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Water Pollution in a Natural Stream and Its Impacts on Society and Environment: A Review of Studies on *Meda Ela*, Sri Lanka

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Abstract: *Meda Ela* which originates from *Kandy* Lake and runs through *Kandy* city is considered to be one of most polluted tributaries of *Mahaweli* River. The objective of the study was to critically review the published research findings related to *Meda Ela* pollution to existing problems, research gaps and the means to rectify the situation. The review was carried out under the categories of socio-economic background, land use changes, sources of pollution, solid and waste water disposal, water quality, cost due to water pollution, economic benefits and major stakeholders and their interactions of *Meda Ela*. Study identified a very high urbanization rate in the watershed during the last decade compared to previous 30 years. Major point sources include the hospital, bus stand, railway station, central market and the residences on either side of *Meda Ela*. According to the literature, elevated pollution levels are reported during wet season and NO^-_3, NH^+_4, PO^{3-}_4, suspended solids, heavy metals, DO, BOD and COD showed above threshold limits. This is an indication of non-point source pollution which is responsive to hydrological conditions. Impacts of water pollution include vector borne diseases such as *Dengu* and *Chickengunya*, bad odour, flash floods and contamination of shallow groundwater with heavy metals. The social and management setup in the watershed is very complex since many stakeholders are involved in polluting and managing *Meda Ela*. The analysis revealed that the relationship among different stakeholders is highly diverse and as a result, their contribution to control water pollution in *Meda Ela* is also very different. Hence, a strong connection should be established between community and other stakeholders to develop an efficient and effective management plan to safeguard *Meda Ela* stream and its watershed.

Keywords: Black water and Grey water, Biological indicators, Dissolves oxygen, Ethnic groups.

Introduction

Water, hitherto considered as an abundant resource, is nearing exhaustion due to increasing demands for irrigation, industry and domestic uses with continuously growing population. This paper deals with one of the widely studied water resource in the central hills (*Kandy*) of Sri Lanka. Available published research articles related to the study area were reviewed and organized under different topics focusing on proper watershed management as a mean of preserving its quality.

Kandy is recognized as a world heritage city by the United Nations Educational, Scientific and Cultural Organization (UNESCO) on account of its history and cultural treasures. A water canal called Mid-canal or "*Meda Ela*" originates from the overflow sluice of the *Kandy* Lake located next to the Temple of Tooth Relic, runs through the densely populated city, and thereafter drains into the *Mahawelli* River which is the largest river basin in Sri Lanka [1]. *Meda Ela* consists of seven major tributaries covering 1456.38 ha of land area (Figure 1), contributing to its inflow in addition to the main supply from the *Kandy* lake [2]. The length of the canal is about 8 km and the width varies from 10 m to 15 m along its course from the lake sluice to the confluence with the *Maliaweli* River at *Getambe* [3].

The *Meda Ela* is considered to be the most polluted running water system in the *Kandy* district [4]. This natural stream has been modified by constructing concrete banks and paving the bed with cement at certain places. However, a major part of the canal still flows as a natural course. The banks of the *Mada Ela* have been reinforced by concrete walls from the point of its origin (i.e.

Lake Sluice) to about 100 m downstream. The canal flows underground (<1 km) from the sluice up to the *Kandy* railway station. The *Meda Ela* then merges out and connects with a network of waste water canals draining from various parts of the *Kandy* city. The banks of certain parts of the *Meda Ela* have also been modified by cement walls from the railway station up to the *Mulgampola* area (up to 3 km). Beyond *Mulgampola*, up to *Getambe*, the canal flows along a more or less natural course.

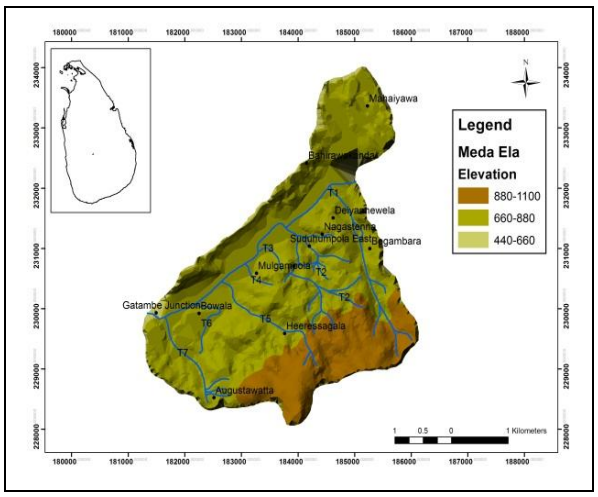

Figure 1: *Meda Ela* watershed, its tributaries and topography [2]

