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Catchment Protection of Gin Ganga (River) as part of Water Safety Plan (WSP) in Greater Galle Water Supply Scheme (GGWSS)

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Abstract: Gin Ganga (River) is the main raw water source to Greater Galle water Supply Scheme (GGWSS). Managing drinking water quality from catchment to consumer is the main objective of the Water Safety Plan (WSP) of GGWSS. There are three Water Treatment Plants (WTP) purifying and delivering 80,000m³ of treated water per day to approximately 450,000 people through 15 distributions centers. The Gin River has a total length of 113km and a catchment area of about 932 km² Catchment of the Gin River includes Galle, Matara, Ratnapura and Kalutara administrative districts. The Gin River originates from the Gongala mountains in Deniyaya and flows to the Indian Ocean at Gintota in Galle. Gin River annually discharges about 1268 million m³ of water to the sea. Rainfall pattern in the catchment is bimodal, falling between May and September and again between November and February. Rapid changing of land use pattern and high rate of application of agrochemicals and fertilizers has significantly affected the raw water quality. A quantitative and continuous assessment of water quality along Gin River is necessary to identify the trends and to develop sustainable remedial actions. Content of heavy metals in raw water is also an important parameter to be tested due to lack of previous data. The WSP Team is already established and the Greater Galle WSS WSP has been completed. The External Stakeholder Team consists of relevant stakeholders; the Galle District Secretary, relevant Divisional Secretaries, Health Authorities, Irrigation Officials, Agriculture Officials, Central Environmental Authority etc. The initiatives and the encouragement of the External Stakeholder Team to implement the catchment protection program for Gin River is commendable as the group has already carried out a Sanitary Survey and pollution source identification exercise along the Gin River. The objective of this paper is to present the Water Quality Modeling System prepared for Gin River and its effectiveness in protecting the catchment to effectively implement the Greater Galle WSS Water Safety Plan.

Key words: Catchment, Consumer, Gin River, Water Safety Plan

1. Introduction and Background

The water quality of the Gin River is of vital importance since Gin River is the major source of the potable water supply in the Galle district. The deterioration of water quality of river created adverse impact on human health and hence the socio economic development of the entire District. Most of individual water source (dug wells, surface water sources) are being continuously polluted by different source of waste such as domestic, agrochemical, industrial and electronic wastes. The sources mainly include point sources, industrial discharge and uncontrolled sewerage discharge and non – point sources of pollution which primarily include the storm water runoff from residential, industrial, commercial and agricultural land use. Regulatory bodies have already paid increasing attention to safeguard the water quality in Gin River and other related branch streams connected with the main river from Gongala kanda at Deniyaya to Gintota at Galle. Multiple stakeholders contribute their important service to accomplish water quality in Gin River. Provincial Water Quality Surveillance meeting (PWQSM) headed by the Chief Secretory of the Southern Province and District Water Quality

Surveillance Meeting (DWQSM) headed by District Secretary of Galle are the two most important meetings conducted by every three months intervals. These two meetings mainly focused on pollution of water sources by various activities of communities and changing of climate patterns. National Water Supply and Drainage Board, Irrigation Department, Agrarian Service Department, Agriculture Department, Central Environmental Authority, Coastal Conservation Department, Assistant Government Agents, Regional Health Officers, Public Health Inspectors, Department of Sri Lanka Police and several other direct and indirect stake holders are participated both meetings and discuss the current issues and implement various mitigation actions. Some of them are such as structural and non-structural best management practices and. however the effectiveness of this mitigation action is still limited due to the time, cost and political influence. In this context, in depth understanding on the trends of pollution, spatial and temporal variability of river water quality, interrelationship between key water quality indicators are of crucial importance to increase the effectiveness of mitigation action and water quality monitoring program. Consequently this research study to be conducted to understand the water quality statues of Gin River, trends of pollution and identify the relationships between key water quality indicators.

