.41          |                                      |                |
|                   | 7 106°51'27.85" 6°12'44.51" | Kebon Manggis |      | 8.90          |                                      |                |
|                   | 8 106°51'27.06" 6°12'43.78" | Kebon Manggis |      | 7.53          |                                      |                |
|                   | 9 106°51'26.66" 6°12'43.35" | Kebon Manggis |      | 7.09          |                                      |                |
|                   | 10 106°51'22.16" 6°12'41.67" | Kebon Manggis |      | 7.71          |                                      |                |
| III               | 11 106°50'45.02" 6°12'30.08" | Menteng |          | 2.21          |                                      | 16.96          |
|                   | 12 106°50'44.04" 6°12'29.50" | Menteng |          | 1.25          |                                      |                |
|                   | 13 106°50'39.92" 6°12'28.13" | Menteng |          | 3.86          |                                      |                |
|                   | 14 106°50'36.00" 6°12'27.00" | Menteng |          | 4.00          |                                      |                |
|                   | 15 106°50'38.04" 6°12'27.52" | Menteng |          | 5.64          |                                      |                |
| IV                | 16 106°50'12.31" 6°10'58.56" | Kwitang |          | 1.93          |                                      | 12.66          |
|                   | 17 106°50'10.70" 6°11'3.35" | Kwitang |          | 1.59          |                                      |                |
|                   | 18 106°50'11.46" 6°11'42.00" | Kwitang |          | 5.41          |                                      |                |
|                   | 19 106°50'13.47" 6°11'6.70" | Kwitang |          | 3.73          |                                      |                |
| V                 | 20 106°50'19.46" 6°11'09.17" | Kebon Sirih |      | 0.55          |                                      | 1.53           |
|                   | 21 106°50'26.41" 6°11'10.15" | Kebon Sirih |      | 0.56          |                                      |                |
|                   | 22 106°50'26.59" 6°11'08.85" | Kebon Sirih |      | 0.42          |                                      |                |

The result from the research shows that in first location and second location there are 5 point of an illegal solid waste heap in each location. The volume of illegal solid waste in those locations are the largest volume compared to the other five locations. The distance between residential settlements and riverbank is only 5-20 meters. That matter has the potential to cause people living in the riverbanks to throw their household waste into the riverbank. The result of interviews with people living in the riverbanks shows that residents in that location were still very often throwing their household waste directly into the riverbank. This is due to the availability of individual bins and communal bins that are not evenly distributed in the riverbank areas. The availability of Integrated Waste Management Sites in the riverbank area is not fulfilled. The lowest volume of Illegal solid waste heap is in location 5 with 1.53 m³ with 3 points of an illegal solid waste heaps. The result of interviews with people living in the riverbanks shows that residents in that location were rarely throwing their household waste directly into the riverbank. In this location, Integrated Waste Management Sites, garbage carts, and the availability of communal bins are evenly distributed. The availability of facilities and infrastructure related to waste management in the five research locations can be seen in Table 2.

A large amount of illegal solid waste produced on the riverbanks is due to the behaviour of the people living in the riverbanks who still very often throw of their household waste directly into the riverbank [10]. Another factor that causes a high volume of illegal solid waste on the riverbank is the availability of facilities and infrastructure in waste management in the residential area. Facilities and infrastructure in supporting solid waste management include the availability of individual and communal bins, the availability of public facilities and infrastructure such as garbage transport carts, garbage transport trucks, and Integrated Waste Management Sites (WMS) [11].

The area along Ciliwung riverbanks, in fact, is not supported by the presence of green open space (RTH) which is capable of functioning as an ecological, aesthetic and socio-cultural and economic, it happens due to the imbalance in the proportion and distribution of green open space on the riverbank area [12].
Table 2. Availability of solid waste facilities and infrastructures.

| Research Location | Availability of Solid Waste Facilities and Infrastructures | Communal Bins | WMS | Garbage transport |
|-------------------|----------------------------------------------------------|----------------|-----|------------------|
| 1                 |                                                          | Not available | Not available | Available         |
| 2                 |                                                          | Not available | Not available | Available         |
| 3                 |                                                          | Available     | Available     | Available         |
| 4                 |                                                          | Available     | Available     | Available         |
| 5                 |                                                          | Available     | Available     | Available         |

Mapping of the point of illegal solid waste heap in five locations can be seen in Figure 1.

![Figure 1. Mapping of the point of illegal solid waste heap in segment 6 Ciliwung Riverbanks.](image)

3.2. Illegal solid waste compositions

The highest percentage of the waste composition in the five research locations was an organic waste of 45.56% and the lowest percentage composition of waste was an inorganic waste in the form of rubber/leather waste of 2.01%. The high value of organic waste is caused by a large amount of organic waste produced by household waste in settlements along the Segment 6 Ciliwung Riverbank. The results of the analysis of the composition of the illegal solid waste heap can be seen in Figure 2. Based on the current condition and to reduce the illegal solid waste heap, in solid waste management can be implemented in integrated solid waste management in the area along the Segment 6 Ciliwung Riverbank.
In some developing countries such as in Indonesia, the largest composition of solid waste is organic waste. As in Gujranwala City in Pakistan, the average composition of waste produced consists of 61.40% organic waste, 7.88% paper, 9.46% plastic, 0.13% metal and 21.13% other such as grass, textiles, wood, etc. [13]. Most of this illegal waste in Gujranwala disposed of in illegal dumps such as riverbanks or vacant land in the city [14].

3.3. Correlation between illegal solid waste heap and water river quality
Disposal of solid waste caused by increasing human activity will potentially produce leachate, whose presence can pollute the aquatic environment [15]. The emergence of illegal solid waste heap points along the riverbank has the potential to cause pollution to the river. The presence of leachate carried by runny water into the river will cause a high value of Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) and cause low levels of Dissolved Oxygen (DO) in water [16]. It can be concluded that waste contributes to polluting the river and can cause a decrease in water quality.

