



## Water Quality Modelling of Gin River Downstream

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**Abstract:** This study was aimed to evaluate the water quality of Gin River downstream by using QUAL2k modelling software. Calibrated and validated QUAL2k model was used to predict key water quality parameters; Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Nitrate (TN) and Total phosphate (TP), between Lankagama and Wackwella (83 Km) along the downstream of Gin River. Predicted water quality along the river downstream were compared with the available WQ standard (central environment authority, WHO). Calibrated model showed that Lankagama to Batuwangala had a good WQ for drinking with a simple treatment while that for Batuwangala to Keppetiyagoda had average WQ and Keppetiyagoda to Wakwella had minimum WQ. It was also noticed that for washing and bathing, Lankagama to Thawalama except Neluwa has a good WQ while Thawalama to Wakwella had average WQ. As a further improvement of the research, user-friendly software was developed separately which can visualize the model results clearly in any location between the upstream (Lankagama) and downstream (Wakwella). In spite of some limitations, it is recommended to use calibrated QUAL2k model for water future resources management in Gin River downstream.

**Keywords:** Water quality modelling, Gin River, Downstream, QUAL2k

### 1. INTRODUCTION AND BACKGROUND

The anthropogenic activities like industrialization and agricultural practices introduces significant amount of organic matters and nutrients into the river flow that resulted contamination of surface water and degrade the quality of water available for human consumption (Hossain et al, 2014). Urbanization and the lack of adequate waste disposal and management facilities have worsened the water quality of rivers in Sri Lanka. Entering of pollutant in to river cause to decrease the Dissolved Oxygen (DO) and increase the other water quality parameters such as BOD5, COD, TN, TP, etc in river water.

Gin River, which is starting from the Gonagala Mountains and end from Ginthota, forms the most significant watershed in Galle District due to various reasons. People along the Gin River use river water for their daily water consumptions. According to the status of National Water Supply & Drainage Board (NWS&DB), it is a requirement of applying a better water management system to Gin Rivér for planning of their future activities along the Gin River basin. Two water intakes for the supply of water to the Galle are located at downstream of the river; Baddegama and Wchwella. Downstream of the Gin River runs through densely populated areas and receives much organic pollution in the last 50 km stretch due to the discharge of untreated sewage and domestic effluents.

Therefore it is a current need to manage the River water quality using an advance method. To maintain the minimum standard of the water quality, efficient water management including monitoring and research is necessary. Even though there are many water managing systems it has found that water quality modelling is the most effective water managing system. Water-quality modelling has evolved appreciably since its innovation in the early years of the twentieth century. The first attempts to apply mathematical equation to river water quality problem were done by Streeter and Phelps in 1925, on Ohio River (Chapra and Pelletier, 2003). During the past few decades there has been significant development in water quality modelling. This applies to methodologies, as well as computer software and hardware (Laszlo, 1997). At the moment, the U.S Environmental Protection Agency



(USEPA)'s QUAL2E has been the most widely used stream quality model which can be adopted on personal computers (Somlyody et al, 1998). The model is numerically accurate and includes an updated kinetic structure for most conventional pollutants (Chapra and Pelletier, 2003). QUAL2Kw is the modernized version of QUAL2E (Kannel et al, 2007) model.

This research was aimed to model the Gin River downstream using QUAL2kw modelling software. The calibrated and verified models were then used to predict the water quality along the Gin River downstream from Lankagama to Wackwella, and to find whether the river water quality is within required Sir Lankan standard and WHO guideline. Please follow the format of this paper faithfully in order to help ensure that all contributions in the final publication are professional and consistent. Please read through the following instructions before beginning your paper.

## 2. MATERIALS AND METHODS

Total length of Gin River is 116 km and the selected length for QUAL2k modelling was limited to 83 km (Lankagama to Wackwella). Figure 1 shows the selected study area for this research.

