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Concentration Characteristics of Runoff Pollutants using Statistical Techniques during a Storm: The Case Research of Driveway Site in Korea

Jaehwan Ahn[1], Hyecheol Oh[1], Seogku Kim[1], Hyundong Lee[1,2], Heejae Oh[3]

[1] Korea Institute of Civil Engineering and Building Technology, Environmental and Plant Engineering Research Institute. 283 Goyangdae-ro, Ilsanseo-gu, Goyang-si, Gyeonggi-do, Republic of Korea
[2] University of Science and Technology, Construction and Environment Engineering. 217, Gajeong-ro, Yuseong-gu, Daejeon, Republic of Korea
[3] D&Shine Co.,Ltd., 76 Hanggongdaehak-ro, Deogyang-gu, Goyang-si, Gyeonggi-do, Republic of Korea
{jhahn, hcoh79, sgkim, hdlee}@kict.re.kr, ohj@dnshine.co.kr

Abstract. This research was conducted to investigate the magnitude and nature of the emission of runoff pollutants with the goal of quantifying stormwater pollutant concentrations from driveways site. A statistical summary for concentration characteristics of driveway runoff is provided based on the various analysis techniques. Runoff water qualities in temporal variation were generally higher in wet season than in dry season with a high degree of variability. Concentrations of water quality constituents in urban stormwater are often expressed in probabilistic terms using statistics such as the mean and standard deviation and selected quintiles. This research presents the concentration changes and characteristics during storm occurrence.

Keywords: Driveway, Stormwater, Statistics, Probability distributions, Correlation

1 Introduction

Korea has made tremendous advances in the past 30 years to clean up its aquatic environment by controlling pollution from point sources. Although point source discharges have decreased in recent years, many water bodies or rivers are still impacted and are either eutrophic, with excess algae biomass and episodes of toxic algal blooms, or oxygen depletion [1].

Nonpoint sources (NPSs) are the cause of many of the problems. Especially, vehicle emissions have different pollutants such as heavy metals, oil, grease and particulates from sources such as fuels, brake pad wear and tire wear. A storm event usually leads to highly polluted runoff from roadside and bridges which directly affect the water quality near the site. Many studies have attempted to develop relationships among pollutant load, observed storm events, and site characteristics [2-5].

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This research is performed to find pollutant characteristics in the magnitude of statistical pollutant concentrations during storm periods. Studies that determine the impact of site and event characteristics on statically analysis are rare. This research suggests a new concept to explain the relationship among the driveway runoff stormwater parameters and influent characterization effects by using statistical technique. This concept is useful to determine the quantitative analysis on the runoff water quality.

2 Materials and methods

Monitoring was performed at a roadside site in the Korean city of Goyang, to measure rainfall, runoff rate and runoff quality and to be performed by nine events during rainy days. Goyang city is geographically located between 126º56.5′ and 126º45′ in the east longitude, and 137º34′ through 137º41′ in the north latitude. The city is located in the north of South Korea, 32 km from Seoul, the capital city of Korea. Its population in 2013 was 1 million, and the city covered an area of 267.41 km^2.

The water quality parameters from storm water runoff, including total suspended solids (TSS), turbidity (NTU), chemical oxygen demand (COD), biochemical oxygen demand (BOD), dissolved organic carbon (DOC), total nitrogen (TN), and total phosphorus (TP) were analyzed. Detecting the first flush required grab samples to be collect throughout the storm but especially in the early runoff period. Grab samples can be collected manually. The manual sampling provided greater flexibility, allowing larger sample volumes to be collected as well as special samples using different bottles. The first sample was collected at the very beginning of runoff and five grab samples were collected in the first hour of runoff in order to catch the first flush phenomenon. The additional samples were collected each hour until the end of runoff per event.

Summary statistics and frequency distributions were calculated to address the distributional and statistical characteristics of stormwater runoff quality. Summary statistics were calculated for each constituent, which include information such as the total number of data, minimum and maximum detected values, mean, and standard deviation. The distributions of runoff quality data for each constituent were evaluated for approximate normality prior to performing additional data analyses. Goodness-of-fit tests are used to test the hypothesis that a sample distribution is drawn from a specified distribution. The probability distributions were determined by fitting select distributions to measured data by the help of goodness-of-fit tests which were chi-square, Kolmogorov-Smirnov, and Anderson-Darling tests. The simulation software is used in fitting distributions, which provides values of the test statistics, and allows the user to determine the best fitting distributions. We performed Pearson's correlation analysis due to the correlation between water quality parameter-parameter reflects the degree to which the variables are related.

3 Results and discussions

Nine storm events were monitored annually at driveway site during the wet seasons (October through April) and dry seasons (March through November). Five of the most common statistical properties have been selected. These are mean, median, standard deviation, coefficient of variation (C.V), skewed and kurtosis including the 95% confidence interval of lower and upper to the arithmetic mean. Among the water quality parameters, BOD showed the most skewed with the highest level of kurtosis (a high degree of variability) and coefficient of variation (C.V). All water quality parameters had the 95% upper and lower confidence interval values to the arithmetic mean much greater than the median and the geometric mean.