2. Study Area

Gin River originates from the Gongala Mountains and flow to the Indian Ocean at Gintota. Rainfall pattern is mainly depending on Northeast monsoon between November and February and Southwest Monsoon between May and September followed by inter-monsoon rains in remaining months. Annual rainfall is less than 2500mm in downstream and above 3500mm in the upstream. Gin catchment consists of mainly natural and plantation forest, agriculture and settlements of communities. Cultivation includes paddy, tea, rubber palm oil and cinnamon.

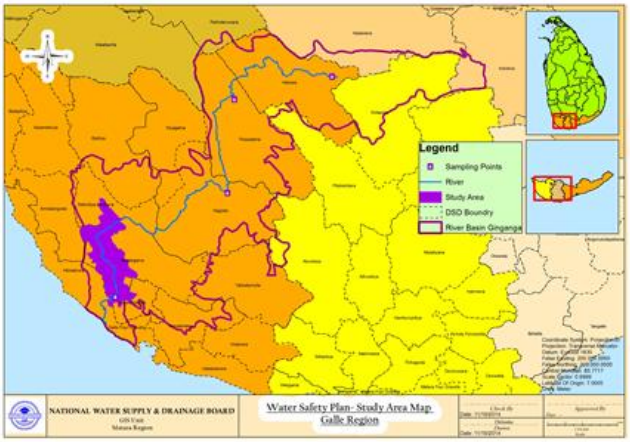

Figure 1: Gin River Basin

Nearly 83% of the catchment are belongs to Galle district and balance shared by Matara, Kalutara and Ratnapura District. Catchment consist of 932 km^2 and lies between coordinates 80° 08" E to 80° 40" E and 6° 04" N to 6° 30" N. Galle districts' water supply systems mainly depend on the water resources in Gin River basin and presently covered by 34% of district population and planned expand 60% of district population in year 2025. Present extraction quantity of row water is about 80,000 m^3 per day and it will be increased by 100% in year 2025 to achieve planning goals. Studies are mainly focused to identify point –source pollution, non-point source pollution, changing of land use pattern, quantity and quality of fertilizer application for cultivations. The major industries in Gin River basin included relative to tea, rubber, cinnamon and palm oil. As the first stage of WSP concentrate area is limited up to upstream of catchment covered with Baddegama, Bope-Poddala and Velivitiya - Divitura divisional secretaries' limits and monitoring of water quality parameters is covered upstream up to Lankagama Neluwa Divisional secretory limit.

3. Methodology

Water Quality is a function of chemical, physical, and biological characteristics. Changing of concentration of chemical, physical or biological parameters due to the human and natural actions is directly affected to the water treatment process. As Gin River is an invaluable water resource, NWS&DB has been monitoring water quality since 1972 and but it was limited to physical parameters and it was developed from year 2000 onwards by implementing laboratory with a Chemist at Wakwella Water Treatment Plant. The analyses of available water quality data in this paper mostly on Wakwella and Baddegama water intakes. Water samples have been analyzed in Galle and Matara Regional laboratories of NWS&DB. These laboratories of NWS&DB are well equipped to carry out the required water quality tests (physical, chemical and biological) in water supply schemes operated and maintained by NWS&DB to maintain Sri Lanka standards for drinking water quality. Water and Environmental laboratory of University of Ruhuna provide facilitate to test the heavy metals as needed. Row water qualities of the Gin River are regularly measured at once or twice a month. The specific test methods employed in the laboratories are summarized in Table 1.

The water quality data for Color, pH, Turbidity, Electrical Conductivity (EC), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total Alkalinity is the main parameters were studied to find significant variation of row water quality. In addition to these parameters it is needed to pay more attention on Chemical and Heavy metal concentration of row water with parallel to changing of land use pattern, community settlement and industrialization of the catchment area. These parameters are still under observation level

