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Assessment of pollution status of Meda Ela (*Middle Canal*) and its influence on Mahaweli River, Sri Lanka

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Abstract: *This study mainly bases on Middle Canal (Meda Ela) of Kandy city which is known as an affluent of Mahaweli river. It has a complex catchment area with diverse type of land uses including densely populated urban areas. Meda Ela is the main urban drain runs through Kandy city and it is one of the main storm water drainage canals which discharging storm water in the Kandy city basin into Mahaweli River. Since the canal is topographically situated at a low elevation, many side canals drain into the Mid-canal with their heavy pollutant loads. Water from this affluent ultimately drains into the Mahaweli River. Therefore, the main purpose of this study will be understanding the correlation between Meda Ela and Mahaweli River and determine whether Meda ela discharges a significant amount of pollutants into Mahaweli River that cause rapid increase of pollution level of the river.*

Key Words: *Meda-Ela, Mahaweli River, Pollution, discharge, water quality index.*

1. INRODUCTION:

Urban water pollution has emerged as one of the most critical forms of environmental degradation in Asia. In Asian countries, water pollution is clearly an environmental and political issue. Water pollution, which is a common phenomenon in almost all Asian urban areas, results from the environmental impacts of urban growth, failure of regulations, and the increase of unplanned settlements with lack of basic sanitary and sewage systems. On the other hand, this is partly a result of the failure of the state institutions, weakness of central and local authorities and the historical negligence of environmental issues.

Previous studies that had been conducted on Meda-Ela had proved that the water quality of Meda Ela was not in a satisfactory level and it had been polluted due to many aforementioned reasons. Meda Ela is the main urban drain runs through Kandy city and it is one of the main storm water drainage canals which discharging storm water in the Kandy city basin into Mahaweli River. Since the canal is topographically situated at a low elevation, a large number of side canals drain into the Mid-canal with their heavy pollutant loads.Water from this affluent ultimately drains into the Mahaweli River.

Mahaweli is the largest river basin in Sri Lanka, draining about 16% (10,327 km2) of Sri Lanka's land surface. In recent times, with increasing population and rapid urbanization, settling around townships, especially on the banks of Mahaweli, has shown a marked increase causing significant pollution of this important water resource (Abeygunawardane et al,2011). On the other hand, Kandy, the second largest city in Sri Lanka, is believed to contribute a significant amount of pollutants into the headwaters through a number of tributaries including Meda Ela, Pinga Oya, Maha Oya, etc. around the city (Wijekoon and Herath, 2006).

Considering these facts we can assume that there might be a significant impact of Meda Ela on Mahaweli River. According to my knowledge the previous studies that had been focused on particular area (Meda Ela catchment) do not address the interconnection between Meda Ela and Mahaweli River. Therefore the main purpose of this study will be understanding the correlation between Meda Ela and Mahaweli River and determine whether Meda ela discharges a significant amount of pollutants into Mahaweli River that cause rapid increase of pollution level of the river.

Not only environmental perspective but also economical point of view in minimising or prevention of water pollution of Mahaweli River is beneficial to the society. For instance according to Abeygunawardane et al.2011 water treatment cost of the Greater Kandy Water Treatment Plant (which locates approximately 5km downstream to Meda ela confluence) can be minimized by enhancing the water quality of the River. The objectives which are addressed by this study help to comprehend the current status and identify appropriate water management strategies that could assist to minimize the water pollution in Meda Ela and eventually in Mahaweli River.

2. METHODOLOGY AND SAMPLING SITE SELECTION

The catchment area of Meda Ela is comparatively complicated than the catchment area of section of Mahaweli River. For instance, Meda Ela flows thru highly urbanized and congested environment. And, within the route of the canal, there are some establishments / facilities that might provide significant contribution for water pollution. As a result of this environmental condition, it was identified 2 sampling locations in Kandy Lake which is the origin of Meda Ela and 3 locations in Meda Ela. These 5 locations were selected in approximate similar distances as represent the entire canal and the unique characteristics of each location were also considered prior to select locations. In order to confirm whether there is a significant impact on Mahaweli River due to Meda Ela obviously we should identify the water quality variation of Mahaweli River once Meda Ela discharges into the River. Consequently, 2 locations were selected in Mahaweli River that locates upstream and downstream to the Meda Ela confluence.