According to [2], the urbanization rate in *Meda Ela* watershed has drastically increased from 10.14 ha/year to 17.2 ha/year during the past decade (2003-2014) when compare to 1972-2003 periods. Therefore, amount of solid waste, sewerage, waste water and other disposal material generation also has increased drastically, but without enough facilities for proper disposal [5]. People who are living in these unplanned areas of the watershed directly or indirectly dispose wastes into natural environment which finally confluences with the *Meda Ela* since it is draining at the lowest part of the watershed [2].

Socio-economic background

The census of population and housing in 2001 revealed that the total population of the *Kandy* district was 1,279,028 of which 109,343 people permanently live within the *Kandy* Municipal Council (KMC) area [6]. *Kandy* city also caters to a floating population of 157,000 during day, 111,000 during night and a very high seasonal floating population during the *Perahera* (Buddhist festivals) season [7]. The population density of the *Kandy* district is over 660 people per km^2 and statistics from 1981-2001 indicate an increasing trend [8]. Nearly 350 houses are located along the *Meda Ela* canal bank [1]. There are different ethnic groups living in the area and the majority (66%) of them are Sinhalese, 23% Muslims and 10% Tamils [5]. The education level is relatively good and 94% of people sat for Ordinary Level Examination [1]. The average land extent owned by a household is 325 m^2 and the majority of people fall into the medium income level with a gross domestic product of US $2400 [1]. Of the total population, 19% are engaged in government employment and 37% work in the private sector and others have not permanent employment [5].

Approximately 87% of residents have potable water supply through connected pipes either by KMC or National Water Supply and Drainage Board (NWS&DB) and 9% of people have common pipe water supply while some of residents still use unprotected wells on the canal bank for domestic purposes. Average family size is five and average consumption of water per family is 995 L/day. About 91% of the families use piped water for bathing and washing and only 4% use common bathing places [1].

Land use change in the entire catchment

Unplanned urbanization is believed to be an important cause of destruction and degradation of natural water resources. Owing to rural-urban migration, it has been estimated that approximately 50% of the population will live in growing cities of less developed countries by the year 2025 [9]. Figure 2 displays the overall land use change in the *Meda Ela* catchment during the past 50 years. The urban area of the catchment has increased in recent years and yet the forest area remains mostly the same. The forest cover that contributes to the entire catchment consists of *Dunamadalawa* and *Udawatta kale* forest reserves and very small extents of forest areas are located in other places. Since two forest reserves are protected areas, it is not possible to encroach. The amounts of paddy lands have been drastically reduced during this period. On the other hands, home gardens show a remarkable increase during 1980 – 1992 time periods mainly owing to the construction of *William Gopallawa* road [2]. It is evident that the construction of this road has initiated the urbanization and development in the area resulting in increased land value.

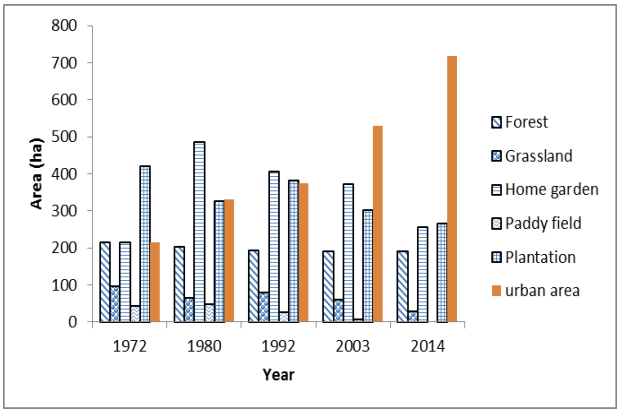

Figure 2: Land use changes of the whole *Meda Ela* catchment [2].

