Journal of Environmental Science International
28(10); 873~885; October 2019
pISSN: 1225-4517 eISSN: 2287-3503
https://doi.org/10.5322/JESI.2019.28.10.873

**ORIGINAL ARTICLE**

# Assessment of Pollution Levels in the Jangsungcheon Watershed Using Load Duration Curves and Analysis of the Causes

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## Abstract

In this study, a load duration curve was applied to the Jangseongcheon, one of the tributaries of the Yeongsan River, to assess whether the target water quality was achieved. In addition, pollution of the water body was investigated to develop and suggest the optimal management time with respect to polluted flow sections and monthly conditions. The average flow rates of sections JS1 and JS2 were 0.25 $m^3/s$ and 1.08 $m^3/s$ , respectively. The BOD and T-P for water-quality standards at JS1 were rated at II, whereas the COD and TOC were rated at III, thus indicating a fair level of water quality. By contrast, the BOD at JS2 was rated at III, the T-P at IV, and the TOC at V, indicating poor water quality in this section. The load duration curve was plotted using the actual flow data measured in eight-day intervals for eight years from 2011 to 2018 at locations JS1 and JS2 in the Jangsungcheon Basin. In an assessment using the load duration curve on whether the target water quality was met at location JS1, all of the water quality parameters (BOD, COD, TOC, T-N, T-P, and SS) satisfied the target water quality. By contrast, at location JS2, parameters COD, TOC, T-N, and T-P exceeded target values by more than 50%, indicating the target water quality was not met. The discharge loads of locations JS1 and JS2 were analyzed to identify the reasons the target water quality was exceeded. Results revealed that the land system contributed considerably. Furthermore, the discharge load of JS2 accounted for more than 80% of the load on the entire basin, excluding that of JS1. Therefore, the best method for restraining the inflow of pollutants into the stream near location JS2 must be applied to manage the water quality of the Jangsungcheon.

**Key words** : Load duration curve, Target water quality, Jangsungcheon, Total maximun daily load

## 1. Introduction

In Korea, BOD and T-P are set as management subjects and target water quality is allocated for maintaining water quality in basins. Also, the water environment standards such as DO, COD, TOC, SS, T-N, and Chl-a are suggested for maintaining the health of basins. The water quality characteristics in basins are affected by pollutant sources that are discharged from environmental basic facilities and pollutant sources that occur during precipitation (Han et al., 2015). Although the pollutant sources vary depending on the characteristics of basins, the improvement of its management is required because the pollutant sources are managed by certain items at basin outlets (Beak and Yim, 2012). The current water pollution load management is easy in terms of the allocation and regulation of pollutant sources (Cho et al., 2018), but it is difficult to determine locations and time of the pollutant sources. In particular, because

**Received** 2 October, 2019; **Revised** 22 October, 2019;
**Accepted** 29 October, 2019
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there is a risk of an imbalance between developments based on the size of a unit basin and reductions of pollutants (Hwang et al., 2016), it is necessary to analyze and manage pollutants as a small scale focused on tributaries (Park et al., 2011). In addition, items subject to management are required according to the characteristics of watersheds rather than the management of pollutants according to the uniform management target setting (Hwang et al., 2016). It is necessary to perform an analysis with long-term flow rate data and water quality monitoring in order to analyze and manage pollutants in basins. The Four Major Rivers Environment Research Center at the National Institute of Environmental Research (NIER) has been accumulating data through eight-day interval monitoring for streams in small basins since 2010. Also, many researchers use the Load Duration Curve(LDC) for analyzing the behavior of pollutants in basins based on these observation data. The LDC based on flow rate and pollutant load data is used for the planning of the TMDL (Total Maximum Daily Load) in the U.S. and Europe as a way that can identify the characteristics of water quality and loads for the entire flow condition in streams (USEPA, 2007).

In Korea, studies based on the LDC have been actively conducted. In addition, studies based on the LDC with Flow Duration Curve (FDC) by preparing long-term flow data measured every eight days have recently been conducted. In the application study of the LDC, a preceding study, Hwang et al.(2011), compared the FDC established by using daily flow rate data through calculating a watershed model with the FDC built by practical measurement data at intervals of eight days during the same period. In the result of this comparison, it has suggested that a FDC, which represents the cumulative flow rate frequency of a stream, can be prepared if data are accumulated at a constant interval for a long period of time. In addition, Cho et al.(2017) analyzed the time of exceeding the quarterly and monthly period of the Gomakwoncheon watershed using measured flow rate and water quality data at intervals of eight days. Also, Jung(2018) verified the applicability of the weekly (eight days intervals) flow rate data for the assessment of the water pollution level in the tributaries of the Nakdong River main stream. In addition, Cheong et al.(2016) used the LDC to assess the achievement of the target water quality of the unit watershed, which applies the water pollution load management, in the Yeongsan River and the Tamjin River basins. As mentioned above, the LDC is easy to analyze the characteristics of pollutant sources by dividing the sections of the flow rate and the time of exceeding it monthly, and it can find a way to manage the water quality by calculating the time of the occurrence of the pollutant sources.

