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Identification of Problems Leading to Degradation of an Urban Watershed - A Case Study on Middle Canal (*Meda Ela*) in Kandy Municipality of Sri Lanka

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ABSTRACT. *A watershed can be considered as a basic unit for integrated planning in resource utilization. Kandy and its environs contribute to a hill country watershed. The Mahaweli River traverses Kandy and one of its important tributaries is the Middle Canal, originating as the outflow of the Kandy Lake and fed by effluent discharging canals and sewerage drains up to the point of discharge. The existence of suspended solids and heavy metal pollutants in associated waterways provides firm evidence confirming the severity of pollution. The Middle Canal discharges its effluents into the Mahaweli at Getambe, upstream from the location of sacred water-cutting ceremony site and the location of the Kandy Municipal Council Water Intake. Furthermore, the Ceylon Electricity Board plans to construct a dam at Getambe, to supplement the national grid and to facilitate pumping of water for the Kandy Municipality. Evacuation of dwellers, inundation of land, spread of sewage - sewerage water-related diseases, siltation and eutrophication are associated problems. The focus of the present study is on the less-researched and less-tractable land use problems of the up-stream and effects down-stream of a selected micro-watershed: Anniewatta Tributary of the Middle Canal, as a case study. The watershed problems were studied in the up, mid and down stream using the watershed approach, the scientific and technological approach and the socio-economic approach. The educational approach was adopted as a means of educating and conveying the importance of pollution prevention to the society. The priority issues were highlighted in an opinion poll in order to prevent further degradation and protect, conserve and improve on the available resource base to minimize pollution through better management. Public opinion was unanimous in that a key role must be played by the State. Law enforcement and the necessity of punitive procedure were also evident.*

INTRODUCTION

Water serves as the base of existence of all life and is considered as an abundant resource, which is still available free to most people. With growing population, increasing demands on agriculture, irrigation, industry and domestic uses, fresh water resources are nearing exhaustion. This paper deals with this important resource: its distribution, its mismanagement through human interventions and the necessity of focusing on proper watershed management as a means of preserving its quality through awareness and intervention.

There is mounting evidence of unaccounted solid waste and effluent discharges to *Meda Ela*, the Middle Canal, in spite of the fact that a regular solid waste

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disposal service is in operation. Roadsides, reservation areas, streams and rivers and the Kandy Lake have become convenient dumpsites for the whole society. Recent studies by Poddalgoda (1997); Silva (1996); Dissanayake *et al.* (1987a,b), provide proof on the existence of suspended solids and heavy metal pollutants in the Kandy Lake, the Middle Canal and Mahaweli water. While providing a firm basis for understanding the extent and severity of water pollution, attention is drawn for establishing means for minimizing the problems associated with harmful effluents and emissions. Harmful pollutants disappear in a number of ways such as volatilization, leaching, chemical processes, bio-degradation, etc. Phosphates mainly pollute surface water. The most serious threat to ground water comes from nitrates and fecal contamination. Nitrate pollution is due to excessive use of agro-chemicals. Discharge of effluents from pit latrines, soak ways and septic tanks causes bacterial contamination of ground water. Analysis of well water from the banks of Middle Canal in Kandy highlights the influence of polluted surface water in wells. This problem is critical in urban areas where human excreta either in-situ or effluents from septic tanks /soakage pits are discharged directly. In densely populated areas the distance between soakage pit and wells is mostly less than 6 m. A load of 712 - 1507 kg BOD_5 day^{-1} has been detected in the Middle Canal which drains the Kandy city's untreated urban waste water into the Mahaweli River at Getambe (NARESA, 1991).