In 1972, only a small stretch of land was under urban use and much of the land was occupied by home gardens, paddy and plantations as shown in Figure 2. In 1980, much of the home gardens have transformed in to urban areas and by the year 1992 the paddy lands have begun to disappear from the land use [2]. In 2014, the majority of the catchment areas of 3rd, 4th and 7th tributaries have been converted from home garden to urbanized areas. With the improvement of the road network and due to the lack of land, the home gardens have been converted in to urban areas. The catchment area of the 3rd and 4th tributaries which have higher slopes and low time of concentration display the highest extent of land use change and both catchment areas are now completely under urban land use (buildings and houses). This is very dangerous for the local hydrology as more impervious lands have been formed from the natural pervious ground. With steep slopes and relatively high time of concentration of the catchment, it is possible to create flash floods in the downstream as well as landslides within the catchment area.

Source of pollution

Water quality of the *Kandy Lake* has been maintained to a certain standard due to its close proximity to the *Dalada Maligawa* (Temple of the tooth relic). There are many hotels, restaurants and private hospitals around the lake. Wastewater discharges from these locations into the lake are monitored in order to protect the lake. But it cannot be controlled and continues waste disposal is progressing. The contamination of the *Meda Ela* from downstream begins from *Kandy* market, which is maintained by the KMC. More than 20 meat and fish stalls are located in the complex [10]. Wastewater with very high organic loads from meat, fish and vegetable stalls and restaurants is discharged directly to relatively unpolluted water flowing in the *Meda Ela* from the *Kandy* Lake. The *Kandy Bogambera* prison, which is located adjacent to the market, also was releasing wastewater into the *Meda Ela* until the prison and slaughterhouse were closed recently.

Kandy is one of the focal points of public transport in Sri Lanka. According to the traffic police, more than 30,000 vehicles enter the city every day. The runoff from the bus stand, railway station and vehicle service stations carrying oils, grease and suspended particles attached with heavy metals, flows into the *Meda Ela*. The base hospital in *Kandy* is a large teaching hospital with all modern facilities for medical treatment. Wastewater of the hospital goes through a treatment facility within the hospital and is then discharged into the *Meda Ela*. Occasionally, the treatment plant does not function, and untreated wastewater is discharged into the *Meda Ela* [10] creating a situation which can cause infectious diseases.

Commercial laundries (*dobby* communities) located along the canal also discharge untreated wastewater into the *Meda Ela*. The *dobby* community has been living at this location for more than a hundred years. Clothes from operation theatres and wards of the hospital are also washed in these laundries resulting in a heavy pollution of water in the *Meda Ela* with pathogens and other microbes. The concentration of phosphate in the *Meda Ela* may be due to the detergent used in these laundries [10].

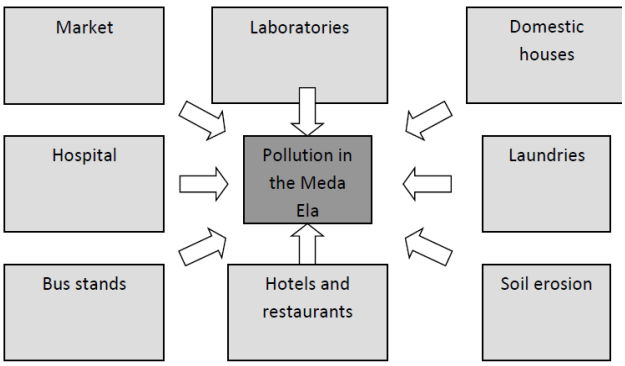

Figure 3: Multiple sources of pollution of the *Meda Ela* (Modified from [10]).

Figure 3 illustrates the possible point source of pollution of the *Meda Ela* watershed, but high number of non-point source of pollution is also involved in polluting the *Meda Ela* water during wet and dry seasons. As shown in Table 1, 90% of the respondents consulted express concern over untreated effluents generated by the market centre, general hospital, central bus stand, hotels, eating houses and soil erosion from building sites. Ninety present respondents commented on the untreated

effluents generated by the railway station, slaughterhouse, storm-water runoff and soil erosion from construction sites. There were several other agents also responsible for the damage.