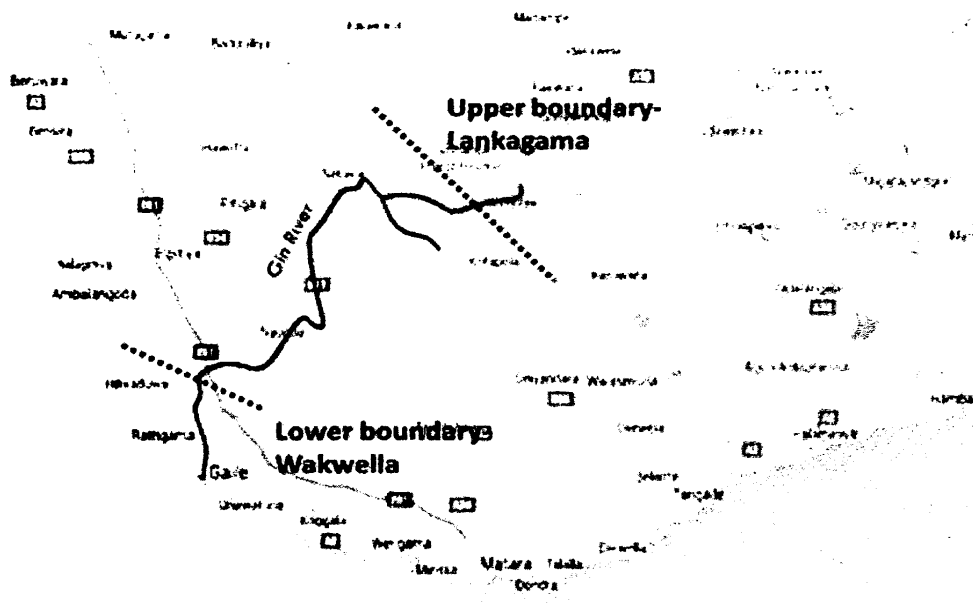


Figure 1 Study area of the Gin River downstream

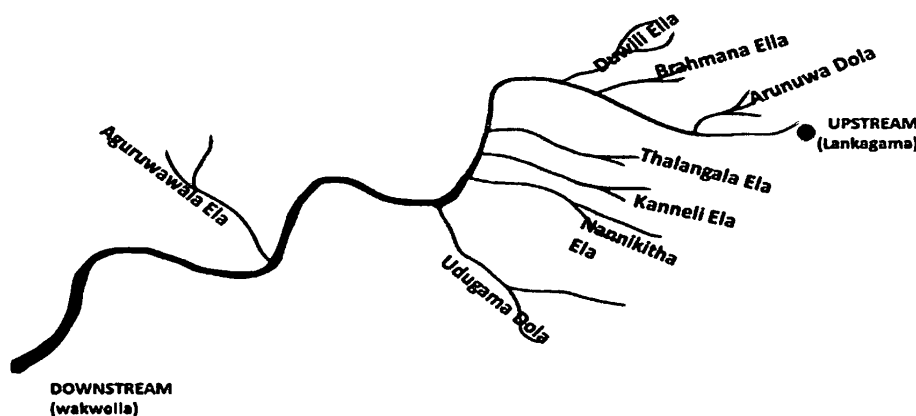
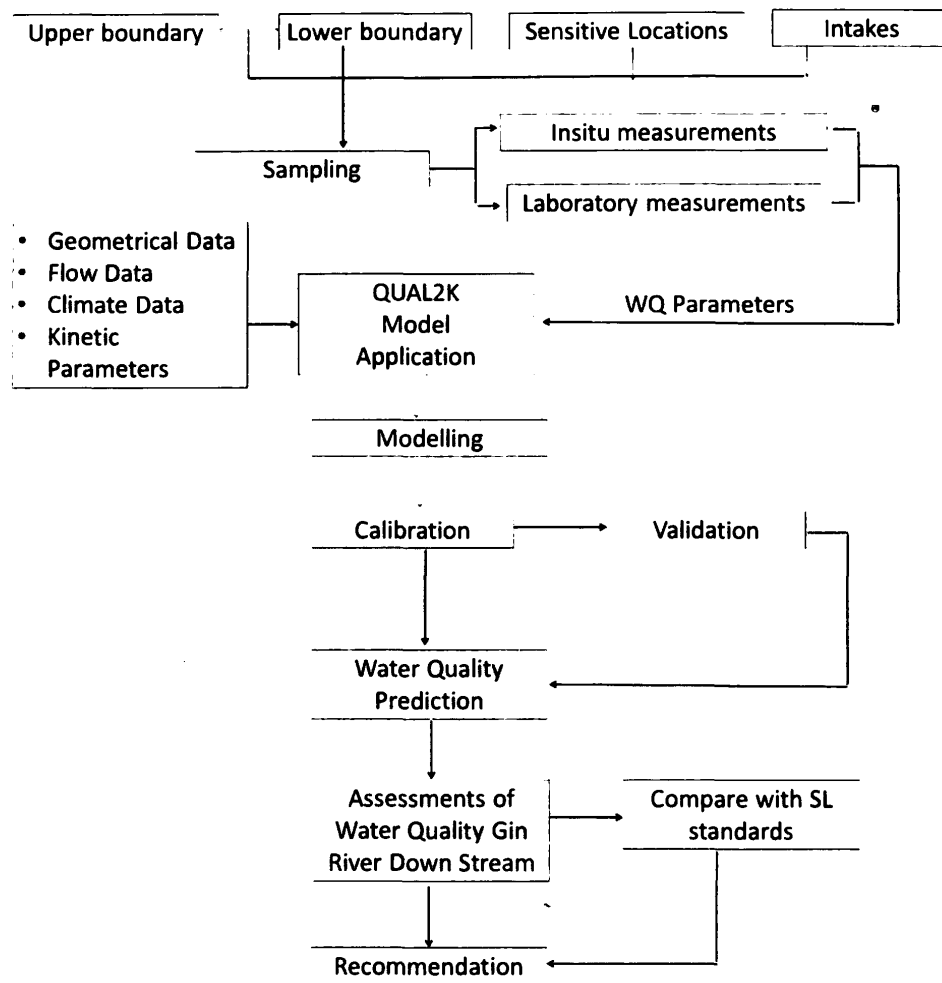