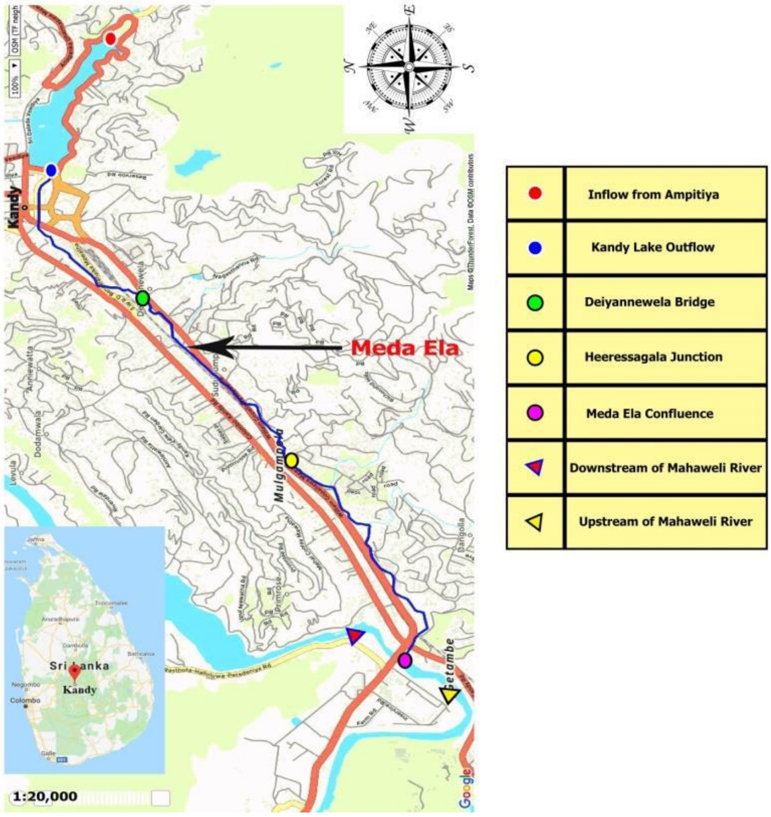

Fig1. Monitoring Locations in Meda Ela

Location	Location	Description
ME1	Inflow from Ampitiya	One of the main inlets of Kandy lake and it is the furthest point from Lake Outlet. (N $7^0$17’ 18.02, E $80^0$38’ 47.33)
ME2	Kandy Lake Outflow	The point where Meda Ela originates (N $7^0$17’ 28.82, E $80^0$37’ 13.94)
ME3	Deiyannewela Bridge	End of Underground Section (N $7^0$17’ 10.83, E $80^0$38’ 44.31)
ME4	Heeressagala Junction	Heavily congested area at Downstream of Meda Ela (N $7^0$17’ 38.25, E $80^0$38’ 1.22)
ME5	Meda Ela Confluence	Discharge point of Mede Ela (N $7^0$17’ 17.10, E $80^0$38’ 17.64)
MR1	Upstream of Mahaweli River	400 m upstream to Meda Ela Confluence (N $7^0$17’ 8.61, E $80^0$38’ 8.31)
MR2	Downstream of Mahaweli River	400 m downstream to Meda Ela Confluence (N $7^0$17’ 28.74, E $80^0$38’ 22.26)

Table 1: Description of sampling locations

2.2 Selection of Water quality Parameters

The water quality parameters that were tested in selected monitoring locations are discussed under this topic. Parameters were selected to meet research objectives. These include Temperature, Dissolved Oxygen, Biological Oxygen Demand, pH and Total Dissolved Solid.

3. RESULTS & DISCUSSION:

3.1 Monitoring Data

Water quality monitoring was carried out in selected locations in dry season and wet season of 2018. Following tables show the water quality monitoring results of each season.