In this study, the target water quality of the monitoring points in the Jangsungcheon watershed is assessed using the LDC, and the subjects under management are selected and proper water quality management measures are also provided by analyzing the causes of the excess pollutant loads.

## 2. Materials and methods

### 2.1. Study area

The Jangsungcheon watershed, a subject region of this study, is a class II local stream that flows through Naju City and flows into Yeongsan River starting with Daeshin-dong, Gwangsan-gu, Gwangju Metropolitan City, and its length and area are 14 km and 57.46 $km^2$ respectively. The JS1 and JS2 points, which are located in the upper and end parts of the Jangsungcheon watershed, were selected to analyze the characteristics of the pollutant loads discharged by the land use and pollutant source distribution. The land uses of the JS1 and JS2 points in the watershed are shown in Table 1. in which the JS1 point has a large area of forest and a small area of farmland, and the JS2 point shows a small area of forest and a large area of urban and agricultural land (Fig. 1.).

**Table 1.** Land uses by subwatersheds in the Jangsungcheon watershed

| Subwatershed | Land use (km²) | | | | | |
|---|---|---|---|---|---|---|
| | Urban | Agriculture | Forest | Grass | Water | Total |
| JS1 | 0.94<br>(8.4)* | 3.57<br>(31.9) | 3.92<br>(35.1) | 2.12<br>(19.0) | 0.63<br>(5.6) | 11.18<br>(100.0) |
| JS2 | 5.50<br>(11.9) | 18.88<br>(40.8) | 14.93<br>(32.3) | 4.93<br>(10.7) | 2.05<br>(4.4) | 46.28<br>(100) |
| Total | 6.44<br>(11.2) | 22.45<br>(39.1) | 18.85<br>(32.8) | 7.05<br>(12.3) | 2.68<br>(4.7) | 57.46<br>(100.0) |

* Area ratio(%) : each land use area / total land use area

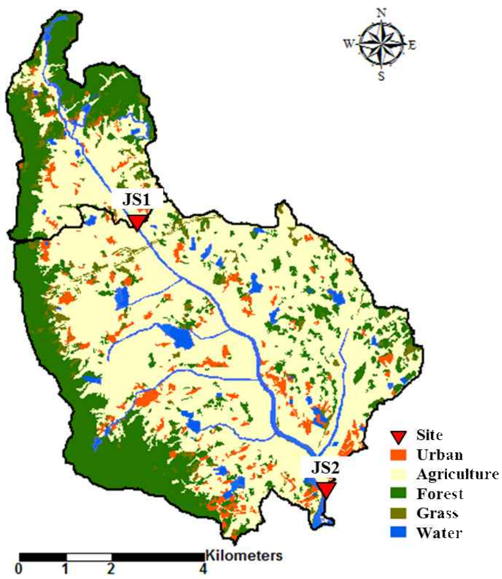



**Fig. 1.** Location of study area.

### 2.2. Methods for measuring water quality and flow rate

The flow rate and water quality data were collected and used for eight years from July 2011 to October 2018. The water quality and flow rate measurements were performed at an average interval of eight days, and the sampling and water quality analysis were applied by the Water Pollution Standard Method (National Institute of Environmental Research, 2010) in which the analysis items were BOD, COD, TOC, SS, T-N, and T-P. The flow rate measurement at the site was implemented using the flow rate measurement method in the Stream Flow Measurement Guide For the flow rate current flow meter (Price USGS Type AA, LV; USGS Pygmy) and Doppler flow meter (Flow Tracker; Sontek), commonly used, were used, and the flow rate was calculated according to the velocity-area method (midsection method). The calculation showed 120 seconds for the velocity below 0.2 m/sec and 40 seconds for above.

### 2.3. Load duration curve method

The LDC arranges the flow rate data at each point from high to low and ranks each flow rate value in order to calculate the excess percentage (Eq. 1). The percent of days flow exceeded of the accumulated flow rate frequency is presented on the $x$-axis, and the corresponding flow rates are presented on the $y$-axis (Hwang et al., 2016).

$$Percent\,of\,Days\,Flow\,Exceeded\,(\%) \\ = Rank/Number\,of\,data \times 100 \qquad (1)$$

The LDC can be presented by multiplying target water quality (water environment standard) based on the prepared flow rate duration curve (Eq. 2), and the achievement is evaluated according to the target water quality of the subject watershed through presenting the measured load data.

$$Load\,(kg/day) = Flow\,(m^3/s) \times$$

**Table 2.** Classification of pollutant sources according to hydrological conditions

| Pollutant source | Hydrologic condition | | | | |
|---|---|---|---|---|---|
| | High (0%～10%) | Moist (10%～40%) | Mid-range (40%～60%) | Dry (60%～90%) | Low (90%～100%) |
| Point source | | | | Medium | High |
| On-site wastewater systems | | | High | Medium | |
| Riparian Area | | High | High | High | |
| Storm water : Impervious | | High | High | High | |
| Combined sewer overflows | High | High | High | | |
| Storm water : upland | High | High | Medium | | |
| Bank erosion | High | Medium | | | |

