IDENTIFICATION THE QUALITY OF STORMWATER WASHOFF IN DIFFERENT URBAN LAND USES

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ABSTRACT

Fresh water is one of finite resources for the whole world which is essential to sustain the lives. Thus, water sources should be preserved, however, stormwater washoff that carries various accumulated pollutants on impervious surfaces resulted from uncontrolled urbanization further accumulates to the surface water bodies without treatment. The hydrologic, physiochemical and biological characteristics of water bodies are adversely affected because of the received pollutants in the washoff. Thus, mitigatory measures on stormwater pollution are vital importance to safe guard the urban water quality. Characteristics of stormwater is essential to determine to propose mitigation strategies. However, the effectiveness of such mitigation is limited due to lack of knowledge on pollutants generated on different urban land uses. In this study, quality of stormwater washoff on road surfaces, which have the same characteristics in different urban land uses namely residential, commercial and industrial was determined. Collected stormwater samples from three road surfaces in each land use, maintaining minimum antecedent dry period of five days between each event while ensuring not to mix with other wastewater were tested to determine physical, chemical and biological characteristics of stormwater according to standard method of water and wastewater analysis published by American Public Health Association. Temperature, turbidity, total solids (TS), total suspended solids are the physical parameters measured. The chemical parameters tested were the biochemical oxygen (BOD_5), chemical oxygen demand (COD), alkalinity, chlorides, electrical conductivity, pH and hardness. Fecal coliform and total coliform were the biological parameters measured. Both univariate and multivariate data analysis techniques were used. Parameters exceeded the standards for inland waters of Sri Lanka, CLASS 1 Waters: Drinking water with simple treatment published by Central Environment Authority in 2001, were identified based on univariate data analysis. Those are COD, BOD_5, turbidity, alkalinity and fecal coliform. It shows that organic matter concentration is significant in stormwater washoff with exceeding of BOD_5 and COD. There is discriminated stormwater quality recognized in residential and industrial land uses according to PCA, which is the multivariate data analysis technique used further to recognize the correlation between different urban uses. Stormwater washoff can be collected and treated for the parameters exceeded before entering to the water bodies and future development projects can be carried out based on these results to have cost effective and efficient wastewater treatment system to avoid the contamination of fresh water.

***Key words*:** Stormwater washoff quality, urban land uses, road surfaces,

1. INTRODUCTION

Uncontrolled urbanization results a significant increase of impervious surfaces such as roads, roofs and parking lots. Stormwater washoff is originated when rain flows over the impervious surfaces which prevent the infiltration [1]. Various types of pollutants which have been deposited and accumulated on these impervious surfaces receive to the water bodies even with a trivial rainfall event [2]. Thus, urban stormwater washoff has been recognized as a non-point pollution source of deterioration of water quality in surface water bodies [3].

In the 1950s, quantification of pollutant loads in urban runoff was begun and based on those analyses depicted that the shock load to a receiving water from urban stormwater washoff could be 100 to 1000 times greater than for sanitary wastewater, and having significance dominating effect on the quality of receiving water [1]. Consequently, attention was then focused upon quantifying the source of these

pollutants in micro scale through the 1960s [4] and further efforts have been focused upon identifying and quantifying the individual sources to form of water pollution. Land use has been subsequently become one of major factor which affects the types and levels of pollutant generating activities of man and nature [5]. Furthermore, researches have been carried out to identify the different impervious surfaces for the contamination of urban stormwater runoff classifying as road surfaces, roof surfaces and parking lots. Pollutant concentration of washoff generated due to impermeable roads and parking surfaces are significant compared to other impervious surfaces and vary with traffic density, wind drift, duration and intensity of stormwater events [2].

Very limited stormwater quality monitoring has been carried out in study area, Galle. Evaluation of stormwater quality in different impervious surfaces have already been carried out. Thus, this research was conducted to determine the quality of stormwater washoff on road surfaces in different urban land uses namely residential, commercial and industrial while identifying the correlation between pollutants and different urban land uses and they are finally compared.