In the near future, the Ceylon Electricity Board (CEB) hopes to construct a rubber dam, across the Mahaweli River close to the Buddhist Monks' Retreat, to generate 14 MW of hydro-electricity for the national power grid. Sequel to the dam construction spread of sewage – sewerage, water-related diseases, dysentery, and mosquito infestations would lead to inevitable health hazards. These must be viewed especially in relation to the inflow of the effluent discharges of the Middle Canal into the Mahaweli River at Getambe, a few meters upstream from the proposed construction site and the location of the Kandy Municipal Council (KMC) water intake for public supply. Consequences of effluent accumulation and sedimentation will pose an enormous threat to the city water purification and supply created by the backlash. The present study was undertaken to examine this proposal and its ramifications. Had the today's adult population been educated or made aware of the environmental issues in their educational curricula, perhaps the present day's crisis would not have been as acute as it exists now. Therefore, the main objective of the study is to examine the problems of pollution of Middle Canal and identify the causes through a case study of a selected main tributary.

MATERIALS AND METHODS

The existing problems were first studied using the watershed approach (FAO, 1991), through observation and identification of factors causing watershed degradation. The scientific and technological approach helped in quantifying the damage at specific selected locations in the up, mid and down stream along the watercourse. The socio-economic approach was used in eliciting information linking the human contribution to watershed degradation through pollution and how it could be reduced through authoritative action by responsible institutions. The priority issues are highlighted in order to prevent further degradation and protect, conserve and improve on the available resource base.

The Middle Canal micro watershed is located within the Kandy Administrative District (7° 15` N 80° 35` E), which has an altitude of 500-750 m., a

mean annual temperature of 22.5°C-25.0°C, a mean annual rainfall of 1700 mm (year round), well–drained reddish–brown latasolic soils and a mountainous terrain. The climate is very strongly influenced by the elevation of the land, which ranges from about 600 m in the valleys to over 800 m in the mountaintops of Upper Hantana and Bahirawakanda. In the high mountains, a total annual precipitation of up to 2300 mm occurs with much fog fall. In the valleys, annual rainfall is about 2100 mm with less fog. The drier seasons occur during the months of February and August.

Much of the Southern part of the watershed / catchment, Eastern and Western boundaries are mountainous. The valley of the Middle Canal is located towards the west of the township of Kandy. The valleys of several important tributaries contain wide alluvial plains and rolling terrain to hilly foot slopes which have been developed for agriculture, mainly rice cultivation. Most of the wetlands on both sides are now threatened due mainly to rapid urbanization. The population density of the Kandy District is over 250 people km^{-2} and statistics from 1891-2001 indicate an increasing trend according to Urban Development Authority (UDA, 1996).

The main land use in this region is permanent agriculture (70% of the land area): rice, vegetables, tea, perennial spices and cash crops. Kandyan Forest Garden is the most prevalent farming paradigm in the region where the climate and socio-economic conditions are ideal for such tree-gardens. According to the data obtained from UDA, the Land Use Pattern for Kandy City, as an urban watershed is shown in Table 1. 75% of the total land area is densely inhabited by the resident, commercial or visitor population and therefore highly likely to be subjected to some form of human intervention.

The outflow from the Kandy Lake continues through the valley formed by the Hantana Range and Heerassagala Hills on one side and the Bahirawakanda Range, Anniewatta, Primrose Hill on the opposite side. The Dunumadala Oya, which originates from the Hantana Range, is joined by more streams from that range mingles its waters with the outflow of the Kandy Lake and criss-crosses its way through the Kandy Town as the Middle Canal. This is joined by more streams and tributaries on either side of the valley, along its way through densely populated area to meet the Mahaweli River. These tributaries in micro-watersheds are subjected to severe pollution through human interventions. The Anniewatta tributary, was selected for the research study in order to evaluate the extent of damage along its course due to human intervention out of more than 108 typical tributaries, as Anniewatta represents the most desired and the affluent residential area of the KMC.

The micro watershed of the Anniewatta tributary selected for the study constitutes an area from which water drains into the stream which has its origin around the Anniewatta Hills. The high ground separating the adjacent catchment area forms the watershed of this stream. The reference line at the railway line drawn across the stream defines the micro-watershed or the catchment area. All the area from which, surface run off waters pass through this line constitute the micro-watershed under study. The boundary of the micro watershed is indicated by the perimeter defining the area delineated using fixed topographic properties of the area. A network of stream tributaries constituted by tributaries of the 1st order, 2nd order and 3rd order leads to the common mouth at the chosen reference line.