Source: U. S. EPA, 2007

$$Water\ Quality\ Standard(mg/L) \times 86.4 \quad (2)$$

In general, if the excess rate is less than 50% by presenting the measured load, then the target water quality is achieved (Hwang et al., 2011). In the analysis of the LDC, the flow rate condition was divided into five different conditions based on the excess flow rate probability, such as [high flow condition (0～10%), moist condition (10～40%), mid-range condition (40～60%), dry condition (60～90%), and low flow condition (90～100%)], and the conditions shown in Table 2. are referred for the analysis of the causes according to the grad of the flow sections.

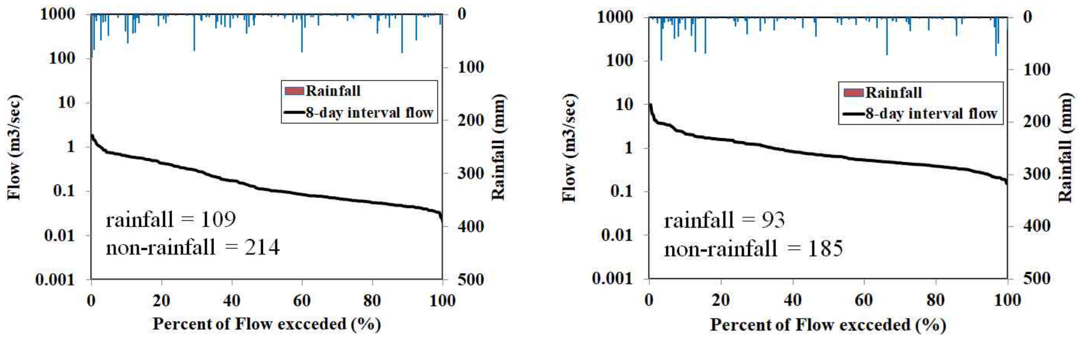
### 2.4. Investigation of pollutant sources

Since various pollutant sources are distributed within the watershed and these are also different from each subwatersheds, this study examined the status of the pollutants according to the data of the population, livestock, and industry in the subject watershed. For investigating the characteristics of the pollutant source of the loads discharged from the Jangsungcheon watershed, the pollutant source was classified into different systems, such as living, livestock, land, industry, farming, and landfill, based on the national pollutant source investigation, 2015, NIER in order to analyze the causes of the excess target water quality using the pollution load data obtained by pollutant sources.

## 3. Results and discussion

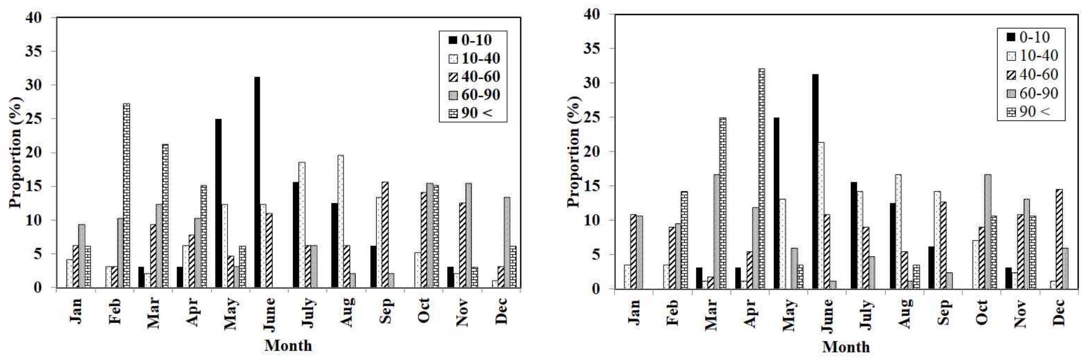
### 3.1. Analysis of runoff characteristics for measuring points using the flow duration curve

In this study, the flow rate and water quality data obtained by the monitoring at intervals of eight days were used to analyze the runoff characteristics of the upper (JS1) and end (JS2) parts of the Jangsungcheon watershed. The number of monitoring for precipitation and non-precipitation periods of the JS1 point with an interval of eight days was 109 and 214 times respectively, and 93 and 185 times for the JS2 point respectively. The runoff rates of the JS1 and JS2 were about 0.02～1.85 (average : 0.25) and 0.15～10.10 (average: 1.08) $m^3$/sec respectively. The LDC were built using the measured flow rate data (Fig. 2.), most of the flow rate within 10% of the high flow period occurred during precipitation or when there was a prior precipitation according to the analysis of the flow rate characteristics by flow rate sections. For considering the monthly distribution in the flow rate sections, the JS1 point shows heavy precipitation in the high flow (0-10%) and moist (10-40%) periods in which the results of the flow rate measurement from May to