Figure 2 Main eight tributaries of the river downstream



There are no any industrial zones established upstream from the Lankagama area which could be affected to Gin River, and the most downstream water intake is situated in the Wakwella. Those were the main facts which were caused to select the upper boundary and the lower boundary for the research study. Except this there were major eight numbers of tributaries which are connected to Gin River also considered for the research. Following Figure 2 shows the study area with the main 8 tributaries. Figure 3 shows the overview of the modelling process of the Gin downstream. QUAL2Kw is a steady state, 1-D model that primary simulates DO and other important water quality parameters. The model permits the input of wastewater discharges, tributary flows, incremental flows and withdrawals.



**Figure 3 Overview of the modelling approach**

QUAL2k model requires water quality, hydrological, geometrical, climatic data and kinetic parameters for its calculation. Necessary secondary data were collected from NWS&DB, Irrigation department, surveying department and Metrological department. For the calibration and validation processes two separate water samples were collected along the Gin River from fourteen numbers of randomly selected points in two separate time periods. Samples were analysed in-situ and laboratories of faculty of Engineering and NWS&DB. The sampling locations used for the calibration and validation processes has shown in the following Figure 4, which was generated on the Google earth map using the GPS locations. The study area of the river were divided into 12 reaches for QUAL2k modelling purpose. Within this study area 8 major tributaries were selected as point sources in to the main River.

The major data required and the source has mentioned in the following Table 1. The selected River portion is subdivided into different reaches according to the geometry of the River. Schematic of the system segmentation is displayed in Figure 5, along with locations of tributary flow inputs, type of pollution sources and as well as abstractions from the river and their locations.