Table 1: Water quality test method

Parameters	Test Methods
Colour	Calibrated colored disks
Turbidity	Nephelometry
PH	PH meter
Electrical Conductivity	Conductivity meter
Chloride (Cl)	Titrimetric
Alkalinity	Titrimetric
NO3-N	sectrophotometric
Fluoride (F)	colorimetric
Total Suspended Solids (TDS)	Gravimetric
Hardness	Titrimetric
Calcium (Ca^{2+})	Titrimetric
Iron	colorimetric
SO^{2-} 4	sectrophotometric
No of Coliform	Membrane filtration
No of E Coli	Membrane filtration
Biological Oxygen Demand (BOD)	Titrimetric

4. Physical Observations

Sand mining is livelihood of communities living close to the river bank. Erosion of river bank and unbalance ecosystem is created due to the excessive sand mining from downstream at Wakwella intake to up to Neluwa divisional secretary limit. Branch streams which are connected with Gin River also polluted with agrochemicals residual and waste dumped by Tea factories, communities living in river bank, hotels and vehicles' service centers. Irrigation Canal (Ship block) which was constructed for collecting excess water of paddy field was connected with Gin River at Wakwella just upstream of intake. Buffalos and oxen are freely living most areas of river bank in down streams. Death of these animals due to various diseases, bodies were dumped in to the river and it was increased during the flood period. It was observed that the several agrochemical empty containers also were dumped to

river by the farmers due to non-awareness. Little amount of e- waste also was visible in downstream of the river in semi urbanize area near to Udugama Nagoda Agaliya, Baddegama and Galle. These wastes are collected across the bridge crossings near to intake structure. People along Gin River use water for their daily water consumption without proper disinfection system.

Figure 1: Irrigation canal with high concentration of agrochemical just upstream of the Wakwella intake

Available data of testing row water at Wakwella and Baddegama WTPs is also used for analysis and find any trend of variation with time. Water quality will be affected by flow volumes, and affecting both concentration and total loads. Regional Chemist of NWS&DB attends periodical testing of required parameters and Water resources and Environmental laboratory of University of Ruhuna facilitates testing for heavy metals. Research studies mainly focused to formulate a model for predict the concentration of physical, chemical and biological water quality parameters with changing of concentration in various location of upstream in Gin River. Data to be collected with related to land use pattern, quantity of fertilizer application and its contents, quantity of pesticides and weedicides applications, identify the point pollution sources and non-point pollution areas and content and concentration of discharge waste are the main activities to be carryout under data collection and analysis. Ongoing research predicted that land use drop of cultivated areas from 1983 in 51% to 2020 to 34% [1]. But data is not available to prove the reduction of application in pesticides and fertilizers even though the reduction of cultivated land. It is needed to collect the data to do analysis to predict the affecting to row water quality

Figure 2: Point source of pollution in Gin River Near to Nagoda

5. Results and Discussion

Figure 3 shows the monthly variation of colour during 2010 to 2014 at water quality intake point at Wakwella. Colour is refers to aesthetic appearance of water and provide indicator to quality of row water for which level it has to be treated to make best for human usage without suspicious.

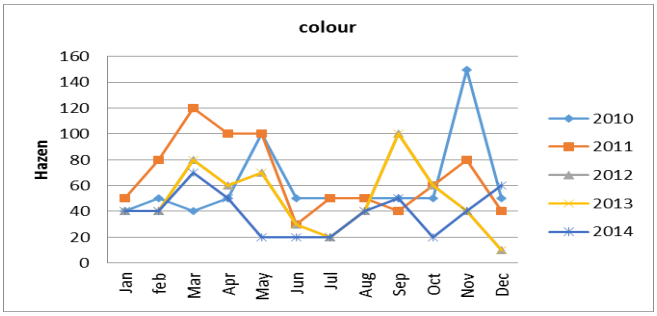

Figure 3: Monthly variation of average color

High colour values were observed during the Northeast monsoon between November and February and Southwest Monsoon between May and September.