Parameters	Unit	ME1	ME2	ME3	ME4	ME5	MR1	MR2
Temp:	^{O}C	24.6	24.1	25.4	26.8	25.1	24.3	23.9
pH	-	8.25	8.57	7.1	7.7	8.07	7.4	7.3
TDS	mg/l	216	198	181	153	226	39	38
DO	mg/l	5.03	6.24	5.7	5.2	7.26	7.6	6.9
COD	mg/l	57	14	65	20	7	11	8
BOD 5	mg/l	11.7	3.7	5.9	12	2.7	6	8

Table 2: Monitoring results of Water Samples Collected in wet season (October 2018).

Parameters	Unit	ME1	ME2	ME3	ME4	ME5	MR1	MR2
Temp:	^{O}C	25.4	25.1	26.2	27.8	26.6	28.6	27.4
pH	-	7.14	7.69	7.11	7.2	7.08	7.5	7.6
TDS	mg/l	230	205	250	330	264	80	80
DO	mg/l	7.3	7.9	5.7	1.8	2.8	4.7	4.9
COD	mg/l	47	27	29	92	48	19	18
BOD 5	mg/l	4.2	2.2	2.4	55	40	1.6	2.4

Table 3: Monitoring results of Water Samples Collected in dry season (February 2018)

3.2 Water Quality Index (WQI)

The objective of water quality index is to change the complexity of the water quality data into information that can be used easily by the public. A single number is not enough to describe all of water quality parameters that are not included in the index. On the other hand, a water quality index based on some very important parameters can provide a single indicator of water quality.

In formulation of water quality index the relative importance of various parameters depends on intended use of water. Mostly it is done from the point of view of its suitability for human consumption. However in this case since Meda-Ela is a polluted canal and people do not consume its water directly, WQI calculations are done from the perspective of its environmental impact.

3.3 WQI Calculation

Calculation of WQI was carried out in this work by Horton’s method. The WQI is calculated by using the expression given in Equation (1).

$$WQI = \frac{\sum q_n W_n}{\sum W_n} \qquad (1)$$

Where, q_n = Quality rating of n^{th}water quality parameter.
W_n = Unit weight of n^{th}water quality parameter.

3.3.1 Quality rating (q_n)

The quality rating (q_n) is calculated using the expression given in Equation (2).

$$\boldsymbol{q_n} = \left[\frac{(V_n - V_{id})}{(S_n - V_{id})}\right] \boldsymbol{X100} \qquad (2)$$

Where, V_n = Observed value of n^{th} water quality parameter at a given sample location.
V_{id} = Ideal value for n^{th} parameter in pure water.

In most cases V_{id} = 0 except in certain parameters like pH, dissolved oxygen etc.,
Calculation of quality rating for pH & DO ($V_{id} \neq 0$)

$$q_{pH} = \left[\frac{(V_{pH} - 7.0)}{(S_{pH} - 7.0)}\right] X100$$

$$q_{DO} = \left[\frac{(V_{DO} - 14.6)}{(S_{DO} - 14.6)}\right] X100$$

S_n = Standard permissible value of n^{th}water quality parameter.

3.3.2 Unit weight

The unit weight (W_n) is calculated using the expression given in Equation (3).

$$W_n = \frac{k}{S_n} \quad (3)$$

Where, S_n = Standard permissible value of n^{th}water quality parameter.
k = Constant of proportionality and it is calculated by using the expression given in Equation (4).

$$\boldsymbol{k} = \frac{\mathbf{1}}{\sum \mathbf{1}/\boldsymbol{S}_{\boldsymbol{n}=\mathbf{1},\mathbf{2}\ldots\boldsymbol{n}}} \quad (4)$$

The water quality parameters are selected based on its direct involvement in deteriorating water quality. The standards for discharge of effluents into inland surface waters, recommended by National Environmental (Protection and Quality) Regulations No.1 of 1990 and Proposed Ambient Water Quality Standards for Inland Waters Sri Lanka Parameter Unit (CEA/SLSI 2001) are considered for the computation of quality rating (q_n) and unit weights (W_n).

For the purpose of calculation of WQI for the study area, five water quality parameters have been selected. They are pH, TDS, DO, BOD, COD. The values of these parameters are found high above the permissible limits in some of the samples of the study area. The higher values of these parameters would increase WQI value. The standard values of water quality parameters and their corresponding ideal values and unit weights are given in Table 4.

