



Basin Discharge through HEC-HMS for Estimating Pollutant Load of Urbanized Ungauged River Sub Basin

H.M.S.S.Sandarekha¹, P.A.K.Sameera¹, G.L.Jayathunga¹, B.C.L. Athapattu^{1*}
and G.A.A.U.Perera²

¹Department of Civil Engineering,
Faculty of Engineering Technology
The Open University of Sri Lanka
Nawala, Nugegoda
SRI LANKA

²Wetland management Division,
Sri Lanka Land Reclamation and Development Corporation
E-mail: *bcli@ou.ac.lk

Abstract: *The potable water quality demand increases with growing population, urbanization, and industrialization. The present study focuses on evaluating the pollutant load of Kalu Ela sub basin which is the secondly highest polluted sub basin of the Kelaniriver in Sri Lanka.*

The Hydrological Modeling System (HEC-HMS) was designed to simulate the precipitation-runoff process of five sub catchments of an ungauged river sub basin. Actual flow rate was recorded by calibration and validation of the Modeling system using area, soil type, land use pattern, ground cover and precipitation data of each sub catchments while thirteen water quality parameters were examined for identify most significant pollutants. This method may represent a valuable opportunity in the context of ungauged sub basin to estimate the pollutant loads.

Chemical Oxygen Demand was recorded as the most significant pollutant in all sub catchments and there by pollutant load was estimated. The results were revealed that water quality monitoring mechanisms are essential to control the receiving pollutant loads from industries to river sub basins in order to protect potable water sources for future.

Keywords: *Ungauged catchments, HEC-HMS, Pollutant load, Kalani river basin, Basin discharge*

1. INTRODUCTION

Water is only next to air for the human being and key factor in sustaining human life. The water quality of the rivers is of vital importance since rivers are the major source of the potable water supply in the country. The Kelani river is the main source of supply of drinking water in Greater Colombo, Sri Lanka however it is under threatened due to rapid growth of industries located close vicinity of the river and passes through the most populated capital city (Wijesinghe, 2010). The factories and industries which are located in the lower reach of Kelani river are identified as the polluters of the river due to pollutants of their industries are flowing into river through its tributaries. The major wastewater discharging industries are identified as raw rubber factories, beverage factories, textiles factories, rubber latex factories, milk food industries, steel manufacturing factories, plywood factories, fertilizer manufacturing factories (Mahagamage *et al*, 2014). In addition anthropogenic activities and natural sources including agricultural runoff, domestic and municipal effluents accelerate pollution rate of the river.

Deterioration of water quality is one of the main environmental problems in Sri Lanka and it creates adverse impacts on human health and influence the socio-economic development of the whole country and causes due to the higher pollutant loads resulting from various point source and non-point source (Athukorala *et al*, 2013). The demand for good quality potable water has been increasing in the country with the increasing population, urbanization and the industrialization. Therefore conservation of the Kelani river is very essential component to face water scarcity problems in future and to supply good quality drinking water and cost management of water treatment plants in current situation. Estimation of pollutant load is very effective tool to determine water quality and propose effective solutions for conservation of the Kelani river.

This study considers urbanized ungauged river sub basin. The Hydrological Engineering Center-Hydrological Modelling System (HEC-HMS) is design to simulate the precipitation-runoff process for

ungauged river sub basin. Pollutant loads are estimated with discharge and concentrations of pollutants. Generally researches have used to estimate pollutant loads for gauged basins. The ungauged sub catchment means flow data (or runoff data) are not available which needs to be predicted using other available information of the relevant catchment or using similar catchment (Grimaldi et al, 2012). This method may represent a valuable opportunity in the context of ungauged sub basin to estimate the pollutant loads of Kalu Ela sub basin which is the secondly highest polluted sub basin of the Kelani river in Sri Lanka (UNDP, 2015). Thereby it will be contributed to assure the water quality of Kelani river by mitigating the receiving pollutant loads. Launching water quality mechanisms will be affected to the industries to treat their wastewater up to the standards stipulated by Central Environment Authority (CEA) and this will control of receiving pollutant loads to the Kelani river.

2. METHODOLOGY

2.1. Study Area: Kalu Ela Sub Basin

The Kalu Ela basin covers an extent of nearly 59 km² with latitude- 7.002507 and longitude- 79.911568 at out fall. Topography of the basin is flat (Topography map, Sri Lanka Survey Department, 2016). The study area, Kalu Ela basin which is shown in figure 1, complies mainly low land areas.