3.4. Waste management efforts on the riverbank
Proper management of municipal solid wastes are a serious concern across developing as well as developed countries of the world [17]. Waste management efforts that can be carried out are closing the illegal solid waste heap in the five research locations along the Segment 6 Ciliwung Riverbank and confirms the rules of disposing of solid waste into rivers/riverbanks. Providing learning in managing west with the 3R concept (Reduce, Reuse, Recycle) to people living in the riverbanks [18]. This can reduce the creation of open dumping of illegal solid waste especially in riverbank [19].

From the result of the composition of illegal solid waste in segment 6, the largest waste in the five research locations was an organic waste of 45.56%. Organic waste can be used as household compost and the other waste compositions such as used packaging plastic waste can be used as crafts that can produce economic value. This can reduce the amount of waste from garbage sources. The reduction of waste contributes to the natural resource depletion, environmental pollution, for which treatment in recent years is paid so much attention [20].

4. Conclusion
The research showed that there are 22 illegal heap points of solid waste consisting of 93.38 m$^3$ solid waste volume. The highest volume of the illegal heap point of solid waste was located in Kebon Manggis Area with 34.64 m$^3$ and the lowest volume was located in Kebon Sirih Area with 1.53 m$^3$. The volume of the illegal solid waste heap was influenced by several factors are the distance between residential settlements and rivers, the behavior of the people living in the riverbanks who throw their household waste into the riverbank, and the condition of waste management facilities. The highest waste composition is an organic waste due to a large amount of organic waste produced by household waste.
The existence of illegal solid waste heap on the riverbank has the potential to cause pollution of river water.

References

[1] Douglass M 2013 The Urban Transition of Environmental Disaster Governance in Asia Asia Research Institute Working Paper 210
[2] Polantolo 2009 Problems River in Indonesia (Malang: Metronews Malang Post)
[3] Yudo S 2014 Water Pollution Conditions in Cipinang River Jakarta (Jakarta: Pusat Teknologi Lingkungan, BPPT) 6
[4] Prescott M F and Girot C 2013 Rivers as Organisational Structures: Evolving Attitudes Toward Water in Jakarta, Indonesia 7th EuroSEAS Conference School of Social and Political Science 2013 02-05 July 2013
[5] Apip S S A H and Pingping L 2015 Overview of Jakarta Water-Related Environmental Challenges Water and Urban Initiative Working Paper 4 2-5
[6] Ali M, Hadi S and Sulistyantara B 2016 Study on Land Cover Change of Ciliwung Downstream Watershed with Spatial Dynamic Approach Int. Conf. Intelligent Planning Towards Smart Cities. Series: Social and Behavioral Science CITIES 2015 3-4 November 2015 227 52-59
[7] Regional Environmental Management Agency of DKI Jakarta Province 2007 River Water Quality Monitoring Report in Jakarta
[8] Tchobanoglus G, Theisen H, Vigil S A 1993 Integrated Solid Waste Management Engineering Principles and Management Issues (Singapore: McGraw Hill)
[9] National Statistics Agency 2017 DKI Jakarta in Figures 2017
[10] Padawangi R, Turpin E, Prescott M F, Lee I, Shepherd A 2016 Mapping an Alternative Community River: The Case of the Ciliwung Jurnal of Sustainable Cities and Society 2015.09.001 1-20
[11] Regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia Number 2/PRT/M/2016 About Quality Improvement of Slum and Slum Settlements
[12] Indrawati D, Purwaningrum P 2018 Identification and Analysis the Illegal Dumping Spot of Solid Waste at Ciliwung Segment 5 Riverbanks IOP Conf. Series:Earth and Environmental Science 106 012043
[13] Qu X Y, Li Z S, Xie X Y, Sui Y M, Yang L, Chen Y 2009 Survey of Composition and Generation Rate of Household Wastes in Beijing, China (Waste Management vol 29) (China: Elsevier) pp 2618–2624
[14] Ali M, Marvuglia A, Geng Y, Chaudhry N, Khokhar S, 2018 Emergy Based Carbon Footprinting of Household Solid Waste Management Scenarios in Pakistan (Resources, Conservation, and Recycling vol 13) (Pakistan: Elsevier) pp 283–296
[15] Hoornweg D, Bhada-Tata P 2012 What a Waste: Waste Management Around the World (Wahington: World Bank)
[16] Sudarmo, Unggul. 2013. Kimia untuk SMA/MA Kelas X. (Jakarta: Penerbit Erlangga).
[17] Ali M, Yong G, Dawn R, Dave C, Will R, Joost V 2019 Improvement of Waste Management Practices in a Fast Expanding Sub-Megacity in Pakistan, on the Basis of Qualitative and Quantitative Indicators (Waste Management vol 85) (Netherlands: Elsevier) pp 253-263
[18] Minelgaite A and Liobikiene G 2019 Waste Problem in European Union and its Influence on Waste Management Behaviours (Science of the Total Environment vol 667) ed H H Ngo (Lithuania: Elsevier) pp 86–93
[19] Alavi M, Mokhtaran M, Mokhtaran B, 2009 Municipal Solid Waste Management in Rasht city. Iran (Waste Management vol 29) (Iran: Elsevier) pp 485–489
[20] Zhang X, Huang Q, Deng F, Huang H, Wan Q, Liu M, Wei, Y 2017 Mussel-Inspired Fabrication of Functional Materials and Their Environmental Applications: Progress and Prospects (Applied Materials Today vol 7) (Beijing: Elsevier) pp 222–238