No	Parameters	S_n	Ideal Value (V_{id})	k Value	Unit Weight (W_n)
1	pH	8.5	7	1.299	0.153
2	TDS	500	0	1.299	0.003
3	DO	3	14.6	1.299	0.433
4	BOD	4	0	1.299	0.087
5	COD	15	0	1.299	0.325

Table 4: Standard values of water quality parameters and their corresponding ideal values

3.4 WQI of study area

The WQI values of the study area for wet and dry season samples were calculated separately. Table 5 below gives the calculation of WQI of the Inflow from Ampitiya (ME1) in wet season as an example.

Parameter	Observed value (V_n)	Unit weight (W_n)	Quality rating (q_n)	$q_n W_n$
pH	8.25	0.153	83.33	12.738
TDS	216	0.003	43.2	0.112
DO	5.03	0.433	82.5	35.731
COD	57	0.087	380	32.916
BOD 5	11.7	0.325	292.5	95.011
		$\sum W_n = 1$		$\sum q_n W_n = 176.50$

Table 5: Calculation of WQI of the Inflow from Ampitiya (ME1)

The water quality index (WQI) of Inflow from Ampitiya was then calculated using the weighted arithmetic index formula as follows.

$$WQI = \frac{\sum q_n W_n}{\sum W_n} = \frac{176.50}{1} = 176.50$$

Wet Season		Dry Season	
Location	**WQI**	**Location**	**WQI**
ME1	176.51	ME1	90.05
ME2	85.45	ME2	65.61
ME3	119.79	ME3	70.72
ME4	151.31	ME4	316.50
ME5	91.19	ME5	104.37
MR1	85.31	MR1	51.17
MR2	101.41	MR2	61.25

Table 5: Calculation of WQI of the Inflow from Ampitiya (ME1)

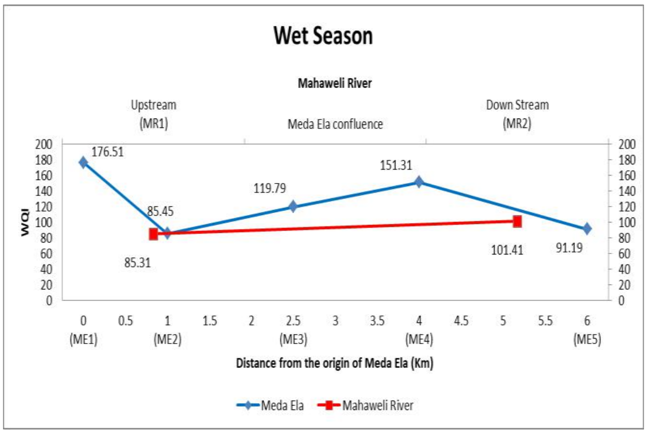

Fig 2: Variation of the WQI in wet season

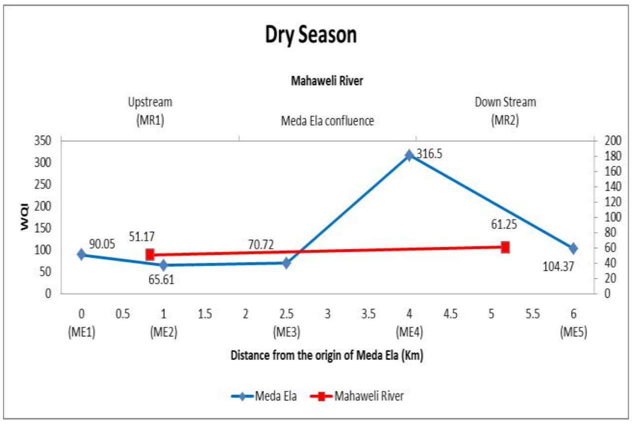

Fig 3: Variation of the WQI in dry season

4. DISCUSSION:

Fluctuation of WQI of Meda Ela and Mahaweli River in wet season and dry season exhibits similar pattern. In both wet season and dry season ME1 shows high WQI value rather than ME2 and ME3. The most probable reason of this observation might be the run off and unauthorised discharging of commercial and domestic establishments that locate in Ampitiya area. This is proved by the WQI of ME1 in wet season because it is comparatively higher than dry season.

