EXISTING CHALLENGE TO SUCCEED A SUSTAINABLE BUILT AQUA-ENVIRONMENT IN MISTY GREEN VALLEYS IN THE HILL COUNTRY OF SRI LANKA; A CASE STUDY

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Abstract: The upper watershed of Dambagastalawa River in Sri Lanka is a precious ecosystem of esthetic beauty that supplies direct drinking, bathing and agricultural water for the people in Pattipola-Ambewela and Agara Pathana areas. Nevertheless, is often subjected to multiple threats due to a range of human related activities. Therefore, a monthly bio monitoring study was carried out in 2007 and 2008 to assess current ecological conditions at five selected sites. The aim was to evaluate future sustainability of the catchments. The invertebrate fauna were collected through i*n situ* direct counting, stone lifting, kick, scope and core sampling methods and evaluation of faunal composition was done preferring to the Biological Monitoring Working Party (*BMWP*) scoring system. A parallel study was carried out to assess the water quality parameters following the *APHA* standard methods. Any visible change in the chatchment land use patterns was also monitored.
The highest faunal diversity (<10) was recorded at highly oxygenated (<7.33 mg/l) up stream sites with little/or no disturbance in Pattipola forest area where Ephemeropterans and Sumiliids were dominant. The second most diverse site (≤ 7) was at the disturbed Agara Pathana site where Hydrosphychids, Chironomids, Plannarians and Molluscs were dominant. The lowest faunal diversity (≤ 3) was recorded at the Ambewela reservoir which is largely colonized by poor water quality indicative taxa *Hydra* and Chironomid (~208 individuals/m^2). The Average Score Per Taxon (ASPT) of the upstream sties (6.8 and 7) were less comparable with reference stream site (8.2 out of 10) studied at the Piduruthalagala peak. ASPT was 4.57 in the down stream. However, significantly lower ASPT values (3.5 at sluice gate and 2.5 at uppermost outlet) were recorded at Ambewela reservoir evidently showing an associated ecological risk. The reservoir was found to received high levels of nutrients (ammonia 0.20- 0.25 mg/l, nitrite 0.09 -0.121 mg/l, nitrate 0.50 -1.35 mg/l and phosphate 0.050 -.075 mg/l) due to effluent run-off from the adjoined livestock and crop farms. It was found to have a periodic eutrophic condition especially during low rain and growing crop seasons. No biological/chemical evidence to prove self-purification in its down stream in Agara Pathana where the river encounters other additional threats. Converting of forest/tea plantations into annual crops, garbage dumping, loading tea dust/other waste is severe in this area thereby water become more turbid (TSS 459.90 mg/l) unpleasant and undrinkable. Present case study showed the agriculture based human activities in middle catchments of the Dambagastalawa river posed significant negative impacts on river quality. In the long run this might affect the entire aqua-environment in the Ambewela/Agra valleys. Actions should immediately be taken to bring these valleys into manageable levels otherwise we may face irreversible loss of sustainability.

Key words: hill country, Dambagastalawa river, bio monitoring, water pollution, ecological risk.

1 Introduction

1.1 Sustainable built aqua-environment

When the phrase "sustainable built environment" is applied to natural environments it would fundamentally include conservation, biodiversity, and enhancement of the site ecology and enhance or safeguard human health as well as wellbeing (www.co.uk). In aqua ecosystems it is significant in many of ecological functions such as recycling of nutrients, purifying water, attenuating floods, recharging ground water and providing habitats for wildlife. It is also significant to use for human recreation and eco-tourism industry. It is known fact the health of an aquatic ecosystem is degraded when the ecosystem's ability to absorb a stress has been exceeded. Since human populations frequently impose excessive stresses on aquatic ecosystems through multiple use, pollution and habitat degradation, most of aqua environments of the world are under intense pressure (Mason 1996[1]). Therefore, the services they can provide to the society through their sustainability have been reduced and the biota is strongly affected disappearing of several aquatic species from some of eco-region (Stanford 1994).