Using the interval graph to represent the 95 % upper and lower confidence limitations to arithmetic mean, fig. 4 presented that ranges of driveway parameter concentrations were the largest in November (C.I: 316.4 mgL^{-1}, 60.95 mgL^{-1}) (TSS), in June (C.I: 189.3 mgL^{-1}, 8.6 mgL^{-1}) (Turbidity), in June (C.I: 189.3 mgL^{-1}, 32.1 mgL^{-1}) (BOD), in May (C.I: 121.2 mgL^{-1}, 4.19 mgL^{-1}) (COD), in April (C.I: 91.6 mgL^{-1}, 20.1 mgL^{-1}) (DOC), in April (C.I: 9.67 mgL^{-1}, 3.68 mgL^{-1}) (TN) and in May (C.I: 0.59 mgL^{-1}, 0.18 mgL^{-1}) (TP), respectively.

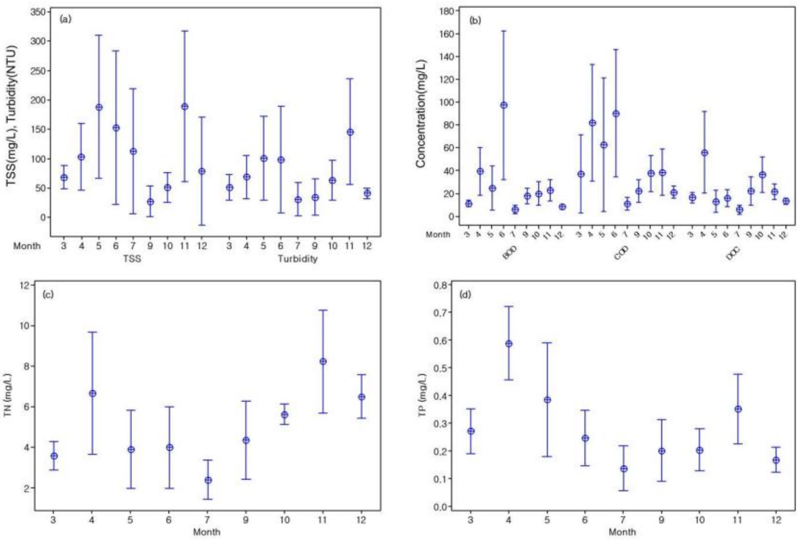

Fig. 1. Interval graph of temporal variations; (a) TSS and Turbidity, (b) BOD, COD, DOC, (c) TN, (d) TP in driveway runoff water quality.

The correlation matrix of all water quality variables shows significant relationships between all parameters ($P<0.001$). Among the relationship, the correlation of between TSS and Turbidity showed relatively strong positive relationship ($r=0.825$). The moderate positive correlations were also observed among parameters associated with Turbidity-TP ($r=0.786$), DOC-TP ($r=0.778$), BOD-TP ($r=0.738$), Turbidity-BOD ($r=0.731$), Turbidity-DOC ($r=0.724$), TSS-TP ($r=0.720$), Turbidity-TN ($r=0.714$), COD-DOC ($r=0.710$), and BOD-COD ($r=0.7$), respectively.

Especially, the main parameters that contribute to the majority of water quality problems in runoff pollutants are: Suspended solids because it is a general indicator of pollution, COD and BOD because they supply a relative indication of the organic pollution. Besides, they are assumed as a reference parameter in many mathematical models simulating the pollutants dynamics during storm water runoff [6].

4 Conclusion

This research summarized and analyzed the characteristics of washed-off pollutants using various statistical techniques from driveway site in Korea. The following conclusions can be made:

1) In the emission characterization of runoff water quality, BOD has largest variability based on the coefficient of variation (C.V) and most of water quality parameters have arithmetic mean much greater than the median due to characterizations of uncertainty distribution of each water quality parameter.

2) Significant difference of temporal variations in runoff water quality parameters were found and were higher in the wet seasons (October through April).

3) The strongest correlations were observed among parameters associated with TSS-turbidity (r=0.825) and the moderate positive correlations were also observed among parameters associated with Turbidity-TP (r=0.786), DOC-TP (r=0.778), BOD-TP (r=0.738), Turbidity-BOD (r=0.731), Turbidity-DOC (r=0.724), TSS-TP (r=0.720), Turbidity-TN (r=0.714), COD-DOC (r=0.710), and BOD-COD (r=0.7), respectively.

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References

1. Kim, L.H., Ko, S.O., Jeong, S., Yoon, J.: Characteristics of Washed-off Pollutants and Dynamic EMCs in Parking Lots and Bridges during a Storm. Science of the Total Environment, 376(1-3), 178-184 (2007)
2. German, J., Svensson, G.: Metal Content and Particle Size Distribution of Street Sediments and Street Sweeping Waste. Water Science and Technology, 46(6-7), 191-198 (2007)
3. Irish, L.B., Barrett, M.E., Malina, J.F., Charbeneau, R.J.: Use of Regression Models for Analyzing Highway Storm-water Loads. Journal of Environmental Engineering, 124, 987-993 (1998)
4. Wu, J.S., Allan, C.J., Saunders, W.L., Evett, J.B.: Characterization and Pollutant Loading Estimation for Highway Runoff. Journal of Environmental Engineering, 124, 584-592 (1998)
5. Characklis, G.W., Wiesner, M.R.: Particles, Metals and Water Quality in Runoff from Large Urban Watershed. Journal of Environmental Engineering, 123, 753-759 (1997)
6. Chen, J., Adams, B.J.: A Derived Probability Distribution approach to Stormwater Quality Modeling. Advances in Water Resources, 30(1), 80-100 (2007)