2.2. Water Quality Analysis of Sub Basin

The sampling locations were selected based on hydrology of Kalu Ela basin and basin was divided as sub basin 1, sub basin 2, sub basin 3, sub basin 4 and sub basin 5 as Galudupita, Horape, Kurukulawa, Mahara, Hunupitiya respectively and confluence point of the Kalu Ela which is located across the Negombo road and Wattala. The confluence point represents total pollutants which flow from tributaries of the Kalu Ela.

Sampling was carried out at mid points of tributaries of Kalu Ela and three samples were collected against to flow direction to obtain the average. Samples were correctly labeled and sample bottles were stored in ice and delivered to laboratory on the same day. Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Phosphate-Phosphorous (PO_4^{3-}) of wastewater were experimented at the Environmental Engineering laboratory of the Open University of Sri Lanka. pH was recorded with Cyber Scan pH 300 digital pH meter. Temperature, TDS, Salinity were measured using Jenway 4520 Conductivity meter.



Figure 1 Kalu Ela Basin

2.3. HEC- HMS Model and Model Setup

The hydrological modeling system (HEC-HMS) is designed to simulate the complete hydrologic process of dendritic watershed systems (US Corps of Engineers, 2015). This model is a product of the Hydrologic Engineering Center within U.S. Army Corps Engineers. HEC-HMS model includes many traditional hydrologic analysis procedures such as event infiltration, unit hydrographs and hydrologic routing (Feldman, 2000).

Basin area and sub basin areas were divided according to contour details. Daily rainfall data which was measured during five years was collected from four precipitation gauge stations near to Kalu Ela basin. Precipitation gauge stations and sub basins of Kalu Ela are shown in figure 2.

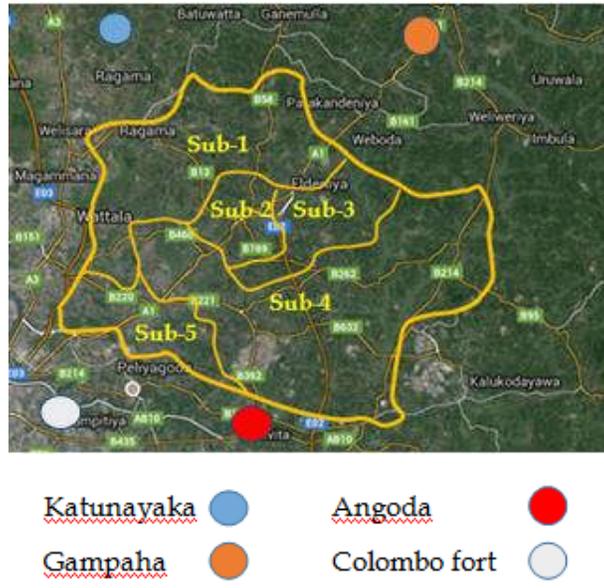


Figure 2 The Gauge Stations and sub basins of Kalu Ela

The daily stream flows were computed using HEC-HMS 4.1 software to simulate the precipitation runoff process of dendritic drainage basins. The basin model of the study area is shown in figure 3. The prepared maps, data and corrected elements were applied to basin model.

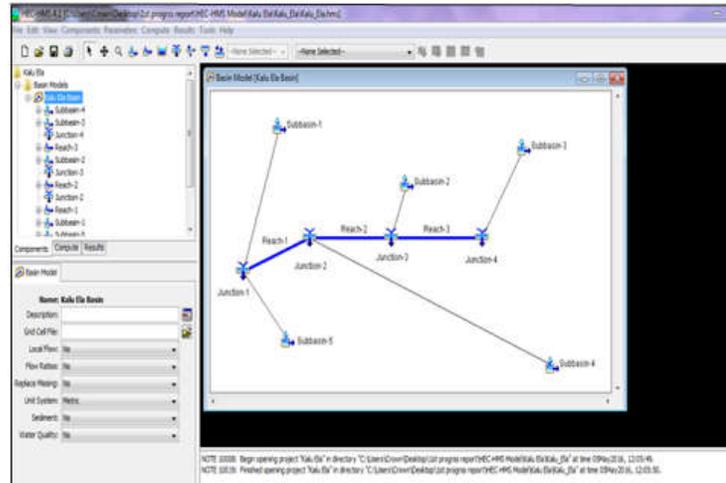


Figure 3 Basin Model for the Kalu Ela basin

Main model input parameters were sub basin areas, SCS Curve number, lag times and precipitation data. The respective areas of sub basins 1-5 were given in the table 1. The mean areal precipitation for each sub basin was estimated using theissen polygon method. The validated rain fall of sub basin 1 is shown in the Figure 4.