Table 1: Public opinion about source of pollution of the *Meda Ela* watershed

Cause of pollution	% Opinion
Garbage - resident population	63
Garbage - visitor population	68
Solid waste	59
Storm water run-off	89
Haphazard car-wash run-off	23
Soil erosion	92
Kitchen wastes	42
Toilet water	68
Untreated effluents	98
Street sweepings	82
Drain block out collections	94
Sewerage	29
Night soil	22

Source: [11]

Solid waste disposal

Rapid urbanization and lack of an organized system to collect and dispose solid and liquid waste is a serious risk factor related to water pollution in the *Meda Ela* watershed. Along its 8 km course, the canal collects massive quantities of effluent and domestic waste products. Topographically, being situated at a lower elevation, a large number of artificial and natural canals empty their waste loads into the *Meda Ela* canal. With respect to municipal solid waste, nearly 100 tonnes/day of solid waste is generated within the KMC area [8] with an average household solid waste generation of 1.5 kg/day [5]. There is obviously a variation of the amount of waste generated depending on the type of establishment. Commercial establishments generate more than 5 kg/day contributing to about 37% of the total generation. Pavement vendors, public eating-houses, restaurants, and groceries generate a high amount of waste (20%). Domestic households generate solid waste and contribute about 13% [11] and balance produced by schools, tea-kiosks, small hotels and wayside tearooms. Waste generation from families is mainly composed of by-products of day-to-day consumption with main contributions are from sweepings and kitchen wastes. According to the type of waste generated, categories are; Biodegradable - Short term (63%), Biodegradable - Long term (12%), Paper (11%), Polythene (6%), Metal (4%), Wood (3%) and Glass components (1%) [11].

There is a relationship between income levels, consumption pattern and ethnic groups to waste generation. Daily solid waste generation by an average Sinhala family is usually less than 2 kg while Muslim families generate more waste (>3kg) when compare to the other ethnic groups. With increasing income levels, the amount of waste generate is also increase [5]. The study done by [1] indicated that 71% of the *Mada Ela* community disposed their waste in municipal waste bins or collecting carts, but 29% of them disposed their waste directly into the *Mada Ela*. Also, the same study revealed that even some people who reside outside the *Meda Ela* catchment also dispose their solid waste into the canal. Solid waste management is a serious problem for the municipal corporation. The central collection system covers a limited number of areas due to the financial constraints. The land available for dumping is also limited. The KMC does not have a sanitary landfill site and open dumping along the streams is common. The dumping of solid waste into the *Meda Ela* becomes an easy way of solving the problem of solid waste, even though it is not a good way to dispose solid wastes.

Waste water disposal (black and grey water)

The colour of water in the *Meda Ela* is generally brown during dry weather flow conditions and looks severely polluted even to the naked eye. The discharge of the canal during the rainy season is substantial and perhaps water carries a heavy loading of particulate and suspended sediment. As a result, water becomes brownish yellow (murky) during most of the rainy seasons. It has also been reported as bad odour in several instances and the canal does not have visual attractiveness [12].

Methods of sewage disposal in urban catchments are also one of the most important factors in protecting water resources. If sewage is disposed without following a proper treatment and disposal methods, downstream people will be affected causing many health and environmental problems. In the *Meda Ela* catchment, pit type toilets (59%) are the most common and followed by septic tanks (30%) [5]). However, 5% of households dispose directly their sewage to the canal as an easy and cheaper method neglecting the adverse side effects. Approximately 1000 m^3/day of sewerage or black water flows into the *Meda Ela* [13] and most people living along the canal bank flush out their sewerage pits during heavy rains to avoid paying

for gully trucks to empty their pits [5]. This is an ideal example to show the way of contaminating water in the *Meda Ela* as a result of a congested and unplanned urban environment and lack of community awareness on possible environmental and health consequences of contaminating water resources.

Water quality

The *Meda Ela* which is considered as an effluent canal has been hardly subjected to any systematic water quality assessment though it is a potential threat to health of people living in the vicinity. The general appearance of the stream is environmentally and aesthetically unacceptable. Several studies conducted time to time have reported basic physico-chemical parameters (e.g. pH, EC, NO_3-N, NH_4-N and DO) and presence of some heavy metals (i.e. Pb. Cd. V and Fe) in the canal. Those analyzed water samples were collected from the canal and several dug wells adjacent to the canal [14]; [15]; [6]; [5]; [1]; [16] and [2] were summarized below.