Table 1. Land use pattern for Kandy City.

Type of Use	Extent (Ha)	% of Total Area
Residential	1153	46.0
Commercial	73	3.0
Industrial	12	0.5
Public and semi-public	68	2.7
Schools	53	2.1
Religious and cultural	38	1.5
Roads and other circulation	20	4.8
Parks and play grounds	91	2.2
Cemeteries	13	0.5
Vacant lands	163	6.5
Paddy lands	98	4.0
Forest reservations	381	14.0
Water bodies	346	14.0
Total	2510	100.0

Source: Urban Development Authority (1996)

This research study focuses on the less-researched and often less-tractable land use problems of the up-stream and effects down-stream. In order to achieve the objectives outlined, three main approaches were used in the data collection process in the site selected for the case study. Primary data for the scientific and technological approach were collected through field observations. All aspects of human intervention leading to watershed degradation such as, encroachment, misuse of state land, illicit activities, non-permitted constructions; were identified and photographed. Analysis of water samples collected from the upstream, midstream and downstream for constituents and microbiological examinations were carried out for determining the extent of contamination along the watercourse with assistance from the KMC city laboratories. Secondary data from available literature were obtained on indicators such as fecal coliform bacteria, dissolved oxygen, chemical oxygen demand, biological oxygen demand, heavy metals, levels of nitrate, levels of phosphate and suspended solids for detection of pollution in Kandy Lake and Middle Canal and Mahaweli waters. Primary data for the socio-economic approach were obtained through a questionnaire from a random sample consisting of sixty respondents from the community in the respective residential, commercial and industrial areas of the micro watershed. This information was compared with and related to, the verifiable indicators obtained through the scientific and technological approach. The point sources and non-point sources of pollution were identified. Furthermore, little attention has so far been paid to the causes of damage, its source, the responsible actors, mode of solution and the responsible institute for cleanup process. In order to elucidate these questions, a public opinion poll was conducted using a second questionnaire at random on 100 citizens on the causes of pollution and the agency responsible for implementation of suggested remedial measures. Secondary data were collected from past records available at the Kandy Municipal Council, Kandy District Secretariat, the Urban Development Authority, the Central Environment Authority (CEA), the National Water Supply and Drainage Board and the Ceylon Electricity Board.

RESULTS AND DISCUSSION

Data obtained through analysis of water samples from the up, mid and down stream locations are summarised in Table 2.

Table 2. Comparison of water samples in *Anniewatta* Tributary.

Characteristic	Upland Stream	Midland Stream	Lowland Stream
pH	6	6.5	7.5
Turbidity NTU	5	466	525
Colour	1	38	70
TDS mg l^{-1}	50	768	1,015
Chloride mg l^{-1}	10	52	78
Ammonium N mg l^{-1}	0.05	17.4	20.4
Nitrate N mg l^{-1}	0.1	10	12
E.coli /100ml	0	8,000	25,500
Col. /ml, 37^{0}C	10	5,100	33,000
Col. /ml, 22^{0}C	100	29,000	800,000

The results clearly show an increase in all measured parameters (Table 2). The severity of fecal contamination increase by about 25,000 fold, as the tributary flows downwards through the mid stream and downstream.

The Table 2 clearly indicates the extent of microbial contaminations as the tributary flows downwards. Absence of *Escherichia coli* in the upstream sample proves the fact that there is no faecal contamination at the point of origin which is the catchment. At some point in mid stream and continually thereafter the high microbial count of *coliforms* at 22^{0}C and 37^{0}C indicate the increase of effluents containing fecal matter, which contaminate the water environment. By the time the tributary discharges its contents to the Middle Canal, it is highly polluted.

