Social conditions in wastewater processing to manage river water quality (study in Cirarab River, Tangerang District, Indonesia)

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Abstract. Water is essential for a healthy ecosystem and socio-economic development. Global water demand increases annually and will continue to increase significantly. However, the availability of clean water is strongly influenced by pollution, which is heavily influenced by the human population. As rivers are often used as sources for drinking water, its water quality is crucial to be maintained and monitored, one of which is the Cirarab River in Tangerang district. The COD and BOD values of the Cirarab River have exceeded the permissible water quality standards, which are associated with the human activities in the river basin. This research aims to determine the social condition in terms of community and industry participation in wastewater processing in the river basin. This research was conducted through field observation, questionnaires, and deep interviews. This study concludes that the community septic tank ownership is moderate (53%), and the industry WWTP ownerships is low (22%). The recommended strategies are: providing establishment of an individual or communal septic tanks, providing assistance to the community and industries, personnel addition of environmental supervisors, surveillance on wastewater treatment plant operations, wastewater discharge permit re-evaluation, and stronger law enforcement.

1. Introduction
Global water is increasingly in demand, as the population grows [1]. Unfortunately, its availability is highly impacted by pollution [2] that also rises as the population grows. Around 1.8 billion people use contaminated water sources that put risk to their health [3], one of which is a river.

The Indonesian Ministry of Environment and Forestry monitored 84 rivers and noted that Indonesia's overall river water quality had decreased [4]. Further, the Cirarab River is considered to be highly polluted [5]. The BOD and COD levels of Cirarab River had also exceeded the environmental quality standards/EQS consecutively from 2015 to 2017 [6,7,8]. The growing numbers of industries and residential buildings in the river basin and the decreasing vegetation area increase the need for proper wastewater management [9]. Hence, social conditions in terms of community and industry participation in wastewater processing are greatly in demand.

Participation, whether in forms of public-community or individual participation, is crucial for effective water management [10]. River water quality is influenced by public awareness of the river, affecting public participation in processing and discharging the wastewater from human activities in the
river basin [11]. Participation holds importance in environmental management as well as river management [12,13]. Moreover, public participation and governmental roles are hand in hand in river management inasmuch as the growing participation of public participation and governmental roles, resulting in improving river conditions [14]. To the authors’ knowledge, little research has focused on the Cirarab River as a study area, in particular focusing on the social conditions at its basin, even though its function as raw water is very important to control water pollution and regulate river water quality. For these reasons, the social conditions in terms of community and industry participation in wastewater processing of people living in the Cirarab River basin are interesting to discuss.

The purpose of this research are (1) to know the social conditions in terms of community and industry participation in wastewater processing of people living in Cirarab River basin, (2) effects of social conditions on river water quality, and (3) try to give recommendation for strategies in river management base on social conditions.

2. Methodology
This study was conducted in the Cirarab River that passes through the Tangerang District – Curug segment on both sides of the river (east and west) (figure 1). The Eastern side covers the villages of Curug Kulon, Cukang Galih, and Kadu Jaya. The Eastern side covers villages of Ciakar, Dukuh, Bitung Jaya, and Bunder. This research employed a mixed-method by conducting field observation, questionnaires, and in-depth interviews to further gain deeper understanding of the topic. Purposive sample was conducted to heads of households above 17 years of age who were or performing economic activities within 50 meters from the eastern and western side of Cirarab River. There were 101 people that fit the criteria.

This research focused on social conditions in terms of community and industry participation in wastewater processing, such as domestic wastewater and garbage. Wastewater Treatment Plant/WWTP data on industries were collected from company semester reports gathered by the Tangerang District Environment and Hygiene Office. There were 212 industries that disposed of their wastewater into the
Cirarab River.

The Cirarab River water quality was concluded from water sampling gathering from three monitoring points, namely Curug Kulon Village (S: 06°15'38,718" E: 106°32'18,78"), Cukang Galih Village (S: 06°15'05,6484" E: 106°32'26,0124"), Kadu Jaya Village (S: 06°13'24,4088" E: 106°33’ 17,9136") that were considered to have had the requirements to determine the water quality condition of Cirarab River - Curug District segment. Sampling collection was conducted in five collection times that represented a 24-hour cycle (7:00 AM; 11:00 AM; 3:00 PM; 06:00 PM; and 10:00 PM) at the same monitoring points. Water quality calculation is based on the Government Regulation No. 82 of 2001 concerning Water Quality Management and Water Pollution Control.

3. Results and discussion

3.1. Septic tanks and WWTP ownership level

The community participation level was assessed based on septic tank ownership of people and WWTP ownership of industries in the river bank. Details on community septic tank ownership are presented in figure 2.

![Figure 2. Septic tank ownership of people living in the Cirarab river basin, n=101.](image)

More than 50% of respondents living in the river basin had septic tanks. Thirty-seven people claimed that they did not own septic tanks and immediately disposed of their domestic wastewater into the river. The majority of respondents who did not own septic tanks had low educational levels (drop-outs of elementary school and elementary school graduates). This finding is consistent with previous research [15]. Interviews with informants revealed the significance of a linear relationship between participation and government roles and are in line with the previous study [14]. Septic tanks built by the local government inspired other people to own septic tanks as well. This demonstrates a need for local government role to encourage community participation. The behavior of disposing of garbage into the river only happened in Kadu Jaya sub-segment, which caused narrowing and silting the river flow and further exacerbated by building constructions in the river basin (figure 3).