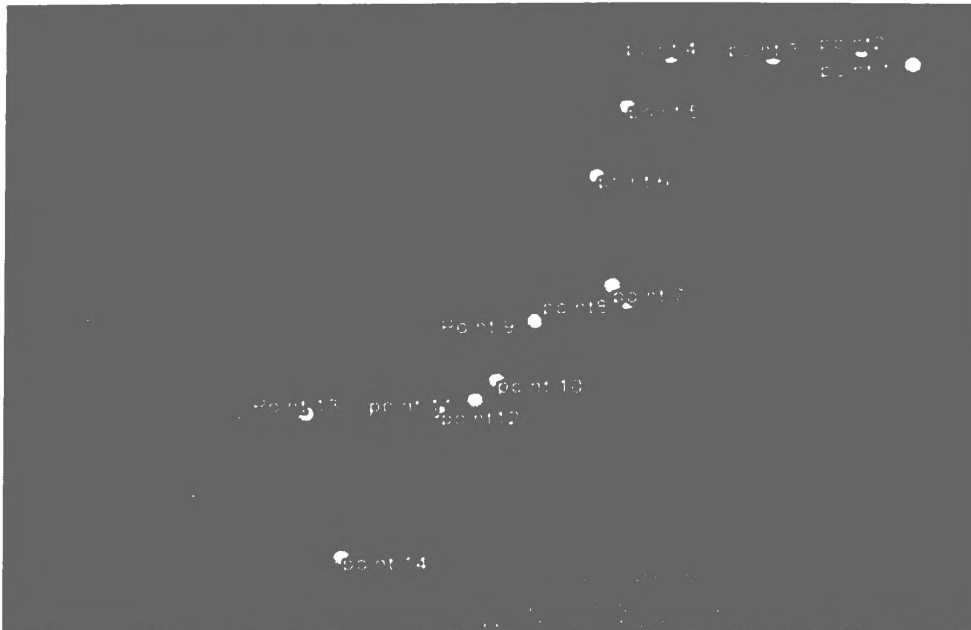


Figure 4 Sampling Locations used for Calibration and Validation of QUAL2Kw

Table 1 Requirement of Data and Relevant Data Sources

Data Requirement	Source
Water Quality Data. i) Main Stream ii) Point Sources	Field Measurements
Geographical Map Data	Survey Department
Flow Data. i) Main Stream ii) Tributary	i) HEC Model ii) Field Measurement
Climate Data	Metrological department
Cross Sectional Data, Bed profile	Irrigation Department
Model Parameters	Literature

Model input parameters for calibration of the QUAL2K model such as sediment oxygen demand (SOD) rate constant, BOD degradation rate, the reaeration rate, Hydrolysis rate, etc, are taken from the literature as in the Table 2. In the calibration process simulated water quality values were fine tuned in to the observed water quality values by adjusting the kinetic rate parameters within the acceptable limitation. Calibrated model was verified through validation before use for water quality predictions.

Table 2 Kinetic rate parameters used for the calibration

Kinetic Parameter	Used Value
BOD Oxidation rate(kdc)	2.94 /d
Re-aeration Coefficient (Ka)-User model-A,B,C	3.6,0.7,-1.824
Organic N Hydrolysis(Khn)	0.3 /d
Organic P Hydrolysis(Khp)	0.005 /d
Organic P Settling(vop)	1 /d