2.3.1. Basin Discharge of Kalu Ela

HEC-HMS model was given output as the runoff series for the Kalu Ela sub basin for the simulation period April 2011 – June 2016. The output through HEC-HMS basin model of the sub basin 1 is shown in figure 5.

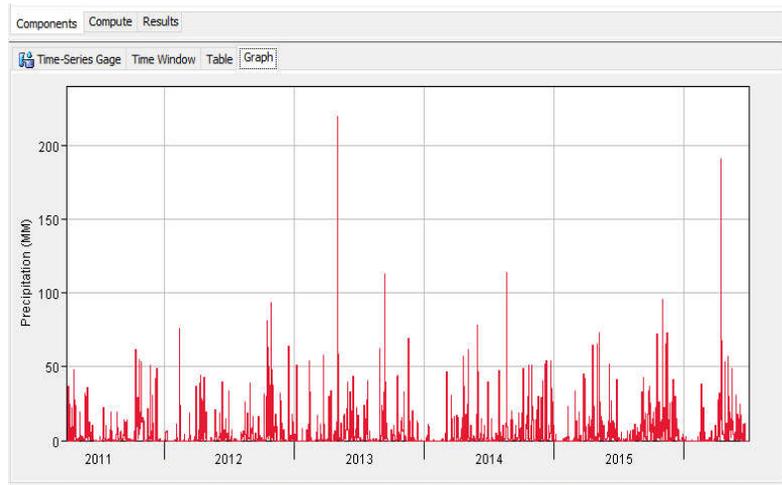


Figure 4 Validated Rain Fall of Sub Basin 1

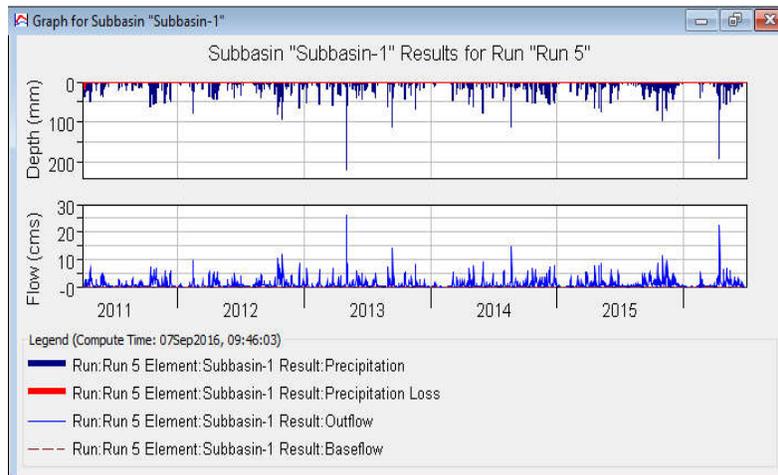


Figure 5 Flow and Precipitation of Sub Basin-1

2.3.2. HEC-HMS Model Calibration and Validation

HEC-HMS Model was calibrated on average flows calculation from different independent methods. Closely matching values from these methods were averaged to get the average daily flows. The prorating factor was 0.66. Average daily flows of sub basins are shown in table 1.

3. RESULTS AND DISCUSSION

Confluence points of sub-basin tributaries are shown considerable increment from ambient water quality standards stipulated by Central Environment Authority. Accordingly, COD & BOD were identified as main pollutants in the sub-basins.