The other parameters *viz.* Turbidity, Colour, Total Dissolved Solids (TDS), Ammonium Nitrogen (NH_4^+) and Nitrate Nitrogen (NO_3^-), also indicated an increase of pollution. The representative tributary shows this trend clearly in spite of its location in a prime residential area. Therefore, it can be assumed that other tributaries, streams and watercourses are subjected to similar pollution through human intervention. The overall pollution from collective sources can be well observed even visually from the grey-coloured waters that are finally discharged into the Mahaweli River at Getambe. The KMC water intake is located only a few meters upstream from discharge point of the effluent canal, which is a factor for earnest attention of the authorities. Whenever there is accumulation, the backlash can pose serious consequences. Studies conducted by Poddalgoda (1997), Silva (1996), Dissanayake (1991a and b), Weerasooriya and Dissanayake (1982,1986a and b, 1988), Dissanayake *et al.* (1987a and b),

Weerasooriya *et al* (1982) have reported high levels of microbial contamination, heavy metals, phosphate and nitrate from the Middle Canal and Mahaweli River waters. It is extremely essential to heed to prior warnings indicated by several scientists on the health risks involved as a result of ground water contamination through leachates. It is therefore highly essential that extreme care be taken and precautionary and remedial measures introduced for a system of continuous or random monitoring of tap water and water purification process even after chlorination.

Information on the solid waste composition, effluent discharge pattern, type of toilet facilities available and the source of drinking water were extracted for comparison from a total of 60 locations. The results presented in Figures 1 – 4, indicate the pattern of variation with regard to these factors.

The response of the survey gives an indication of the kind of enterprise generating the solid waste. There is a variation on the amount of waste generated depending on the kind of establishment. Those that generate waste more than 5 kg are by and large, commercial establishments contributing about 37%. Pavement vendors, public eating-houses, restaurants, and groceries generate a high quantity of waste. Domestic households belong to the category generating 2-3 kg of solid waste and contribute about 15%. The family waste generation is mainly composed of by-products from day-to-day consumption.

The major components of the waste are composed of mainly sweepings and kitchen wastes. Most of the waste paper is generated from offices, schools, tea-kiosks, small hotels, and wayside tearooms. According to the type/kind of waste generated, categorization can be made as Biodegradable - Short term, Biodegradable - Long term, Paper, Polythene, Metal, Wood and Glass components.

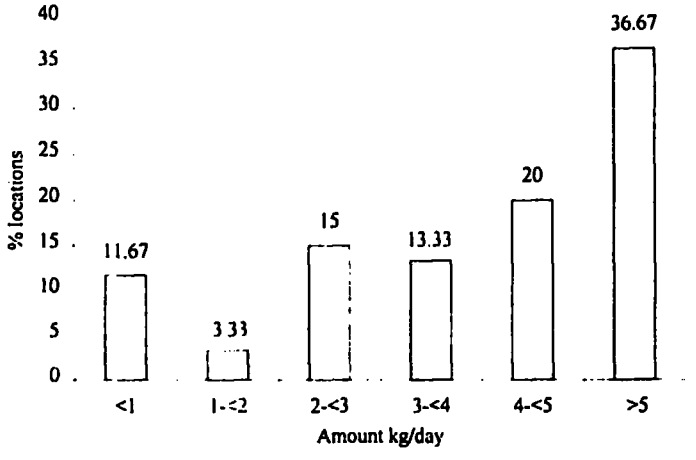

Fig. 1. Percentage of locations based on the weight of solid waste generated (n=60).