Relatively ME2 shows low WQI value than ME1 in both seasons, which means slight improvement in water quality could be observed at the outflow of Kandy Lake. However from ME2 to ME4 gradual deterioration can be observed. Nevertheless, a rapid increase in pollution level is recorded in dry season at ME4. But at the time of sample collection, a flow of black water could be found at the particular location. That unauthorized discharging might be the reason for the exceptional WQI value which recorded at ME4 in dry season. However, ME4 has shown significant pollution level comparatively other monitoring locations of Meda Ela in both seasons. Heeressagala is the most congested area that is passed by Meda Ela. Consequently a high level pollution is taken place due to unauthorized waste discharging and urban runoff.

Meanwhile, a gradual decrease in the pollution level could be identified toward the ME5 in both seasons. Even though ME4 shows significant pollution level, it has been decreased when Meda Ela reaches Mahaweli River due to the significant distance (2.0 Km) from Heeressagala Junction to Meda Ela confluence and there is no significant point source pollution that can be identified.

When we consider WQI fluctuation of Mahaweli River, it exhibits same pattern in both seasons which is high WQI value at downstream rather than upstream. However, overall water quality of the Mahaweli River in wet season remains as poor.

In accordance with the figure 4.8 and figure 4.9, the pollution level of Mahaweli River is recorded as comparatively high in wet season and also a deterioration of water quality can be observed toward the downstream in both seasons. But the intensity of that deterioration is comparatively high in wet season than dry season. In wet season, when we compare WQIs of Meda Ela confluence, upstream and downstream of Mahaweli River, we can see that

Mahaweli River shows rapid increase of WQI even though comparatively low WQI value that recorded at Meda Ela confluence. And also in dry season Meda Ela confluence shows comparative high WQI value but Mahaweli River does not show rapid WQI increasing toward the downstream. Evidently, this WQI variation does not prove that Meda Ela has significant potential that can pollute Mahaweli River. But it does not mean that Meda Ela does not contribute to the pollution of Mahaweli River at all. Meda Ela may affects Mahaweli River to a certain extent but other than the Meda Ela, some point source and nonpoint source pollution such as run-off and unauthorized discharging may results increasing of WQI from upstream to downstream of Mahaweli River.

5. CONCLUTION:

WQI fluctuation of Meda Ela manifests same pattern over the year, but the intensity of the pollution is strong in wet season. And also average pollution level of the Meda ela in wet season is higher than dry season. Basically ME4 is the most polluted location in both seasons. However most prominent feature of this fluctuation is reduction of pollution level toward the Meda Ela confluence soon after it passes Heeressagala junction. This phenomenon can be noted in both seasons. Notwithstanding this rapid decline, Meda Ela shows gradual increase of water quality deterioration from origin to its discharge point in dry season while it exhibits mild improvement toward the confluence in wet season. Nevertheless, the overall pollution status of the Meda Ela in wet season is higher than dry season. The results of the study reflect considerable water pollution in Kandy Lake, Meda Ela and in Mahaweli River mainly because sewage in the downtown area flows directly into drainage system and then into Meda Ela. However during the study we could not identify clear relationship between Meda Ela and Mahaweli River water pollution.

Basically Kandy Lake and Meda Ela demonstrate high pollution level and it fluctuates. However, none of the water quality parameters that were measured at the Meda Ela confluence has exceeded the general standard for the discharge of wastewater into inland surface waters. Notwithstanding this water quality improvement in Meda Ela confluence, Mahaweli River shows water quality deterioration toward the downstream. On the other hand, as per the EIA study which was conducted by Kandy City Wastewater Management Project the flow of the Mahaweli River is about 122,900m^3/ day at the median equivalent to more than 100 times the flow of Meda Ela. Consequently, we can figure out that other than the Meda Ela , there might be several other point or non-point source pollution that contribute to pollution of the Mahaweli River.

The pollution of the Kandy Lake, spread of Algae blooms covering a major part of the lake, flow of pollutant in Meda Ela , and pollution of River water are major environmental problems in Kandy.

In order to minimize the water pollution there should be a proper pollution management mechanism. Following section discusses the possibilities of the management strategies that can be adopted to minimize the surface water pollution in Meda Ela and Mahaweli River.

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