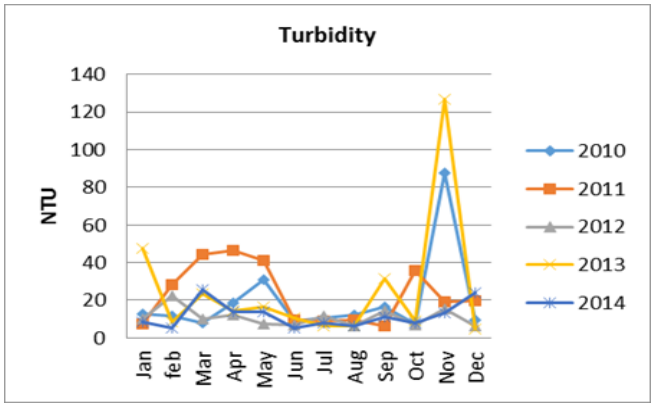

Figure 4: Monthly variation of average turbidity

Figure 4 shows that the monthly variation of turbidity during the same period of colour was monitored. Turbidity is the indicator a measure of water clarity. Turbidity is increased as a resulted of suspended solid particles. Measured results of average colour and turbidity shows that turbidity values were increased the color values also proportionally increased. It was indicated that some amount of suspended particles were dissolved in water and caused to increase turbidity value. Turbidity degrades drinking water quality, aesthetically displeasing opaqueness, producing colloidal material provide adsorption sites for taste and odor, producing chemicals and harmful organism and water treatment may increase.

Figure 5 shows the monthly average conductivity of the row water from 2010 to 2014 and shows that well below the maximum allowable limit even though the sampling point about 2.0km from the coast. There is a salinity barrier across the Gin River constructed in 2004 about 500m downstream of the Wakwella Intake. It was almost closed during high drought period and was affected to maintain the low values of conductivity.

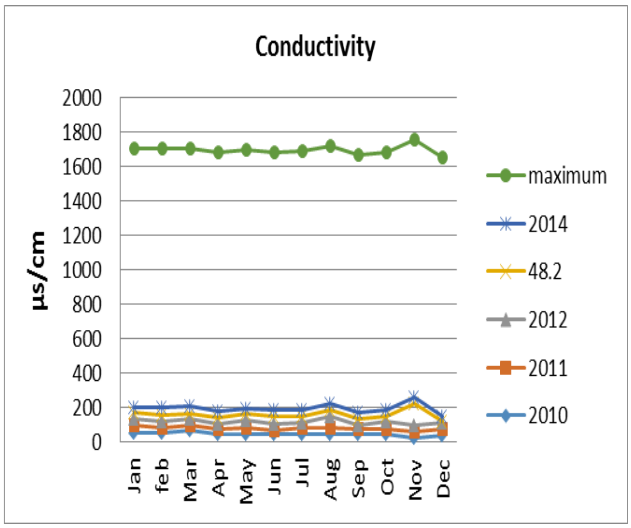

Figure 5: Monthly variation of average conductivity

pH value of row water is a most important chemical parameter with relative to water treatment. Flocculation and sedimentation process is depending on pH value of Row Water. Neutralized pH value should be maintained both consumer taste and in transmission and distribution systems to avoid scaling or corrosion of pipeline. Figure 6 shows average monthly PH value variation in past five years.

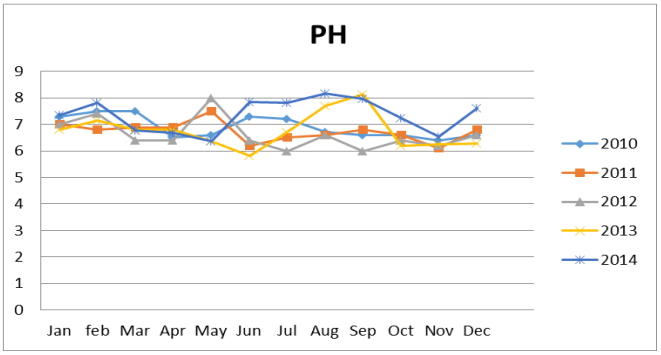

Figure 6: Monthly variation average pH value

It lies between 6 and 8. It is perfect range for row water and can be corrected pH value for optimum dosage of chemical need for water treatment.