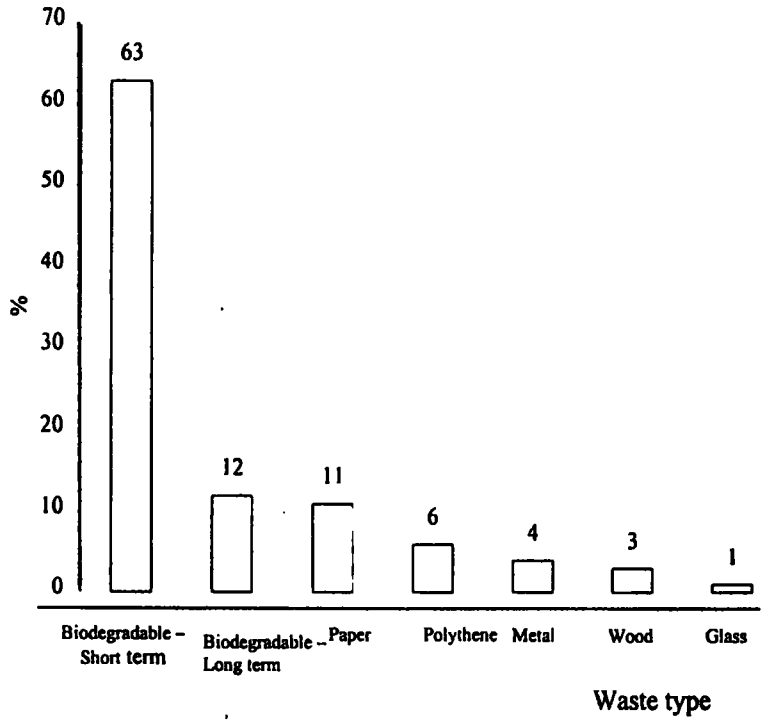

Fig. 2. Composition of solid waste generated (n=60).

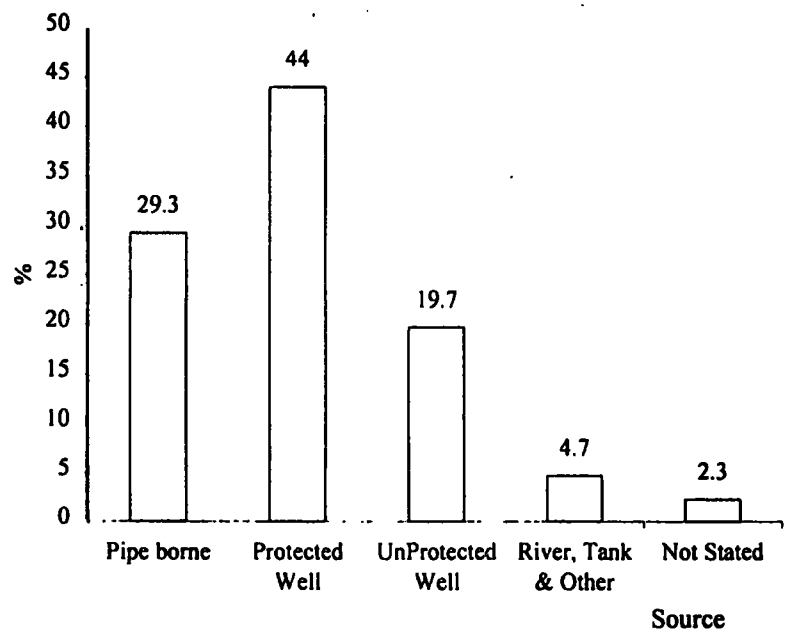

Fig. 3. Distribution of respondents according to main sources of drinking water by % (n=60).

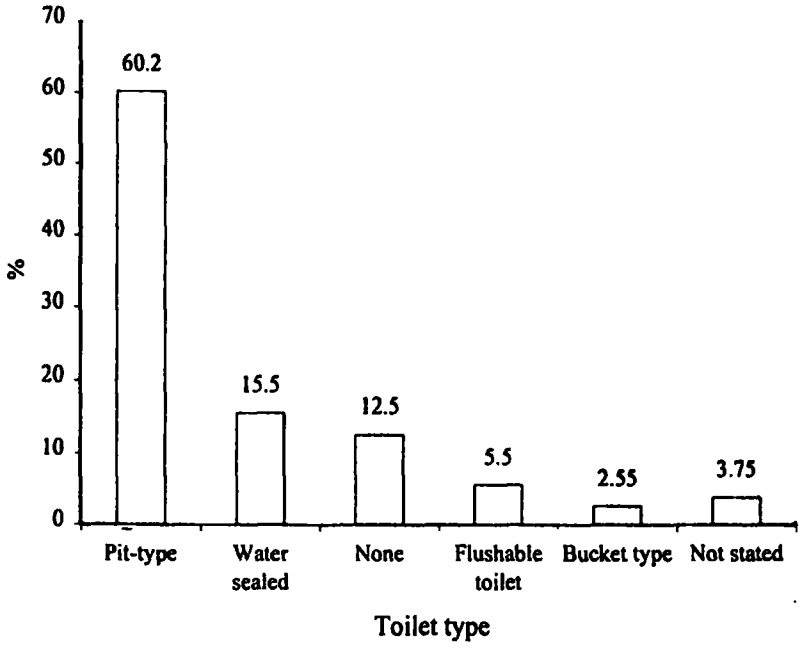

Fig. 4. Distribution of locations according to toilet type (n=60).