2. METHODOLOGY

Three roads surfaces having same characteristics in each urban land uses; residential, commercial and industrial were selected in Galle city. Stormwater samples from three road surfaces in each land use were collected maintaining minimum antecedent dry period of five days between each event while ensuring not to mix with other wastewater. Collected samples were tested to determine physical, chemical and biological characteristics of stormwater according to standard method of water and wastewater analysis published by American Public Health Association [6, 7]. Temperature, turbidity, total solids (TS), total suspended solids (TSS) are the physical parameters measured and chemical parameters tested were the BOD_5, COD, alkalinity, chlorides, electrical conductivity and pH, hardness. Fecal coliform and total coliform are the biological parameters measured. Both univariate and multivariate data analysis techniques were used for statistical analysis [8]. Univariate statistical analysis is used to compare the two parameters measured each other which is the basic and the simplest form of statistical analysis, carried out prior to other advanced data analysis methods. Mean is used for statistical univariate measurements to describe the characteristics of a single variable data set. Parameters exceeded the standards for inland waters of Sri Lanka, CLASS 1 Waters: Drinking water with simple treatment published by Central Environment Authority in 2001 were identified based on the univariate analysis results. Correlations between water quality parameters and land use type were determined using multivariate data analysis technique, Principal Component Analysis (PCA). PCA is a well-known pattern recognition technique of multivariate statistical data analysis which reduces raw data into multiple components while retaining the most variance within the original data in order to identify possible patterns between objects and variables [5]. PCA were carried out for all stormwater quality parameters measured with three different land use types separately and all land types with different water quality parameters, chemical, physical and biological.

3. RESULTS

Figure 1 shows the parameters, which exceed the standards based on the univariate data analysis. It shows that organic matter concentration is significant in stormwater washoff with the exceeding of BOD_5 (3mg/L) and COD (15mg/L).

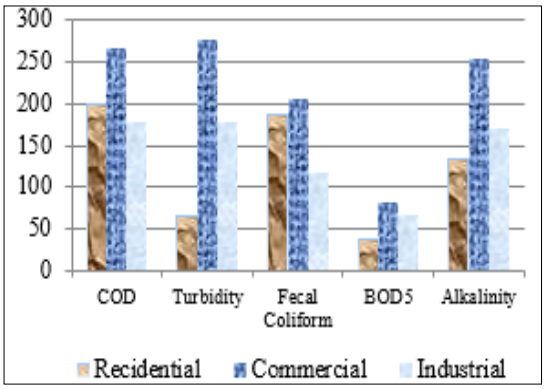
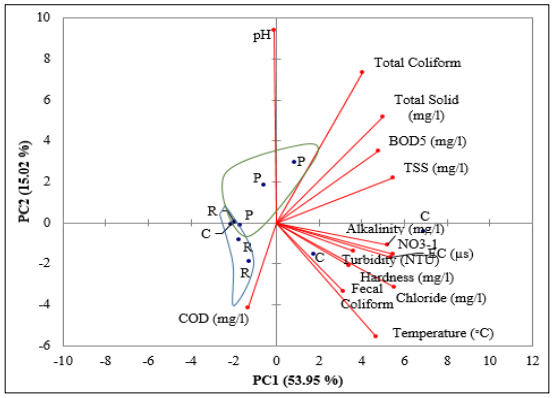


Figure 1: Parameters exceeded the standards

Bi-plot for the all parameters measured and urban land uses obtained from the principal component analysis is shown in Figure 2. There are two clusters of residential and industrial land uses shown in two circles, reveals each land use has different characteristics of pollutants generated in stormwater washoff respectively.

Strongly correlated parameters were also identified. Alkalinity, chloride, hardness, electrical conductivity (EC), turbidity, nitrate (NO_3^{-1}) and temperature are in one quadrant as well as having angles closer to zero degree,

shows a strong correlation. Hardness is a measure of the quantity of divalent ions such as calcium, magnesium, and or other ions in the water. In addition, Calcium Carbonate ($CaCO_3$) which is dissolved in water flow through geology that has limestone and marble is one source of alkalinity. Furthermore, most of the sampling locations are located in Galle that are near to the sea, thus high concentration of $CaCO_3$ can be recorded. Hence, hardness and alkalinity of the stormwater washoff are proportionate each other. Besides, EC in stormwater is also measure based on existing ion concentration of hardness, alkalinity and chloride etc. Therefore, EC, alkalinity, chloride and hardness are strongly correlated parameters which are also proportionate each other. Total solids (TS) and total suspended solids (TSS) are another strongly correlated parameters since TSS is sub group of TS which describe the particulates suspended in a moving body of water.



Note: R- Residential, C-Commercial, P- Industrial

Figure 2: PCA for all parameters and urban land uses

4. CONCLUSIONS

Turbidity, COD, BOD_5, alkalinity and fecal coliform have been exceeded required standards, thus, stormwater washoff should be treated to the acceptable limits prior to release the natural water bodies according to standards of inland water quality published by Central Environment Authority because there is higher concentration of organic matter leads cyclic cause and effects on water bodies.

Besides there is strong correlation between land use type and pollutants, zoning can be done in future infrastructure development. Then it is convenient to treat the stormwater washoff in economical and efficient way. These results can be used to enhance the effectiveness of mitigation measures of safe guarding the stormwater pollution and prevent the contamination of water quality of receiving water, hence protect the available fresh water for the sustain of both present and future all kind of species.

5. REFERENCES

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