According to a study by [14], the nitrate (NO^-_3) concentration of the *Meda Ela* varied between 0.2 mg/L to 3.56 mg/L. The NO^-_3 loading to the canal was attributed to biogenic waste such as human and animal excreta, which accounts for a large percentage of the total nitrogen loading. However, extremely high nitrate concentrations were not reflected in the analytical data as some of the nitrogen species could have been incorporated in organic forms, particularly in the bottom sediments along the canal. A study conducted by [15] found a maximum nitrate value of 7.28 mg/L in a well adjacent to the *Meda Ela*. This value however is within the safe limit for drinking water. Although a large amount of human excreta is discharged into the canal, a complete nitrification does not occur within the system. Nitrogen loaded into the canal could retain as organic complexes, which can eventually be converted to nitrate. NH_4-N levels reported in the same study (i.e. 0.01 - 0.50 mg/L) fall within the acceptable range for running water systems. However, extremely high value of 4.0 mg/L was also reported. The total phosphorous level of the canal ranged from 0.15 mg/L to 15 mg/L. The upper level was extremely high and unacceptable for stream water according to Sri Lankan standards. In general, the total phosphorous levels were higher than the recommended levels compared to nitrate levels in the canal. Extremely high phosphorous concentration in this stream could he attributed to a massive input of phosphorous from human and animal excreta and organic garbage. In the case of heavy metals, the total Pb levels in the canal water varied between 20µg/L and 850µg/L while the average was 268µg/L. The Pb levels ranged from 20 µg/L to 640 µg/L in some wells, of which are higher than the upper limit (100 µg/L), recommended by the World Health Organization [17]. High emission of Pb from automobiles could be a contributory factor for high Pb levels in the canal and adjacent wells since the area is closer to the *Colombo-Kandy* main road. Municipal wastes are also highly contributed to Pb pollution in the *Meda Ela*. In addition, accumulation of Pb in the *Meda Ela* could be due to the waste petroleum products from garages and service stations. The total Cd concentration of the canal water ranged from 10µg/L to 310 µg/L with an average value of 138µg/L. Well water containing 10 µg/L of Cd is the maximum permissible limit recommended by the WHO. The total V concentration in the canal water ranged from 6.5µg/L to 45 µg/L with an average of 18µg/L. In the case of well water, the total V concentration ranged from 2 µg/L to 10.5 µg/L. Possible sources of V are the waste fluids from batik manufacturing factories, hospitals, sewage sludge, petroleum products and decaying plants [15]. The total Fe level of the canal water ranged from 0.1 mg/L to 8.5 mg/L with an average value of 4 mg/L. The well water had a total Fe level ranging from 0.12 mg/L to 2.8 mg/L, but few wells had exceed the recommended level of 1.0 mg/L.

The study done by [6] identified biological organisms to interpret water quality status in the *Meda Ela*. The presence of aquatic fauna is an indication of long term status of water quality providing an opportunity to understand the level of pollution. Measurements of biological parameters have shown that the *Meda Ela* water is polluted at different levels from upstream to downstream. The upstream of tributary 1 identified as having good quality water because of presence of Dragonfly and Damselfly. Both these species are very sensitive to polluted water. In lower part of all tributaries, there were crustacean species, Backswimmers, Water Whirligig Beetles, Water Measures, Water Digging Beetles, Water spiders; those indicate moderate water quality. At origin of the *Meda Ela*, Chironomid Midges (Blood Worms), Gastropods species, Coliform and E.coli were observed and could be categorized as a low water quality compared with other parts of the *Meda Ela*. Presence of pollution tolerant aquatic fauna such as Dipteran larvae, round worms and other annelids with high amount of Chironomid clusters in middle

and end part of the *Meda Ela* indicate very low water quality.

According to the study done by [1] along the *Meda Ela*, the pollution level during the wet season was high. Dissolved oxygen was lower at end of the canal (2 mg/L) and especially in the wet season. The total suspended solids values (wet: 36-3073 mg/L and dry: 27-532 mg/L) had exceeded the discharge limits at all locations tested along the canal. The concentration of BOD_5 (wet: 3.9- 2646 mg/L and dry: 1.5-520 mg/L) and COD (wet: 4-2766 mg/L and dry: 19-741 mg/L) increased towards the end of the *Meda Ela*, and the highest BOD_5 values were much higher than the effluent BOD_5 discharge limit in Sri Lanka (i.e. 30 mg/L). Ammonia concentrations (wet: 2.5-40 mg/L and dry: 3.5-15 mg/L) were above the inhibitory limit for fish and no fish were observed in the canal. The total phosphorus (wet: 0.1-2.75 mg/L and dry: 0.25-1 mg/L) and phosphate concentrations (wet: 0.5-5 mg/L and dry: 0.5-3 mg/L) were high towards the end of the canal. Also, the same study shows that faecal coliform amount is very high in the *Meda Ela* in both wet (58-5400 counts/100 ml) and dry (0-3400 counts/100 ml) seasons.