The contribution of the several activities to overall pollution can now be depicted as a flow diagram shown in Figure 5. The flow diagram very clearly illustrates the various components of human interventions contributing to pollution. The effect of each of the pollutant on the sequence of a cycle can well be observed. The whole process is so harmoniously interwoven such that any damage caused at one point invariably reflects at another and eventually affects the whole ecosystem.

The contributory factors and the substances in the form of impurities contained in each effluent type, which cause pollution, are very clearly recognizable. The permissible levels allowed by the CEA, can be referred for guidance indicating the urgency of precautionary and remedial measures. Legislation, set standards for effluents are more or less confined to records. The results of the public response on suggested causes of pollution are given in Table 3.

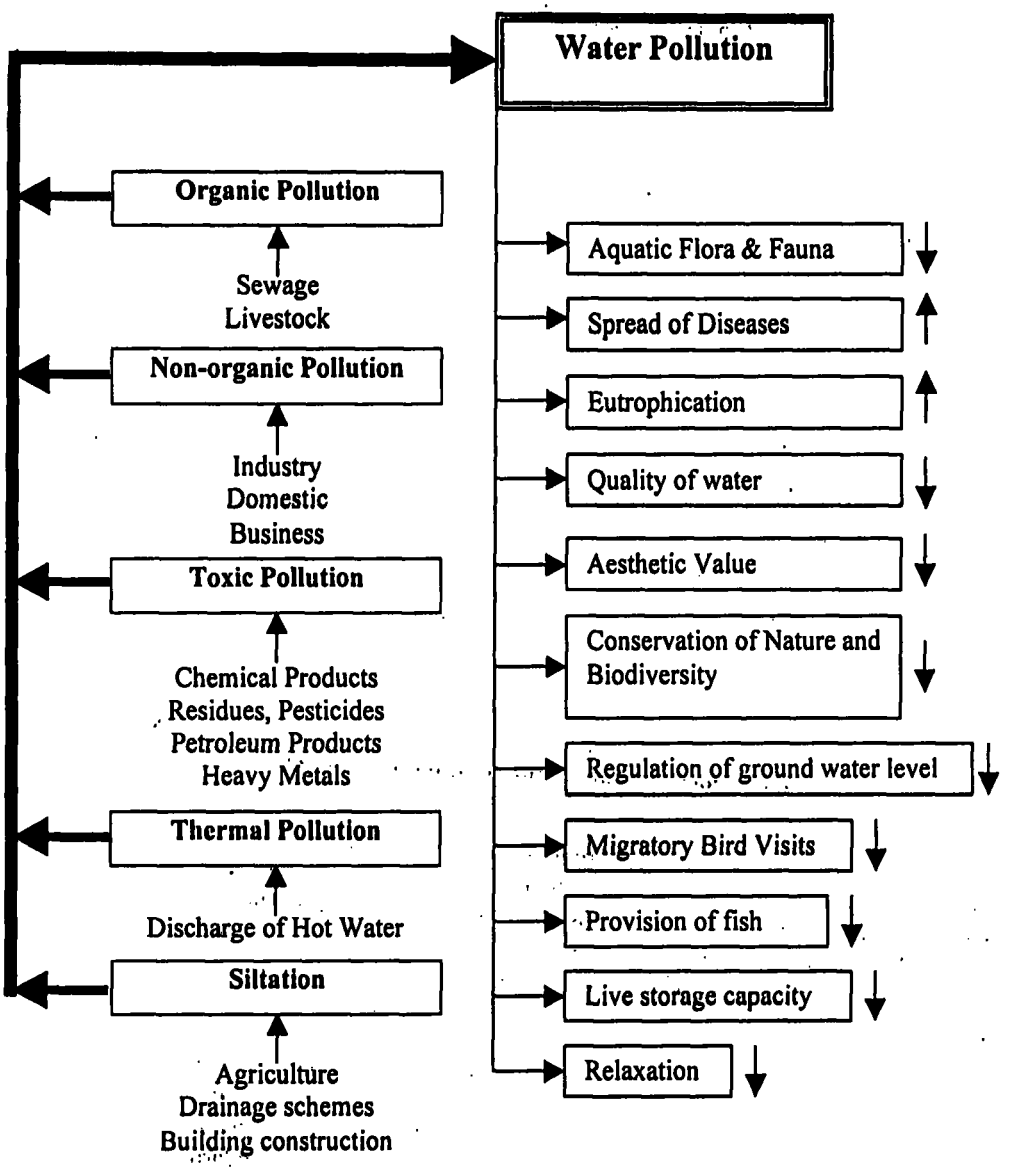

Fig. 5. Flow Diagram indicating the intensity of water pollution created by human activities in the Kandy Lake and *Meda Ela* environment.

As evident from the results, an overall 90% of the respondents consulted express concern over untreated effluents generated by the market centre, general hospital, central bus depot, hotels, eating houses and soil erosion from building sites. Nearly 90% 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 responsible for the damage as indicated in Table 3.

On the basis of the response received, the entities responsible for the damage were easily identifiable – the point sources. Furthermore, the picture also reveals unidentifiable sources of pollution, which cannot be traced to a particular entity – the

non-point sources. On the response received on implementation of the suggested remedial measures the responsible authority is also easily identifiable as well illustrated in Table 4. Based on the public opinion received, 100% or unanimous consensus was evident on the key role that should be exercised by the Central Government (CG), or organisations and institutes affiliated to the state such as CEA and UDA. Law Enforcement and the necessity of Penalization for identifiable victims are also well observed.