1.2 Animal life in aqua-environments

Stress on an aquatic ecosystem can be a result of alterations of its physical *i.e. changes in water temperature, water flow and light availability*, chemical *i. e. changes in the loading rates of bio stimulatory nutrients, oxygen consuming materials, and toxins* and biological environments *i. e. introduction of exotic specie*s (www.towards-sustainability.co.uk/issues/built) which are particularly conducive for composition of living organisms in it (Mason 1996[1]). If any water-body is contaminating with any pollutant, slowly loading any harmful substance or degrading due to any human activity it firstly affect on its living things then to the entire ecosystem. In initial stages, sensitive species would disappear or show decline in abundance while tolerant species become more prolific and dominant. Therefore, animals reflect the build up of impacts of environmental changes on the ecosystem such as the influence of surrounding land use or the effects of pollution. Therefore, faunal composition of any aquatic ecosystem logically expresses its long term condition with more precision than its chemical or physical parameters. Hence, they are important as bio indicators which can give early warning in potential pollution trend or effect of long termed stress conditions (Chessman 1995 and Mason 1996[1]).

1.3 Biological monitoring of pollution in freshwaters

The quantitative studies of organisms and biological communities are known as biological monitoring through which the environmental integrity of many of freshwater ecosystems of the world has been assessed (Aarts & Nienhuis 1999; Anon 1998; Anon 2000 and Diersing 2009). The aquatic macro invertebrates such as insects, snails and worms that are widespread, easy to collect, relatively immobile and provide good information about the environment are very largely used in bio-monitoring studies (Mason 1996[2] and www.epa.vic.gov.au). In such studies data interpretation is commonly done with diversity indices which take account of species richness and evenness *i. e. the number of species and relative abundance of species* and biotic indices that take account of the sensitivities of different species to pollution. The value of diversity index is high in unstressed *i. e. pollution- free* environments while it is low in stressed environments. In biotic indices, a high score is given for the species which are sensitive to pollution while a low score is given for the tolerant species. It is more precise to compare diversity indices as it takes account of the tolerances of individual species to pollution. Hence, biotic indices are largely used and different scoring systems such as *BMWP* (*Biological Monitoring Party Score*), *MRHI* (*Monitoring River Health Initiative*) and *AUSRIVAS* (*Australian Rivers Assessment System*) have been devised and are employed to weigh out healthiness in many of freshwater systems of the world (Chessman 1995; Mason 1996[1] and Matcafe 1996).

1.4 Rational for the study

Freshwaters in the central hills of Sri Lanka are major suppliers of direct drinking, bathing, agricultural, irrigational and hydro-power generating water as, well as they are being good followers of the esthetic beauty of the Island (Arumugum 1969). Despite this, they are becoming constant victims of a number of human activities such as deforestation and excessive use of agrochemicals and fertilizer. Sometimes they have to act as waste sinkers (Silva 1996). Those fats are leading to oppose them from the standards of sustainable build environmental due to frequent changes in their physical and chemical environments in which long run it may result irreversible degradation.

The Dambagastalawa river catchment is the uppermost watershed of the Kotmale River which is one of the most productive and significant sub catchments with highly bio-diverse unique ecosystems of high floral and faunal endemism and precious ecosystems of esthetic beauty (Anon 2001). Since late 1970s its upper catchments area is under large scale crop farming, intensive animal farming, advanced tea plantation, and rapid urbanization (Arumugum 1969, Pethiyagoda 1991). Consequently, the catchment is more likely to have ecosystem degradation due to pollution, rapid seepage, heavy run off, high siltation etc. As such assessment of its healthiness is a timely requirement though it has not been exclusively carried out yet. Therefore, the present study was carried out from April 2007 to October 2008 through an exclusively evaluation of macro faunal composition and some water quality parameters to quantify presence of macro invertebrates in selected sites, identify habitat quality deterioration factors and to assess long term sustainability of the entire catchment.