[18] and [16] identified DO variation along the *Meda Ela* as a good indicator to monitor the impact of urban pollution in the *Meda Ela*. DO results for *Meda Ela* show how a natural stream lost its characters due to urban and domestic activities in the catchment area. At some sampling points, the DO concentrations have reduced to alarming rates. The critical area of pollution in the *Meda-Ela* can be identified from middle area where the DO concentration below 1 mg/L [16]. These areas are the most sensitive due to high urban activities that include the main bus stand, the base hospital and the market [17]. It is a very positive aspect to observe that turbulence and aeration through spills in latter part of the *Meda-Ela* will help in regaining the DO concentration of the stream before it reaches the *Mahaweli* River.

Cost due to water pollution in *Meda Ela*

According to the disease incidents, 13% of the families have got affected by dengue and *Chickengunya* fever during 2009 to 2010 period and the mean health cost was Rs.453.00 per incident per patient. People are aware that the canal provides an ideal breeding ground for mosquitoes due to stagnating water during dry weather flow conditions. This condition is further aggravated due to solid waste disposal and wastewater discharge. People in the area have got used to mosquito nets, repellent coils, repellent mats and fans to protect from mosquito bites. Monthly average cost for mosquito repellents was Rs.162.00 per family. Since the canal is the drainage path of the whole *Kandy* city area, flash floods after heavy rains are very common. It was revealed that 30% of the households that live closer to the canal are affected by intermittent floods and cost to protect from floods is Rs.450.00 family/year [5].

Problems to community due to *Meda Ela* pollution

Nearly 54% of the people, almost all the households near the bank of the canal, reported that they suffer from bad odour and another 28% said that they feel a strong odour during dry season [5]. Also 13% of people were affected by water born disease such as *Dengue* and *Chickengunya*. It was also revealed that 30% of the households that live closer to the canal are affected by intermittent floods.

Major stakeholders and their relationship with each other

[5] Identified KMC, Central Provincial Council (CPC), *Kandy* Divisional Secretariat (KDS), Gangawata Korale Pradeshiya Sabha (GKPS), UDA, Central Environmental Authority (CEA), NWS&DB, Irrigation Department (ID), commercial establishments, individuals and residents who live in the catchment of this canal as major stakeholders. In addition, GKPS, CPC, KDS and District Secretariats of *Kandy* are collaborating with the KMC in granting permission for constructing buildings, houses, etc. They are also providing approvals for management and development activities related to water bodies in the area. Other government related institutions such as ID, CEA and UDA are also involved in water related development activities in the area. Most of the residential population and the business community neglect their social responsibility towards proper waste disposal and wastewater management. Hence, these categories can be identified as key polluters.

The CEA and the HD of the KMC are responsible for monitoring wastewater discharge into the *Meda Ela* from the hospital in *Kandy*. The NWS&DB is responsible for supply of safe drinking water and proper drainage facilities. The HD is responsible for the cleanliness of all roads, drains, markets and the environment. Also implementing the health policy, monitoring effluent discharge of small scale operations (markets, hospitals and restaurants), creating public awareness regarding

health issues and taking legal action are all responsibilities of the HD. PHI is the ground level implementing officers of all activities related to the HD. Legal actions for non-compliance can be taken by the PHI, but actions against polluters, particularly government establishments (ex. hospital) are a challenge for the PHI.

The KMC is responsible for the collection and disposal of solid waste and it consists of different departments responsible for maintaining different aspects of the *Kandy* city. Local government acts, municipal and urban councils' ordinances, the Pradesha Shaba act, Land Development Ordinances (No. 19 of 1935, No. 3 of 1946), the Land Acquisition Act and the Crown Land Ordinance (No.8 of 1947, 9 of 1947 and 13 of 1949) are prescribed in the government policy for land development and rehabilitation, and to maintain the reservation area of the *Meda Ela* [10].

The UDA Act, in Schedule IV (Form E-Regulation 18) also provides for the reservation of waterways. The reservation from the edge of the high water level of the *Meda Ela* from *Kandy* Lake to *Heerassagala* junction, and *Heerassagala* junction to *Mahawelli* river is three and six metres, respectively [10]. In spite of these limits and a large number of local and national government agencies responsible, houses have been constructed and some have expanded into the reservation of the *Meda Ela*. A reservation area is maintained to protect the canal and facilitate the flow of water, particularly during floods. It is also meant as protection from discharge of wastewater and dumping of solid waste.