(a) JS1 (b) JS2

**Fig. 2.** Flow duration curve with precipitation in the Jangsungcheon watershed.




(a) JS1 (b) JS2

**Fig. 3.** Monthly distribution by discharge ranges in FDC.

September, when farming activities take place, showed a large distribution, and the distribution in the mid-range (40-60%), dry (60-90%), and low flow (90-100%) periods was presented from September to April the following year (Fig. 3.). It was analyzed that the monthly flow rate distribution of the JS2 point tends to be similar to that of the JS1 point. In addition, The ratio of the highest flow rate at the JS1 point to the highest flow rate at the JS2 point showed a difference of about 5.5 times (10.1/1.85) depending on the size of the watershed area. In Korea, however, precipitation is concentrated during the summer, May to September, and in the case of the watershed with large farmlands, it is believed to be due to the influence of agricultural water supplied by farming activities. For that reason, agricultural water accounts for more than 50% of the water use in Korea (Chung and Son, 2001), and it has been reported that 33.8～70.8% of the flow rate is returned to the stream based on surface drainage (Chung and Park, 2004).

### 3.2. Analysis of the water quality change in the watersheds

In the JS1 and JS2 points, the distribution of the concentration in each water quality items for eight years is presented in Fig. 4. Then, the arithmetic average values of the water quality items, DO, BOD, COD, SS, T-N, T-P, and TOC were evaluated according to the water environment standard (MOE,