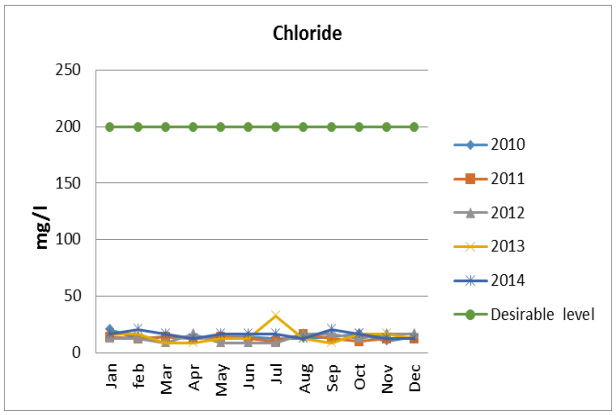

Figure 7: Monthly variation of average chloride

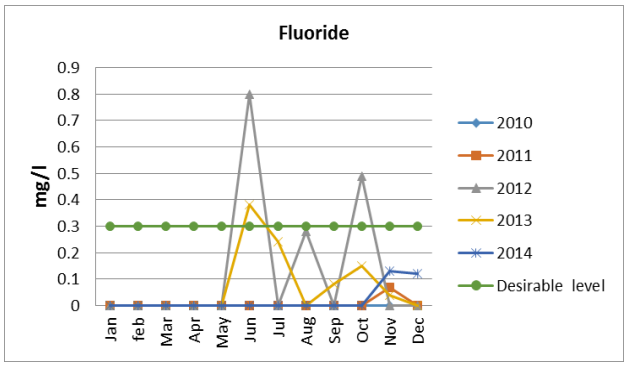

Figure 8: Monthly variation of average fluoride

Figure 7 and Figure 8 shows the monthly average variation of chloride and fluoride from 2010 to 2014. Chloride is well below the desired level. Fluoride is considerably increased than desirable level in year 2012 and 2013 in month of June, August and October.

Figure 9 shows the Total Dissolved Solid (TDS) during the period of 2010 to 2014. TDS refer to suspended matter dissolved in water. Solids may affect water or

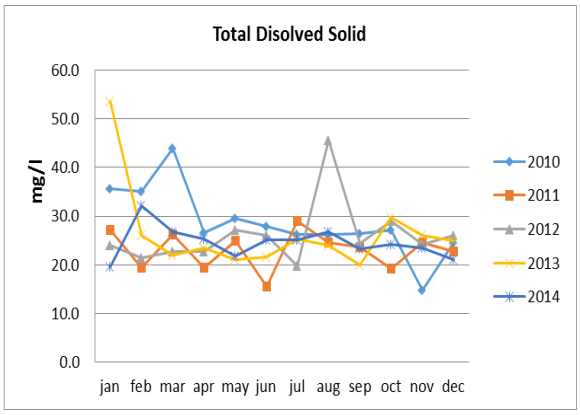

Figure 9: Monthly variation of average Total Dissolved Solids (TDS)

effluent quality adverse in a number of ways. Increased TDS may impart a bad odour or taste to drinking water as well as cause scaling of pipe and corrosion. High TDS level indicates water hardness in respective sampling station. Desirable value of TDS is 500 mg/l and results reveal that far below from desirable level and there is no considerable variation during the observed period. TDS is also considered as general indicator of overall water quality (Tambekar etal 2012). It is a measure of organic and inorganic materials dissolved in water.

Figure 10 shows the variation of monthly average Hardness values and figure 11 shows the variation of monthly average of Sulphates values and they are well below the desired level from 2010 to 2014.

Figure 12 shows the variation of monthly average of Calcium values and they are also well below the monitoring periods.