As illustrates in Figure 4, high number of departments, institutes and authorities are responsible for maintaining and protecting all water bodies including the *Meda Ela*. Lack of good coordination, poor attitudes of offices, political influence, power relation, friendships etc. among those, govern continuous pollution of the *Meda Ela*.

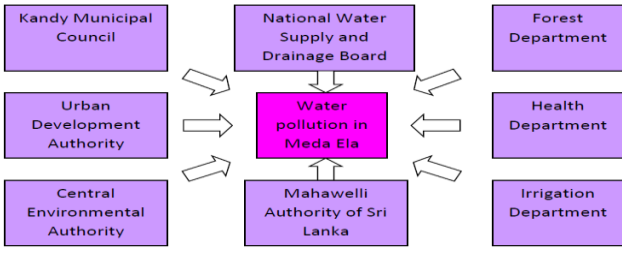

Figure 4: Institutions and departments linked to the *Meda Ela.*

As illustrates in Table 2, the KMC and residents live along the canal bank have a greater responsibility towards controlling water pollution. Though there are different social organizations in every Grama Niladhari (village level administrative unit) Division and high number of research have been carried out by Universities and government organizations, no collective actions have been taken to reduce the pollutant loading to the *Meda Ela*. The canal reservation has been encroached by people as a result of high land value in the area, political blessings and poor response of the law enforcing authorities to control these activities.

Table 2: Responsibility in controlling water pollution as ranked by the people in the *Meda Ela* Catchment [5]

Responsible institution/individual group	Group	Rank
KMC	399	1
People live along the canal	340	2
Kandy Central Market and hospitals	214	3
Other (Slaughterhouse, Hotels, etc.)	37	4
Visitors to Kandy city	34	5

Economic benefits of *Meda Ela*

The uppermost branch streams of the canal are being used by people for bathing, washing and even for drinking without purifying the water. Though the latter part of the canal is polluted, economic benefits are received by people who engage in laundry business and collect worms as fish feed.

Conclusion

The *Meda Ela* has a complex catchment area, which consists of urban centres, densely populated residential areas, hospitals, hotels, restaurants, market places, public transport destinations and a number of government and private sector institutions. As a result, the *Meda Ela* water is polluted due to solid and liquid waste generated and disposed without any treatment from point and non-point sources. According to water quality analysis along the *Meda Ela*, the pollution level in the wet season is high. DO is low at end of the canal and especially in the wet season. The concentration of BOD_5 and COD increase towards the end of the canal, and the highest BOD_5 values are much higher than the effluent BOD_5 discharge limit in Sri Lanka. Ammonia concentrations are also above the inhibitory limit for fish and no fish were observed in the canal. Total phosphorus and phosphate concentrations are high towards end of

the canal and heavy loading of Phosphate promote algal blooms in downstream. The canal carries enamours amount of nitrogenous substances resulting from human and animal excreta. In spite of this, the nitrate and ammonium concentrations are found to be low indicating perhaps existing nitrogen in other forms. There is a possibility of moving nitrate through the alluvial layer of the floodplain of the *Meda Ela*. This is supported by the high concentration of nitrate found in adjacent dug wells.

The high concentration of Pb found in the canal water is a positive sign of lead pollution perhaps due to automobiles and waste petroleum products generated from service stations and garages. The concentration of Cd, V and Fe do not show a threat in the *Meda Ela* in 1987, but lack of a detailed recent study is serious barrier to understand the current situation. It has become a big barrier to identify the concentration of heavy metals in the *Meda Ela* under high and unplanned urbanization during past 30 year period. The ultimate result of this continuous pollution is vector borne diseases such as *Dengu* and *Chickengunya*, and mosquito breeding, bad odour, reduction in aesthetic appearance, flash floods and contamination of surrounding wells.

The awareness on water pollution due to waste disposal is high among the communities that live within the catchment even with good educational level. However, discharge of grey water as well as black water by people who live close to the canal is evident. Though their awareness on water pollution and possible consequences is high, they still continue to practice these activities due to lack of options for proper disposal of solid and liquid wastes. Lack of coordination among the stakeholders involved in the management of this water body has been identified as one of the major cause for unregulated activities that seriously affect the water quality. Hence, community and other stakeholders should get together in order to develop an efficient and effective management plan to safeguard the *Meda Ela* stream and its catchment area.

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