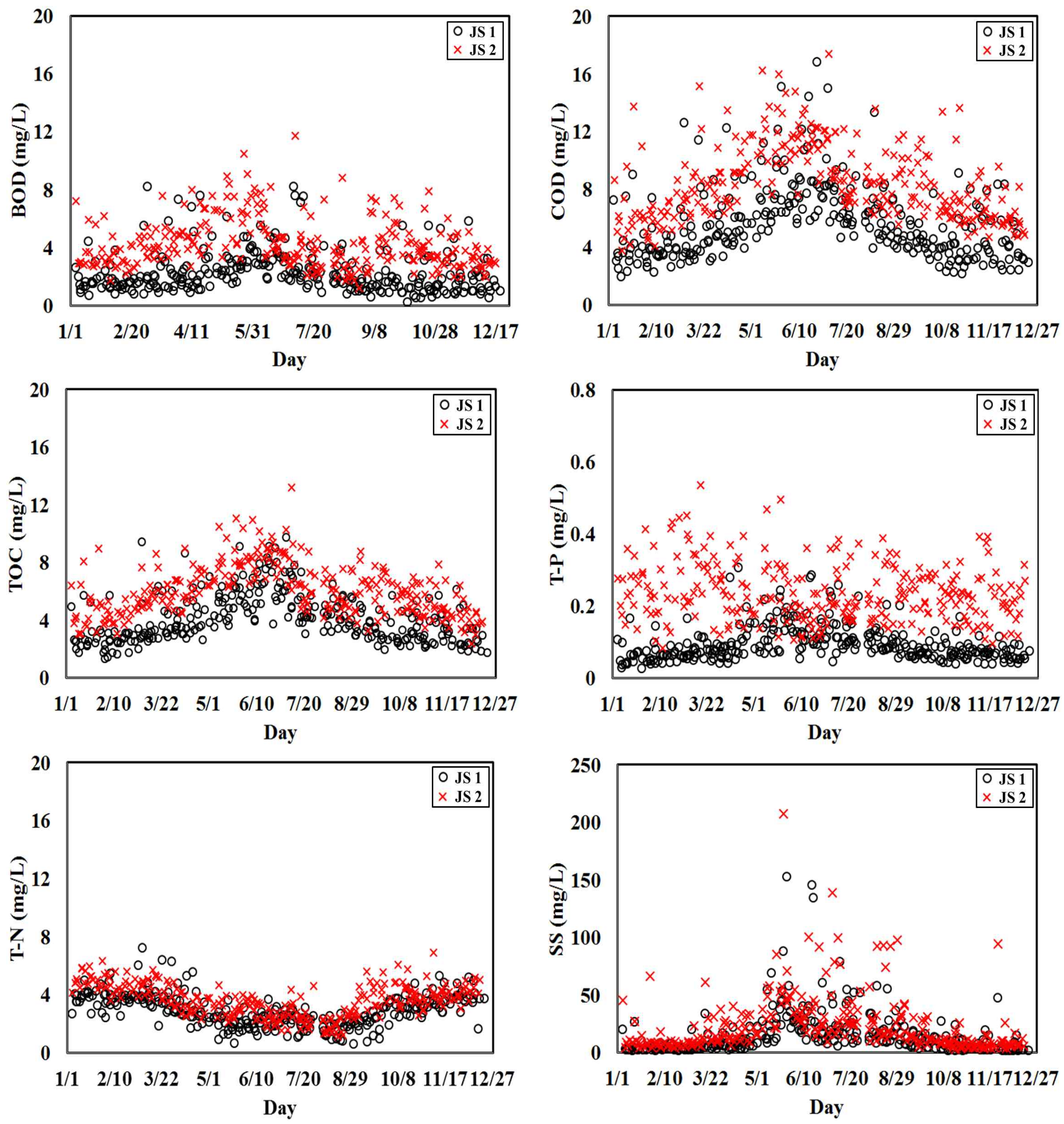



**Fig. 4.** Distribution of the water quality concentrations of JS1 and JS2.

2015). In the JS1 point, the average concentration values of the items DO, BOD, COD, SS, T-N, T-P, and TOC for the entire eight years were 9.97 mg/L, 2.22 mg/L, 5.56 mg/L, 14.84 mg/L, 2.84 mg/L, 0.093 mg/L, and 4.07 mg/L respectively. Based on the water environment standard, the items of DO and SS were determined as Class I, BOD and T-P were Class II, and COD and TOC were Class Ⅲ. In the JS2 point, the average concentration values of the items DO, BOD, COD, SS, T-N, T-P, and TOC for the entire eight years were 10.01 mg/L, 4.25 mg/L, 8.50 mg/L, 22.78 mg/L, 3.63 mg/L, 0.23 mg/L, and 6.09 mg/L in which the items of DO and SS were identified as Class I, and BOD was Class III (Fair), COD and T-P were Class Ⅳ,

**Table 3.** Target water quality using LDC application in Jangsungcheon

| Target Water Quality | BOD[1)] | COD[2)] | SS[2)] | T-N[3)] | T-P[1)] | TOC[2)] |
|---|---|---|---|---|---|---|
| | mg/L | | | | | |
| Jangsungcheon | 4.6 | 7.0 | 25 | 3.63 | 0.153 | 5.0 |

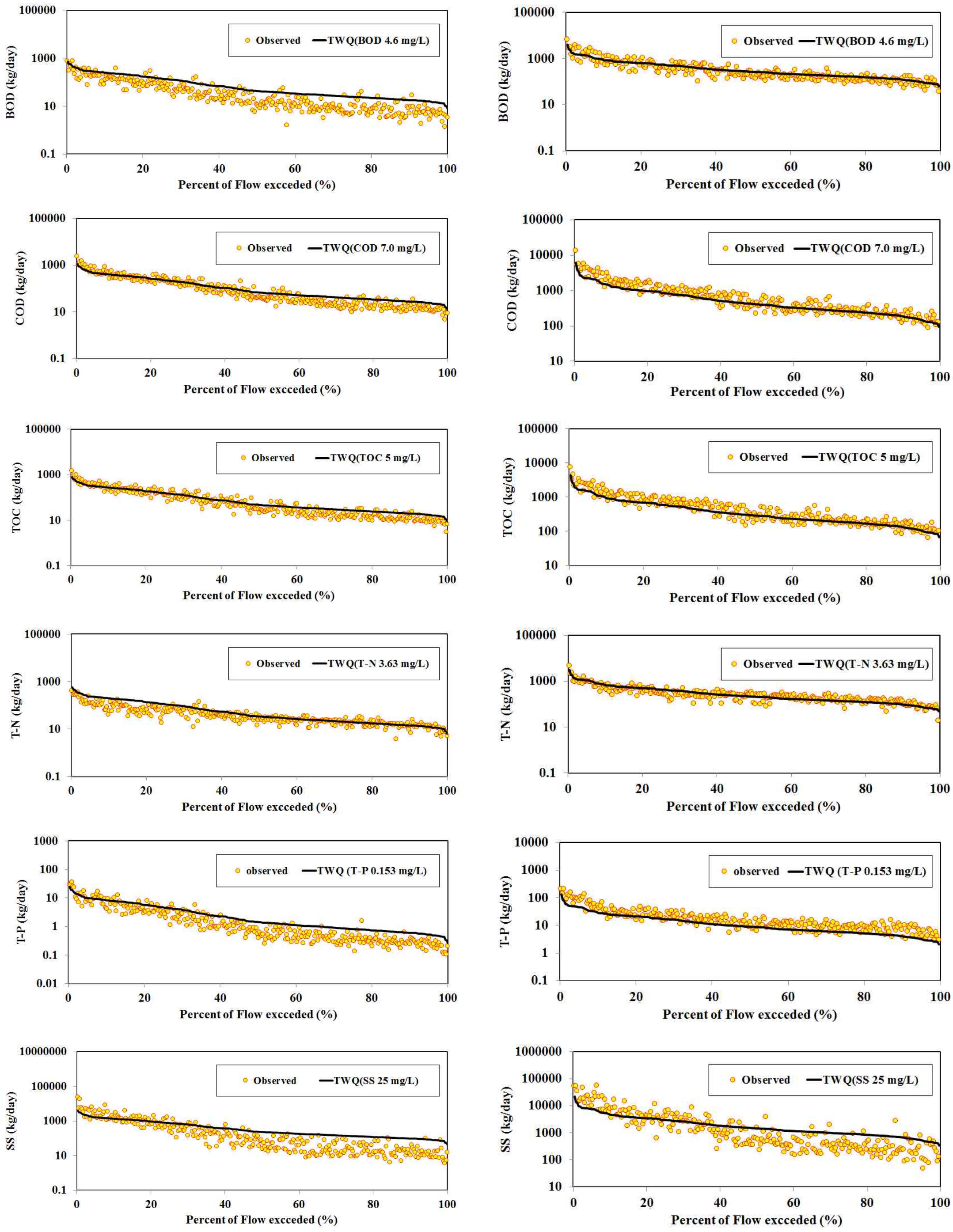
1) TMDL target water quality
2) Water environment standards : water quality III grade
3) 8-year average water quality concentration