Industry participation in terms of WWTP ownership is low. According to the Tangerang District Environment and Hygiene Office, from the 212 reported industries, only 22% of them (50 industries) owned WWTP while the rest (179 industries) did not. The low community and industry participation levels would reduce river water quality because participation is vital for effective river management [16].

The social conditions in the river basin greatly affect the river. Public awareness concerning the importance of the river has a great influence on river quality, which would affect public participation in waste processing and land use in the river basin. Efforts to control river problems would be irrelevant if public awareness of the river's importance is still lacking [13].

River management would contribute to economic, social and ecological goals by merging the participation of government agencies and stakeholders; alongside those who are directly involved in water management. The recommended river management is the Integrated Water River Management (IWRM) [16,17,18], in which public participation is one of the important elements [16]. This river
management is considered a leading concept over the past two decades by academics, decision-makers, and experts.

3.2. The effects of social conditions on river water quality

River water quality monitoring is a requirement to ensure the river status is polluted or not. The Cirarab River water quality was analyzed based on 4 key parameters representing other parameters, namely temperature, pH, BOD, and COD. The results of the Cirarab River Curug Segment water quality are presented in figure 4-8.

Figure 4 illustrates that the Curug Kulon sub-segment had the most abundant water discharge with an average of 5.4 m³/s, followed by MP 3 (Kadu Jaya sub-segment) of 2.18 m³/s and MP 2 (Cukang Galih sub-segment) of 1.4 m³/s. The amount of river water discharge is directly proportional to the cross-sectional area of the river. Observations in MP 3 and MP 1 notes that the river width is in accordance with water discharge. However, MP 2 has a large width but small water discharge. This condition occurs due to the mounted existing of the garbage along the water body, causing the river to narrow and silt.

Analysis of pH parameters in the Cirarab River Curug segment in three monitoring points (figure 5) was ranged from 6.73 to 8.08, which met the quality standards required in the applicable legislation. The highest pH value was in the Cukang Galih sub-segment at 11:00 AM collection time, and the lowest pH value was also in the Cukang Galih sub-segment at 10:00 PM collection time. This finding is consistent with previous research in different rivers in Indonesia [19,20,21].

Figure 5. Acidity level (pH) results in each Cirarab River sub-segment.
Figure 6. Temperature results in each Cirarab River sub-segment.

Figure 7. BOD results in each Cirarab River sub-segment.

Figure 8. COD results in each Cirarab River sub-segment.

The higher the BOD and COD values, the more polluted a river. Analysis of BOD parameters in the Cirarab River Curug segment in three monitoring points (figure 7) ranged from 3 mg/L to 57 mg/L. Analysis of COD parameters in the Cirarab river Curug segment in three monitoring points (figure 8) was ranged from 15 mg/L to 24 mg/L. In general, these results failed to meet the required water quality standards in the regulations. The BOD values are likely to decrease as further down the river downstream due to self-purification in the river flow. This finding contrasts with previous research [22,23], which found that the BOD values increased as further down the river downstream due to the incoming pollutant load.

3.3. Recommendation for strategies in river management

Currently, the Cirarab River is polluted as indicated by the BOD and COD values above the water quality standards, with the largest pollution source from domestic and industrial waste. Individual and communal septic tank construction is a vital strategy to prevent river pollution from domestic community waste. Moreover, public awareness and behavior are other factors that contribute to the improvement of river quality. People living in the Cirarab River basin Curug segment tend to wait for governmental aid for septic tank construction, and they lack the willingness to properly manage wastewater. Hence, the local government should consider these as an opportunity to build people's awareness to further improve their participation.

Industrial wastewater control can be accomplished by streamlining existing industrial supervision. The low level of industry participation in WWTP ownership indicates the low level of company compliance with the applicable regulations. This also suggests the ineffectiveness of environmental supervision from the government. These conditions should be dealt with these actions: a) providing assistance to the industries on the importance of wastewater processing, b) providing a strict form of supervision to the WWTP process, c) performing reinspection on Wastewater Disposal Permit, and d) implementing the law on wastewater processing. Further, effective supervision could be achieved by adding more environmental supervisors at the Tangerang District Environment and Hygiene Office.
Increasing the effectiveness of environmental supervisors is a continuous improvement to protect the environment, as one has been done in China [24]. The recommended strategies should be simultaneously implemented.

4. Conclusion
Community participation in septic tank ownership is moderate (53%), and industry participation in WWTP ownership is low (22%). Social conditions have significant influences on river water quality. Cirarab River management's recommended strategies are: providing establishment of an individual or communal septic tanks, providing assistance to the community and industries, providing personnel addition of environmental supervisors, performing supervision to the WWTP process, performing reinspection on Wastewater Disposal Permit, and implementing the applicable law.

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