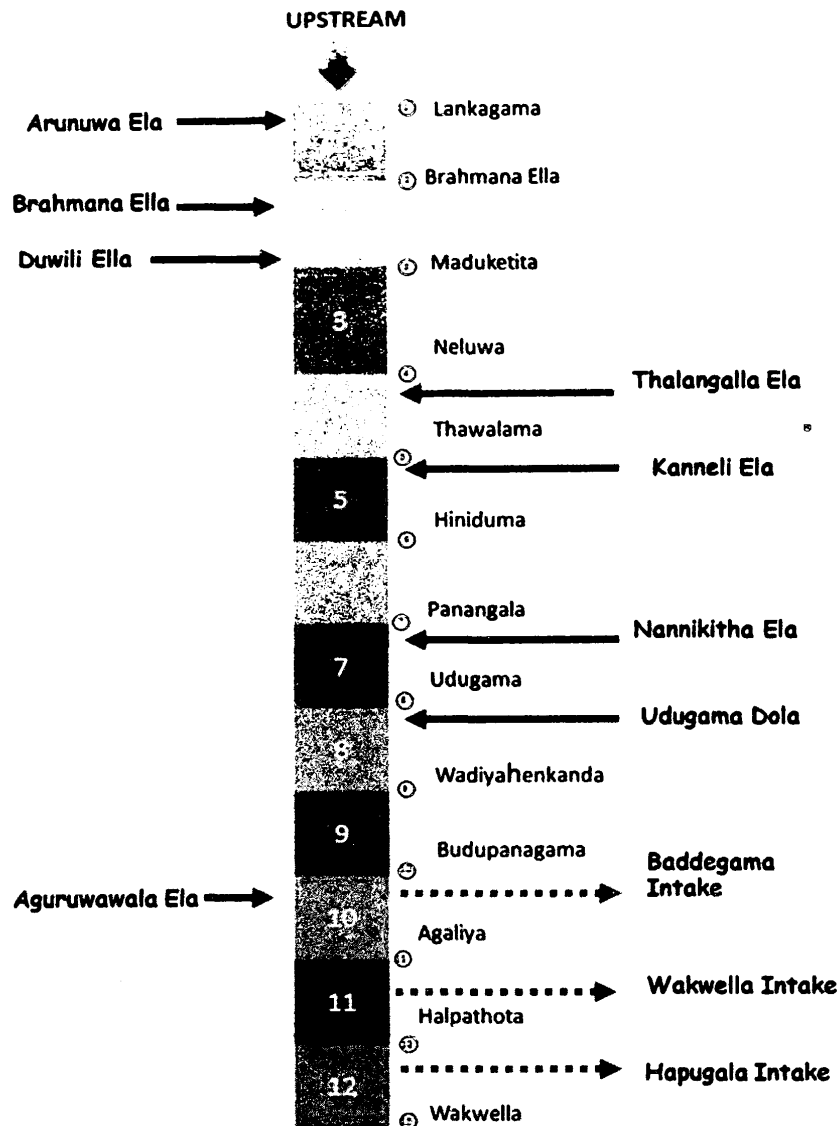


Figure 5 Segmentation of the Gin River Downstream

### 3. RESULTS AND DISCUSSIONS

The calibrated and validated water quality prediction results shows in the Figure 6 and Figure 7 respectively. QUAL2k model was simulated for DO, BOD5, TN, TP, COD, pH and Conductivity. At the model calibration DO and BOD5 were focused as they are the critical water quality parameters. Figures 7(a) and 8(a) show the Dissolve Oxygen (DO) profile along the modelled reach for the calibration and validation phases respectively. Apparently, the simulated results and measured data match well for calibration. Calibrated graph for Dissolved Oxygen shows that there is a big drop of dissolved oxygen in the area of Maduketiya to Thawalama. The reason may due to the highly polluted tributary pollution loads enter to the main stem within this area. The model predicted BOD5 values are shows in the Figure 7(b). There are some variations with the prediction values and the observed values. However observed values are within minimum and maximum boundary of the model predicted values. Figure 7(c) shows the predicted pH values and it was well matched with observed values. COD seems a continuous increment towards downstream of the river with the entering of some of the tributaries which contain high COD. As in the Figure 8 (A to D), the validated model also gave a

satisfactory match between the predicted values and observed values. It verifies the validity for the calibrated QUAL2Kw model.