and TOC showed a high concentration level as Class V (very poor). The fact that the water quality concentration in the lower stream is higher than in the upper stream is also largely influenced by the type of land use. In the consideration of the land use in the Jangsungcheon watershed, the area of forests decreases as they descend from the upper stream to the lower stream, while the area of farmland and land increased. Cho et al.(2018) showed that the items of BOD, TOC, and T-P represented a high positive relationship to farmlands (rice paddies and fields) and other areas, and showed a negative relationship to forest areas in the results of the analysis of the correlation between the analysis results of the land use and LDC and the excess pollutant loads. In particular, Jung et al.(2012) and Shin(2004) reported that the flow velocity is fast due to the rapid channel slope in the case of forests, and DO is high and BOD shows low values due to difficulties in absorbing organic matters because the bottom is made of gravel and sand. However, in the case of farmlands, they showed that the BOD concentration is high due to the effects of compost and chemical fertilizers with high organic content, and it represents a positive correlation to the areas rice paddies and fields. In this study, therefore, the watershed is also believed to be caused by an increase in the release of organic matters (e.g., biodegradable and refractory matters) and nitrogen and phosphorus due to the increase in the area of rice paddies and fields as for the downstream.

### 3.3. Evaluation of the water body pollution level using the load duration curve

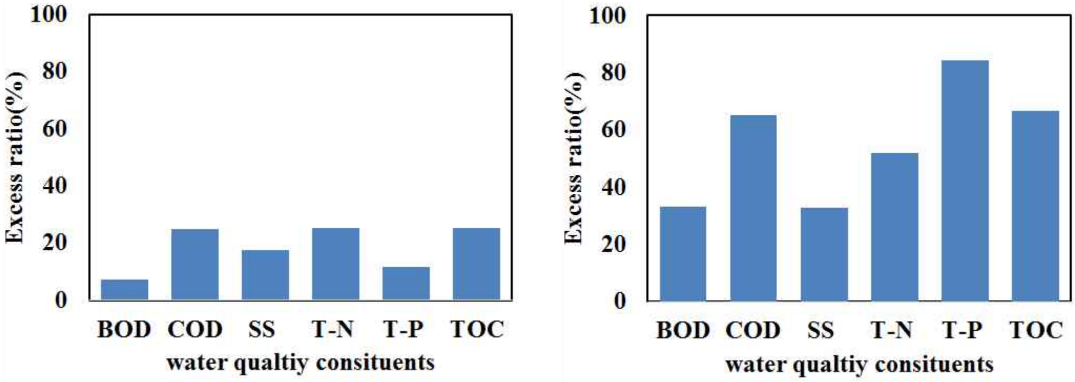
A reference water quality concentration value is required for analyzing and evaluating the water body pollution level. The Jangsungcheon watershed is included in the Yeong-bon D unit watershed, and the target water quality values of BOD and T-P, which are presented for implementing the three-step water pollution load management, were applied by 4.6 mg/L and 0.153 mg/L, respectively Also, in the case of the items of COD, TOC, and SS, the water quality concentration values corresponding to the mid-watershed water quality target grade, which is presented in the operation plan of the water environment measurement network, were applied. Jangsungcheon belongs to the midstream Yeongsan River and its target water quality is "Class III". In the case of T-N, the LDC was built by reflecting the average water quality value of the measured data during the period of this study (Table 3.).

Fig. 5. shows the measured pollutant loads projected on the LDCs. The sum of the excess pollutant loads of BOD, COD, SS, T-N, T-P and TOC at the JS1 were 45.1 kg/day, 104.2 kg/day, 1601.5 kg/day, 4.8 kg/day, 2.8 kg/day, and 61.7 kg/day, respectively which represented high achievement rates of the target water quality with the excess rates of 7.1～25.4%(Fig. 6.). The target water quality was considered achieved if the excess rate was less than 50% by presenting the measured pollutant load after obtaining the LDC. The all items applied with the LDC analysis at the JS1 point