2. Material and methods

2.1 Micro-catchments studied

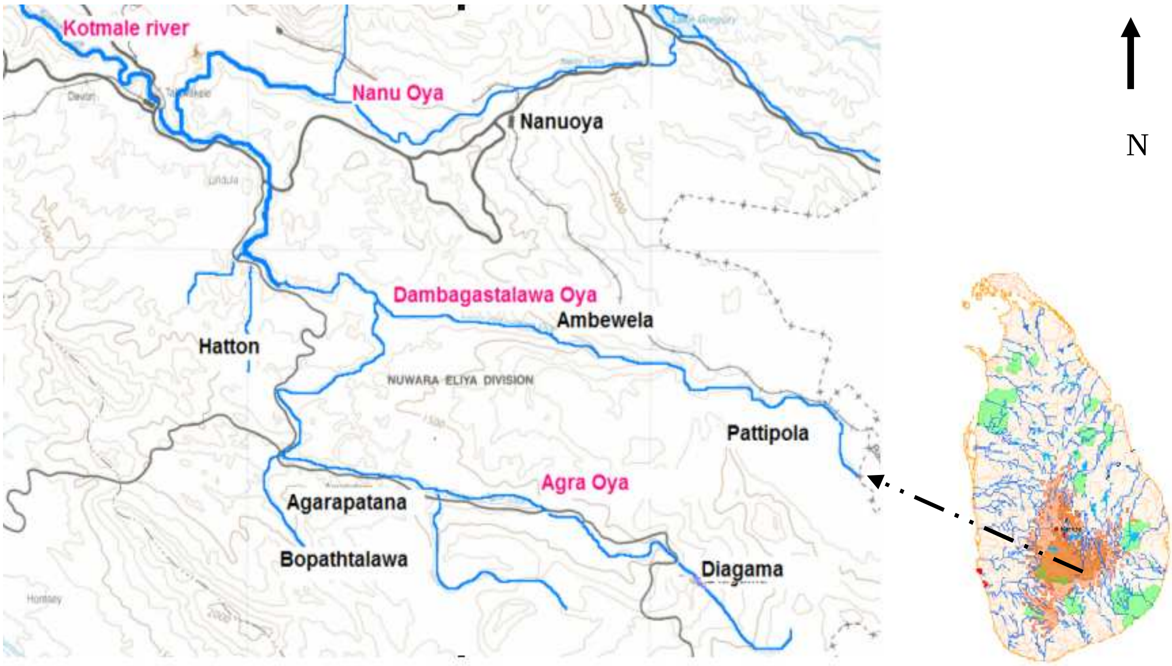

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Figure 2.1 Map of Sri Lanka showing the location of the uppermost catchments of the Mahaweli River and upper reaches of the Kotmale River; *Agra Oya, Nanu Oya and Dambagastalawa Oya*.

The Dambagastawala micro-catchment is located in the central highlands (above 2130 m MSL) of Sri Lanka (5°55'- 9°51'N and 79°41'- 81°54'E). It is one of the economically and ecologically significant uppermost catchments of the Kotmale River that tributes to the River Mahaweli (figure 2.1) (Anon 1988). The Dambagastalawa river harbours several perennial streams that originate in the Ambewela hills, Totupola Kanda and Pattipola area (figure 2.2). These uppermost streams are empty into a reservoir built by impounding the river with a across ridge at Ambewela. This Ambewela reservoir is of 14.25 km^2 catchment area and 113.28m^3 water storage capacity spreads over 60.7 hec. It supplies water to neighboring valleys for an extent of about 404.7 hec. through a link channel leading to a 137.16m tunnel underneath the railway line adjoining the Ambewela railway station (Arumugam 1969). Afterwards the Dambagastalawa river flows through Agra valley, encounters additional streams and subsequently meets Agra river and Nanu Oya to form the Kotmale River (figure 2.1).

2.1 Study site selected

A total of six sampling sites representing the river catchment waterways *i. e. including relatively undisturbed sites and sites that are subjecting to the obvious point source pollution* were selected for the study (figure 2.2). One riverine site in protected forest area in the Pidurutalagala mountain range of the Nanu Oya catchment was selected as reference site as it was found with little or no disturbance.