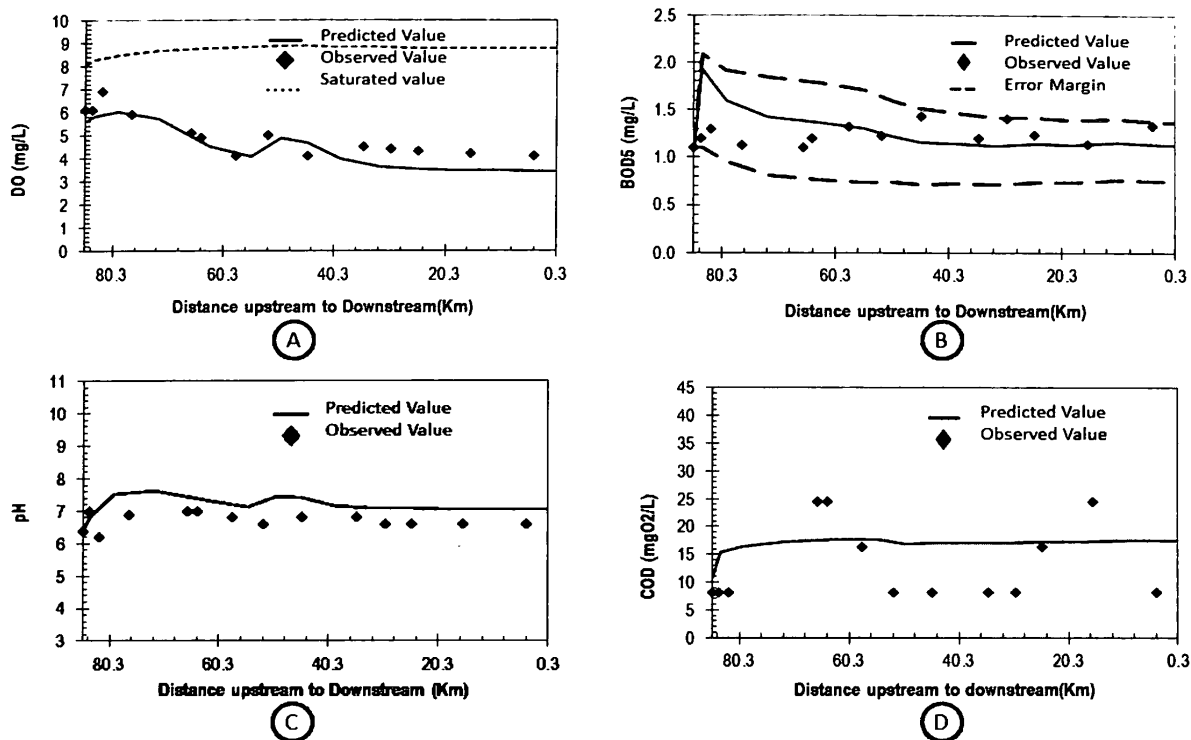


Figure 6 QUAL2Kw Model Calibration

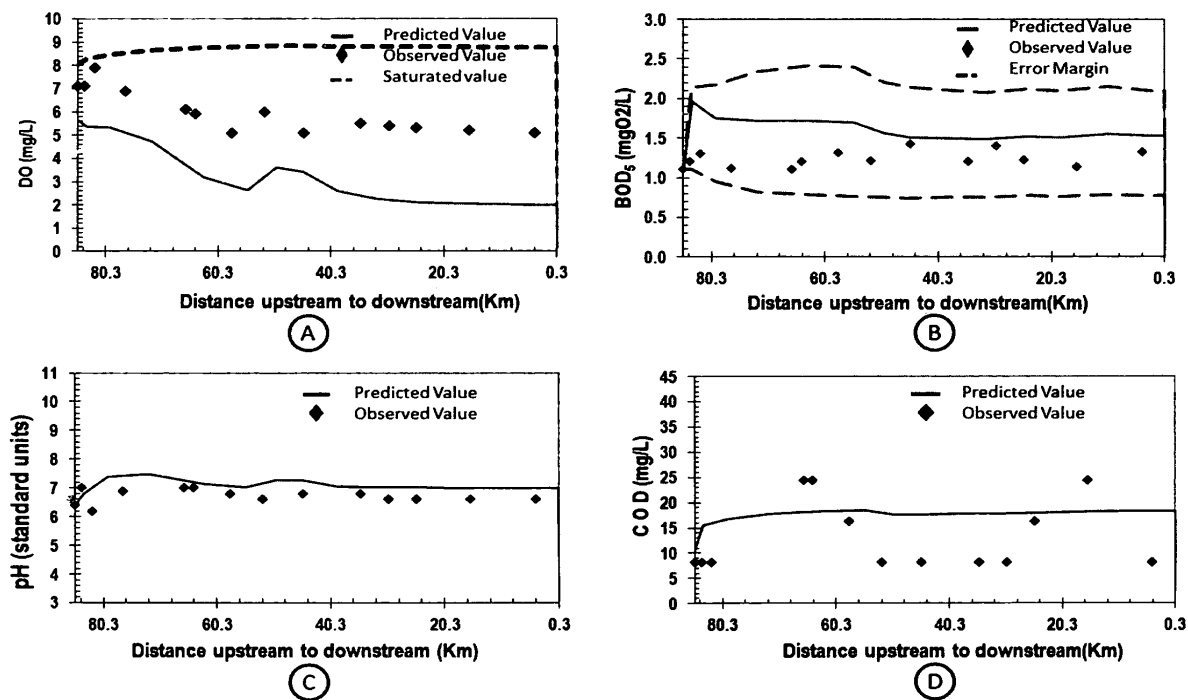


Figure 7 QUAL2K model Validation of Water Qualities



Predicted River water quality was exceeded the CEA standards only for DO and COD (Figure 7-A and Figure 7-D). It was observed that COD/BOD ratio values are higher in Neluwa, Thawalama and Baddegama. This indicates the possible emission of pollutions from the industries which are located in the tributary upstream. Calibrated model showed that Lankagama to Batuwangala had a good WQ for drinking with a simple treatment while that for Batuwangala to Keppetiyagoda had average WQ and Keppetiyagoda to Wakwella had minimum WQ. It was also noticed that for washing and bathing, Lankagama to Thawalama except Neluwa has a good WQ while Thawalama to Wakwella had average WQ. Water Quality for Agriculture is still in the better condition along Gin River downstream.

#### 4. CONCLUSIONS AND FUTURE DIRECTIONS

Calibrated QUAL2k WQ model was used to predict water quality along the Gin River downstream. Results showed that for drinking with a simple treatment; Lankagama to Batuwangala has a good quality while Batuwangala to Keppetiyagoda average quality and Keppetiyagoda to Wakwella minimum quality. When it consider water Quality for washing and bathing; Lankagama to Thawalama except Neluwa has a good quality while Thawalama to Wakwella has average quality. Water Quality for Agriculture is still in the better condition along Gin River downstream. The calibrated QUAL2k model can be effectively used for future water resources management in Gin River downstream.

#### 5. ACKNOWLEDGEMENT

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