(a) JS1 (b) JS2

**Fig. 5.** LDC application and distribution of water quality.




(a) JS1 (b) JS2

**Fig. 6.** Exceeded rate of watersheds by the target water quality.

were found to be satisfied with the target water quality. The sum of the excess pollutant loads of the items of BOD, COD, SS, T-N, T-P and TOC at the JS2 point was 263.4 kg/day, 392.3 kg/day, 5098.5 kg/day, 61.5 kg/day, 10.3 kg/day, and 244.2 kg/day respectively, and the excess rate of the target water quality for each item was 33.1%, 65.1%, 32.7%, 51.8%, 84.2%, and 66.6% respectively. The items of COD, SS, T-N, and T-P failed to achieve the target water quality. For considering the time of exceeding the targe water quality by month, the excess rates of the refractory matter indexes, COD and TOC, and nutrient, T-P, were 73%, 75%, and 63%, respectively, during the farming season from May to September. In the case of T-N during the same period, the excess rate was 17% and that satisfied the average water quality level. However, it was analyzed that the excess rate was 60% from January to March (Table 4.). Based on these results, it was considered that the items of COD, TOC, and T-P were affected by the precipitation period and farming

**Table 4.** Result of monthly Exceeded rate of watersheds

| Item | Site | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | % | | | | | | |
| BOD | JS1 | - | - | 8.9 | 6.3 | 7.7 | 8.3 | 58.1 | - | - | 2.4 | 8.3 | - |
| | JS2 | 6.5 | - | 11.6 | 3.2 | 29.2 | 17.1 | 17.1 | 4.1 | 7.0 | 2.7 | 1.6 | - |
| COD | JS1 | 0.9 | - | 7.3 | 2.6 | 32.3 | 26.6 | 21.1 | 7.1 | - | 0.5 | 1.2 | 0.4 |
| | JS2 | 5.2 | 0.1 | 13.3 | 4.2 | 20.9 | 20.6 | 17.1 | 6.2 | 7.9 | 2.6 | 2.6 | 0.4 |
| SS | JS1 | - | - | 0.9 | - | 41.8 | 32.3 | 17.1 | 6.1 | 0.1 | - | 1.7 | - |
| | JS2 | 5.3 | - | 7.1 | 0.8 | 25.8 | 11.8 | 24.1 | 13.6 | 3.2 | - | 8.3 | - |
| T-N | JS1 | 12.8 | 7.4 | 37.2 | 11.9 | - | - | - | - | - | 4.8 | 18.1 | 7.8 |
| | JS2 | 22.8 | 8.8 | 28.7 | 1.8 | 2.0 | 1.1 | 4.8 | - | 9.5 | 6.4 | 7.9 | 6.2 |
| T-P | JS1 | 0.2 | - | 0.2 | 5.9 | 23.7 | 30.7 | 33.0 | 3.7 | 2.4 | 0.1 | - | - |
| | JS2 | 9.2 | 2.5 | 9.2 | 3.9 | 18.0 | 6.7 | 16.9 | 12.8 | 8.9 | 4.1 | 5.6 | 2.0 |
| TOC | JS1 | 0.4 | 0.1 | 5.2 | 3.3 | 26.5 | 35.2 | 23.4 | 4.1 | - | 0.3 | 1.6 | - |
| | JS2 | 6.2 | 0.1 | 10.0 | 4.4 | 20.5 | 24.4 | 17.9 | 4.8 | 7.4 | 1.9 | 2.1 | 0.2 |

**Table 5.** Discharge pollutant load by watersheds in Jangsungcheon unit : kg, %

| | Pollutant source | JS1 | JS2 | Total |
|---|---|---|---|---|
| BOD | Domestics | 37.8<br>(16) | 205.0<br>(84) | 242.8<br>(100) |
| | Livestock | 41.8<br>(18) | 188.8<br>(82) | 230.6<br>(100) |
| | Industrial | 0.0<br>(0) | 5.1<br>(100) | 5.1<br>(100) |
| | Landfill | 83.2<br>(15) | 466.7<br>(85) | 549.9<br>(100) |
| | Total | 162.9<br>(16) | 865.6<br>(84) | 1028.5<br>(100) |
| T-N | Domestics | 13.1<br>(14) | 81.0<br>(86) | 94.1<br>(100) |
| | Livestock | 28.2<br>(20) | 111.9<br>(80) | 140.1<br>(100) |
| | Industrial | 0.0<br>(0) | 2.2<br>(100) | 2.2<br>(100) |
| | Landfill | 52.1<br>(17) | 260.9<br>(83) | 313.1<br>(100) |
| | Total | 93.4<br>(17) | 456.0<br>(83) | 549.4<br>(100) |
| T-P | Domestics | 1.4<br>(14) | 8.7<br>(86) | 10.1<br>(100) |
| | Livestock | 3.0<br>(21) | 10.9<br>(79) | 13.9<br>(100) |
| | Industrial | 0.0<br>(0) | 1.2<br>(100) | 1.2<br>(100) |
| | Landfill | 4.6<br>(17) | 22.8<br>(83) | 27.4<br>(100) |
| | Total | 8.9<br>(17) | 43.7<br>(83) | 52.6<br>(100) |

and livestock in agricultural areas (Jung et al., 2015), and the item of T-N was also affected by various factors such as water temperature, freezing, and so on. Lee et al.(2018) reported that the domestic river water quality is affected by point sources and base runoff in the season of low flows, and even a small pollutant source may degrade the water quality. Han et al.(2015) suggested that the concentration of organic materials and nitrogen salts represents high levels in the winter and spring seasons based on the results of the monthly change in water quality using the five year water quality data (2009-2013) provided by the national water quality measurement network. In addition, Lee et al.(2018) reported that the excess frequency presents as a high level usually during the spring season (March-May) based on the results of the analysis of the achievement of the target water quality using the LDCs for the major streams in Namhan River. They showed that it occurs when the flow rate is reduced due to drought in the spring season, and the non-spot pollutants that had been frozen in the soil during the winter season are thawed, which is accompanied by base runoff and inflow into the stream.