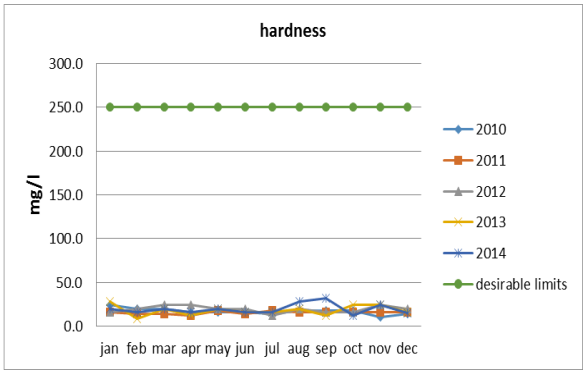

Figure 10: Monthly variation of average hardness

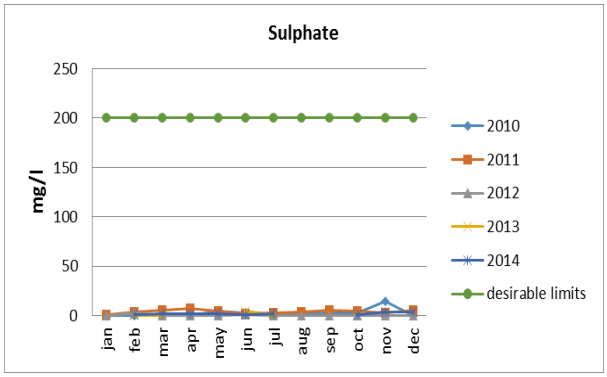

Figure 11: Monthly variation of average Sulphates

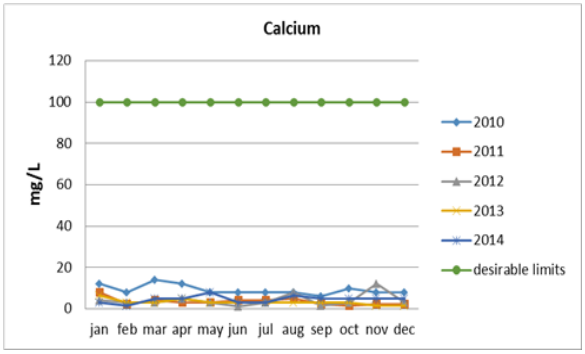

Figure 12: Monthly variation of average calcium

Figure 13 shows the monthly variation of average iron values and it was shown that is exceeded the desirable level. It was also shown that it increase to maximum level during February to June and September to December. That is the North East and South West Monsoon rain periods of the particular years. Excess iron should be removed through the Aeration, Flocculation, Sedimentation and Filtration. Cost of chemical consumption may increase during rainy periods.

Figure 14 shows Coliform values in row water and it is excessively increased than desirable limits. That is Gin River is highly polluted with fecal. Therefore proper disinfection method is to be applied in water treatment process.