Table 3. Public Opinion on Causes of Pollution.

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

It is very apparent that pollution is the result of lack of self-discipline, dedication and commitment and dominance of the human population over all other natural resources. Therefore, pollution control is a primary consideration in checking watershed degradation and relates to measures in minimizing any form of pollution of the watershed. The responsibilities of resurrection must therefore be assigned to respective entities and institutions. Fortunately however, there is also an increasing awareness towards recycling of potential pollutants and a need to curb excessive waste.

CONCLUSIONS

Pollution has intensified under increased population pressures as a sequel to human activities. Environmental degradation, in the form of urban slums, dirty air, polluted waters, stench, noise and natural resource deterioration has resulted in human misery. Pollution has accelerated beyond the carrying capacity of many local environments in and around Kandy City, to absorb the residues of a mass consumption society.

The existing problems in the study area identified using the watershed approach revealed that the intensity of watershed degradation is the cumulative result of human activities through their occupational interventions. Information elicited on the solid waste composition, effluent discharge pattern, type of toilet facilities available and the source of drinking water revealed several encountered problems associated with watershed degradation. As revealed from the study, pollution of watercourses from point and non-point sources is the combined result of several factors of human

intervention such as: lack of proper drainage; encroachment of reservations along the watershed tributaries, streams and canals; illegal occupation of rail and road reservations; dumping of solid and liquid waste of industrial, agricultural, municipal and domestic effluents and suspended sediment loads; result of soil erosion from agriculture, construction sites and deforestation etc.

Table 4. Suggested measures to prevent further deterioration.