For analyzing the characteristics of the target water quality excess rate and pollutant source, the discharge loads at the JS1 and JS2 (excluding the JS1 discharge load) points were investigated. There were no discharge loads of the domestics and landfill at the JS1 and JS2 points. The discharge loads of BOD, T-N, and T-P at the JS1 and JS2 points covered more than 50% of the entire discharge loads, and the livestock accounts for 25～30% of the total discharge loads. Although the discharge load rate at the JS1 and JS2 points were similar, the achievement rate of the target water quality was different. For considering the investigated discharge loads presented in Table 5., the JS1 point contributed about 20% to the Jangsungcheon watershed, and other watersheds about 80% of the discharge loads. Therefore, the JS1 point shows small influence to the result due to its small discharge loads even though it has a great weight of the land and livestock. Thus, it is necessary to manage the pollutant sources discharged from the land and livestock at the JS2 point in order to achieve the target water quality of the refractory matters, COD and TOC, and nutrient, T-P. In addition, it is necessary to perform detailed investigations and to analyze pollutant sources in small tributaries flows into Jangsungcheon in order to effectively manage the river.

## 4. Conclusions

The LDCs were built using the observation data at intervals of eight days for the monitoring points installed at the Jangsungcheon watershed, which is a tributary flows into Yeongsan River. Also, the impaired water body was investigated by considering the excess target water quality, and the causes of the excess pollutant loads were also analyzed. Based on the observation data implemented by 323 and 278 times at the upper (JS1) and end (JS2) points of the Jangsungcheon watershed, respectively, from 2011 to 2018, the LDC analysis was performed by reflecting the reference water quality concentration properly for each subject item.

The runoff rate at the JS1 and JS2 points were 0.02～1.85 (average: 0.25) $m^3$/sec and 0.15～10.10 (average: 1.08) m3/sec respectively, and the flow rate showed high frequencies during the high flows and moist periods, May-September. The average concentration of the items of BOD, COD, SS, T-N, T-P, and TOC at the JS1 point for the recent eight years was 2.22 mg/L, 5.56 mg/L, 14.84 mg/L, 2.84 mg/L, 0.093 mg/L, and 4.07 mg/L respectively, and the JS2 point showed 4.25 mg/L, 8.50 mg/L, 22.78 mg/L, 3.63 mg/L, 0.23 mg/L, and 6.09 mg/L respectively. The water quality has been shown to deteriorate from upstream to downstream, and this is related to the land use share (cultivated land) in that area.

In the results of the analysis of the excess rate of the target water quality, the JS1 point satisfied the reference water quality in all water quality items, but the JS2 point failed to satisfy the reference water quality because the excess rate of the items of COD, TOC, T-N, and T-P was more than 50%. In particular, the excess rate of the items of COD, TOC, and T-P showed high levels more than 50% during the period of May-September. It is considered that while the upper watersheds cover a large area of forest, the lower down the stream, the greater the area of urban and agricultural areas, and the pollutants from agricultural area increase. Also, the results are considered as a result of the impact of the livestock sheds and livestock waste treatment facilities. In the analysis of the discharge loads of the watersheds corresponding to the JS1 and JS2 points for investigating the causes of the pollutant loads that exceed the target water quality, revealing a great contribution of land use. In addition, the JS2 point contributed more than 80% of the rate of the discharge loads for the entire watersheds excluding the JS1 point. Therefore, it is necessary to monitor the unobserved tributaries corresponding to the JS2 point and to trace the causes of the unidentified pollutant sources in order to manage the water quality of

Jangsungcheon.

By the result of this study, it is necessary to make efforts to reduce the non-point agricultural pollutants in Jangsungcheon from May to September. As the management of the irrigation gate in rice paddies for reducing pollutants, it is thought that much of the items of BOD, T-N, and T-P can be reduced. Also, it is considered that about 30% of the entire discharged loads regarding BOD and COD during the farming season can be reduced through treating 10 mm of precipitation treated as baseflow. However, it is necessary to support different policies including education programs to encourage farmers to promote participation and to pay incentives for the effort of reducing pollution in order to reduce non-point agricultural pollutant sources.

## Acknowledgements

This Research was supported by a grant from the National Institute of Environment Research (NIER), funded by the Ministry of Environment (MOE) of the Republic of Korea (NIER-2018-03-03-002).

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