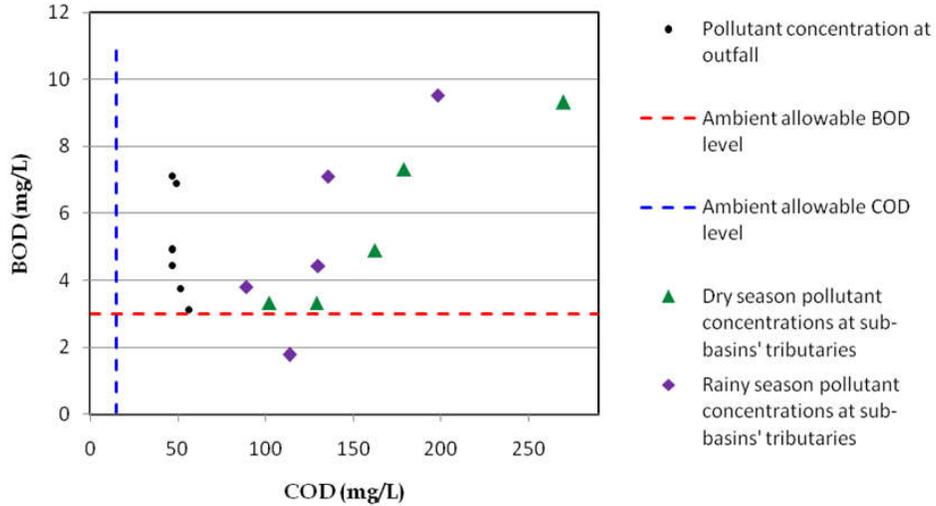


Figure 6 Variation of COD vs BOD at the Kalu Ela Outfall and Tributaries

COD at confluence point was lower than sub basins due to pollutant load of Kalu Ela tributaries was diluted when approaching to outfall. The concentrations, discharge and pollutant loads of Kalu Ela are shown in table 1 while COD vs BOD at the outfall and tributaries are shown in Figure 6.

Table 1 Pollutant load at sub basins and out fall of Kalu Ela basin

Location	Sub basin area (km ²)	Discharge (m ³ /sec)	Pollutant	Concentration (mg/L)	$L=C_{EFF} \cdot D_{EFF}$ (m ³ /sec)
Out fall	59.12	2.88	COD	49.53	0.14
			BOD	5.04	0.01
			PO ₄ ³⁻	0.71	0.002
Sub-basin 1	13.31	0.60	COD	146.08	87.50
			BOD	4.67	2.79
			PO ₄ ³⁻	0.25	0.15
Sub-basin 2	2.29	0.10	COD	121.31	12.25
			BOD	2.55	0.26
			PO ₄ ³⁻	0.35	0.04
Sub-basin 3	8.77	0.42	COD	157.21	66.66
			BOD	7.22	3.06
			PO ₄ ³⁻	157.21	66.65
Sub-basin 4	30.06	1.54	COD	95.48	146.75
			BOD	3.57	5.49
			PO ₄ ³⁻	0.35	0.54
Sub-basin 5	4.06	0.21	COD	234.05	49.38
			BOD	5.04	1.06
			PO ₄ ³⁻	0.75	0.16



COD was recorded as the most significant pollutant in all sub basins while highest concentration was observed in the sub-basin 5. However rainfall runoff simulations provides higher discharge at sub basin 4, which is higher than sub basin 5. Hence pollutant load of sub basin 4 was critical than remaining basins subjected to this study.

4. CONCLUSIONS AND RECOMMENDATIONS

The study implies that the Kalu Ela sub basin of Kelani River is in the critical condition at present. It is envisaged that releasing by-products and hazardous chemicals from industries which are situated in the Kalu Ela sub basin of lower reach of Kelani river basin thereby accelerate the pollution rate. In addition anthropogenic activities and natural sources including agricultural runoff, domestic and municipal effluents increase the pollution rate of the river. If the present pollution status is continued, it creates adverse impacts on human health and influence the socio-economic development of the whole country due to growing demand on the potable water resources. It is concluded that HEC-HMS model appropriates for ungauged river basin to evaluate discharge.

Monitoring water quality mechanisms are essential to control the receiving pollutant loads from industries to river sub basins in order to protect potable water sources in future. Also it should motivate the industries to control the receiving pollutant loads to Kalu Ela basin of Kelaniriver basin and needed to accelerate the proper wastewater management systems based on ambient water quality standards stipulated by Central Environment Authority. Therefore, water quality monitoring is essential for identifying and to mitigate both anthropogenic activities and natural sources of pollution in order to control water scarcity in future.

5. ACKNOWLEDGMENTS

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