No.	Suggested Remedial Measures	% opinion	Responsible Authority
1.	Prevention and complete prohibition of construction above 1400'	100	C.G
2.	Protection of existing forest areas as strict nature reserves	100	C.G
3.	Introduction of environmental education in to school curriculum and compulsory practice	96	C.G
4.	Entrust the school children of the respective vicinity as guardian angels	96	C.G
5.	Protection of the watershed and its conservation for all educational purposes in collaboration with genuine environmental organisations	100	C.G & UDA
6.	Prevention of external interference into the reserve by political power	100	C.G & UDA
7.	Prevention of waste generation at source level	76	People
8.	Introduction of collection centres, bottle, polythene, foil, paper banks	83	KMC
9.	Increasing public awareness on the prospects of waste reuse, recycling and resource recovery	100	C.G & UDA
10.	Education on social ethics	67	C.G.
11.	Involvement of NGOs and community participation	78	C.G & UDA
12.	Introduction of waste treatment plants by all commercial enterprises	93	CEA
13.	Introduction of waste treatment plants by all government institutes	100	CEA
14.	Privatisation of waste disposal services	35	KMC
15.	Introduce methods of avoiding people and traffic congestion:		Traffic Police
	A. Opening 2-way traffic in Dalada Veediya	69	C.G. & D.N.
	B. Complete ban on day-long parking	85	KMC & Police
	C. Modulation of all religious activities of all religions	68	C.G.
	D. Shifting of super-market complex	45	KMC
	E. Shifting of bus stand	58	CTB
	F. Separation of all types of outside commercial activity from travel activity	87	KMC & Police
16.	Identification of polluters and issue of warning letters	98	CEA
17.	Enforcement of taxes	65	UDA
18.	Enforcement of penalties	84	UDA
19.	Enforcement of law and authority	98	C.G.

Public opinion was unanimous in that a key role must be played by the State. Law enforcement and the necessity of punitive procedure were also evident. As

revealed from the survey the responsibility of resurrection must be assigned to respective entities and institutions. The increasing awareness towards recycling of potential pollutants and a need to curb excessive waste can be effectively implemented in the resurrection process.

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REFERENCES

CEB (1997). Ceylon Electricity Board, Annual Report, Colombo, Sri Lanka.

Dissanayake, C.B. (1991a). Humic substances and chemical speciation- Environmental geochemistry and health. International Journal Environmental Studies, 38: 247 –258.

Dissanayake, C.B. (1991b). The fluoride problem in the groundwater of Sri Lanka- Environmental management and health. International Journal of Environmental Studies, 38: 137 –156.

Dissanayake, C.B. and Weerasooriya, S.V.R. (1986a). Chemistry of tap water in Sri Lanka- Implications on health. International Journal of Environmental Studies, 27: 57 –69.

Dissanayake, C.B. and Weerasooriya, S.V.R. (1986b). The environmental chemistry of Mahaweli river, Sri Lanka. International Journal of Environmental Studies, 28: 207 –223.

Dissanayake, C.B. (1988). Nitrates in the ground water in Sri Lanka - implications for community health. Journal of the Geological Society of Sri Lanka, 1: 80 - 84.

Dissanayake, C.B., Niwas, J.M. and Weerasooriya, S.V.R. (1987a). Heavy metal pollution of the mid canal of Kandy - An environmental case study from Sri Lanka. Environmental Research, 41: 24 – 35

Dissanayake, C.B., Niwas, J.M. and Weerasooriya, S.V.R. (1987b). Heavy metal abundance in the Kandy Lake: An environmental case study from Sri Lanka. Department of Geology, University of Peradeniya, Sri Lanka.

FAO (1996). Watershed Approach Framework, FAO, Rome, Italy.

NARESA (1991) Natural Resources of Sri Lanka – Trends and Conditions. (M.F. Baldwin Eds.) Colombo, Sri Lanka.

Poddalgoda, P.D.W.S. (1997). The Status of the Effluent Discharge into Meda Ela and its Impact on the Mahaweli River. M.Sc. Practicum Report, PGIA.

Silva, E.I.L. (1996) Water Quality of Sri Lanka Institute of Fundamental Studies, Kandy, Sri Lanka.

Weerasooriya, S.V.R., Senaratne, A. and Dissanayake, C.B. (1982) The environmental impact of nitrate distribution in the Lake - effluent canal system in Kandy. Sri Lanka Journal of Environmental Management 15: 239 - 250.

UDA (1996) Urban Development Authority. Development Plan for Kandy Urban Development Area, UDA, Sri Lanka