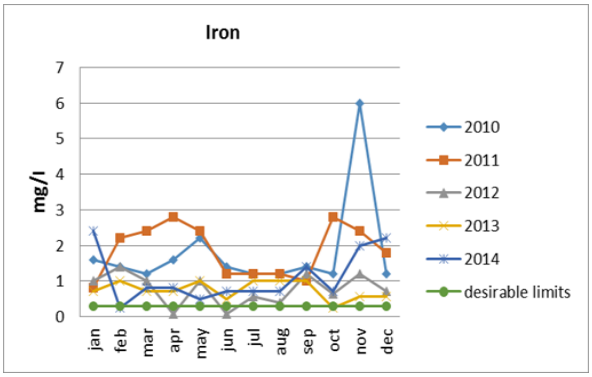

Figure 13: Monthly variation of average iron

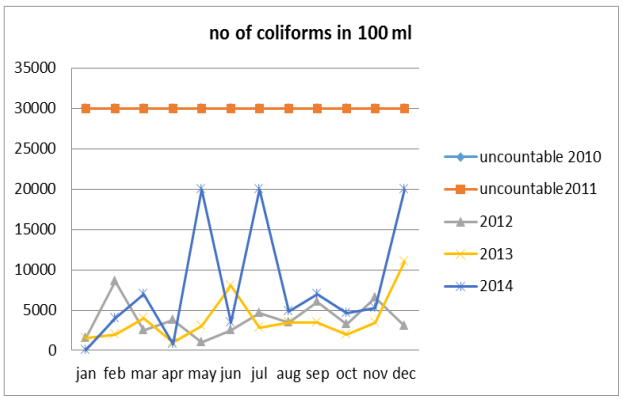

Figure 14: Monthly variation of average coliforms

Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) are measured in year 2015 at Wakwella and Baddegama intakes and shown in figure 15 and figure 16. Dissolved Oxygen is higher at Baddegama intake than Wakwella intake. Main reason for this variation is flow pattern of Gin River. Baddegama intake is situated up stream and river flow is little turbulent and Wakwella intake is situated in downstream and laminar flow is more experience. Monitoring oxygen concentration is a convenient way to feel the clause of aquatic ecosystem. Dissolved Oxygen is an important water quality parameter in

assessing water pollution. The change in oxygen content leads to undesirable odor, under anaerobic conditions. Both intakes are shown that from January 2015 to August 2015 decrease DO by 8mg/l to 6mg/l. Desired level of DO is 4mg/l. It is needed to continue continuous monitoring of DO in both intakes.

Figure 16 shows the BOD variation in year 2015 in both Baddegama and Wakwella intakes. It was not shown any tendency to increase and range of variation is1mg/l to 2 mg/l during the year 2015. Monitoring of BOD and COD are to be further assessing of row water quality as a part of WSP.

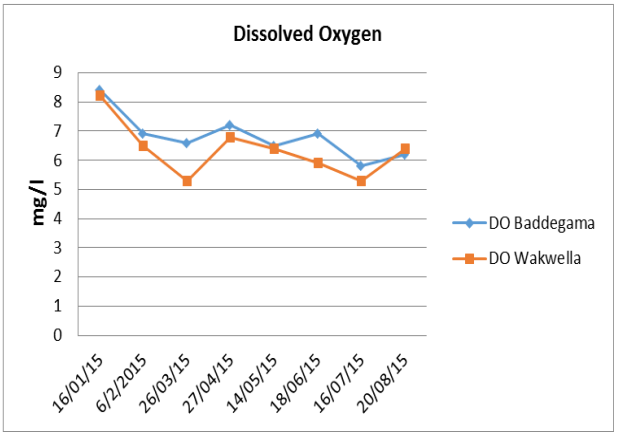

Figure 15: Average Dissolved Oxygen variation at Intakes Wakwella and Baddegama

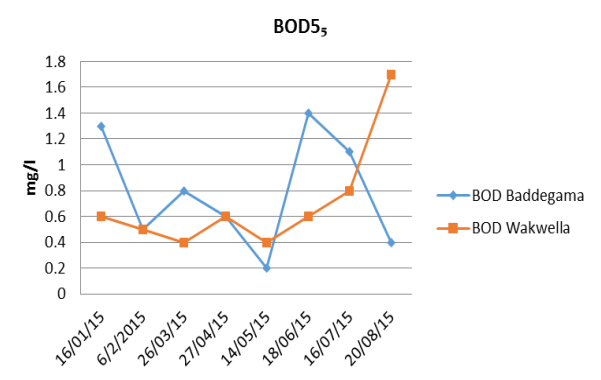

Figure 16: Average Biochemical Oxygen demand in Intakes Wakwella and Baddegama

6 Conclusion

It was noted that some water quality parameters at both intakes in Wakwella and Baddegama were in acceptable level for Sri Lankan standard inland surface water quality standard. Water contaminated from fecal pollution is more obvious than other agrochemical or industrial pollution. Progressive monitoring of other water quality parameters such as heavy metal and agrochemical related element is vital important to long term sustainability of WSP in GGWSS. Direct users of Gin River water for domestic and other related activities are in questionable due to presence of high uncountable coliform counts. Water contamination will increase in future increasing water stress further by considering industrial and agricultural demand. The main purpose of this paper is to initiate water quality modeling as a tool to assist in analyzing various scenarios and developing suitable water quality management option in the Gin River from upstream to two intakes points.

7 Acknowledgements

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