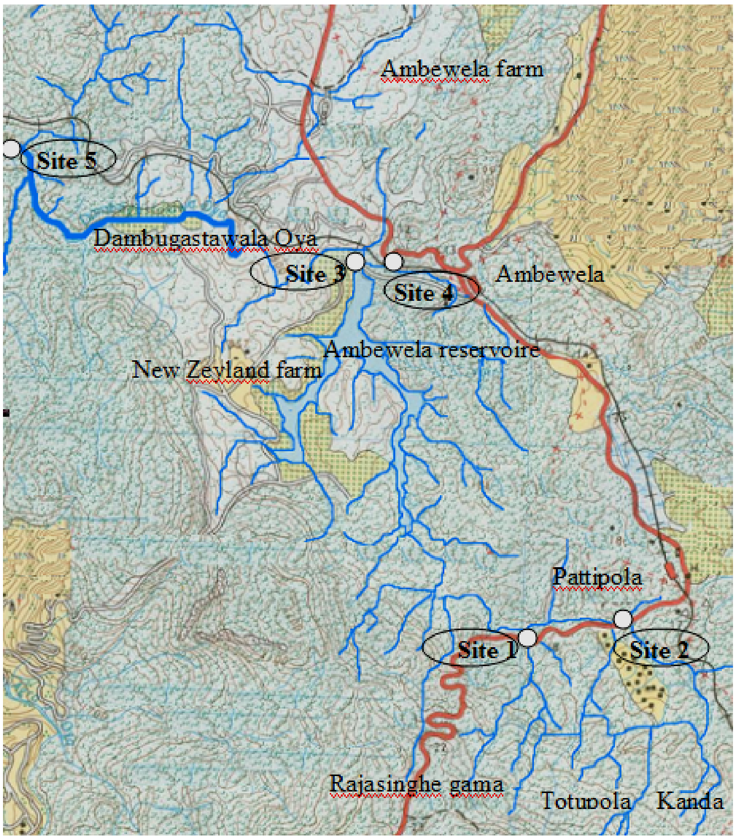

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Figure 2.2 Map of the upper reaches of the Dambagastalawa Oya showing the study sites.

The site 1 is a 3rd order perennial upstream flows through natural forest reserve at off Pattipola and its upper reaches in Rajasinghagama area. The site 2 is a 3rd order perennial downstream originates in the Totupola Kanda mountain region of the Horton Plains nature reserve and flows through forest plantation close to the Pattipola railway station. The site 3 and 4 are the reservoir sites respectively at the dam site (close to sluice gate) and at the uppermost outlet of the reservoir. These two sites are encountering obvious point sources of pollution due to agricultural run off, seepage of animal farming and siltation. The site 5 is a 4th order perennial more downstream flows through agricultural area especially tea and annual crops at Henfold estate at Agarapathana valley. At this point the Dambagastalawa Oya receives water from other animal farm areas as well as from other lands where annual crop farming was intensified in recent past.

2.2 Bio-monitoring procedure

Each study site was monthly visited and mobile invertebrate fauna found on the water surface within a predetermined area, were studied through i*n situ* direct counting. The animals found in water column as well as benthos were collected into a kick sampler subsequently making them to be dislodged and swept into a net by the current. Five randomly selected stream bed boulders of approximately 3 cm × 4 cm in diameter were lifted into a white enamel tray and the anchored animals were then collected with a small paint bush. Aquatic fauna in water column as well as among the aquatic vegetation along the stream bankers were collected sweeping a fine meshed sweep net. Several number of mud samples were randomly collected using a corer and the animals were collected by wet sieving. Later all animals were preserved in 10% formalin for further analysis in the laboratory.

In the laboratory the animals were identified up to possible taxa using Fernando and Weerawardhana (2002); Manuel and Barton (2004); Manuel et al. (2004) and Needham and Needham (1962). Their abundance and generic richness were then calculated as follows.

Abundance = number of individuals/area of surveyed (m^2)

Species richness = number of species

2.3 Chemical monitoring procedure

Some water quality measurements; dissolved Oxygen (*Orion 830A* DO meter), pH (*Orion 260A* pH meter), temperature (thermometer incorporated in DO meter), electrical conductivity (*HANNA HI 8733t* conductivity meter) and turbidity (*HACH 2100P* turbidity meter) were made *in situ.* In the laboratory Total Suspended Solid (TSS), nitrite, nitrate, phosphorus and ammonia level were analyzed following the standards methods given in APHA (APHA, 1998). Bio-Chemical Oxygen Demand (BOD) and Chlorophyll-a content was measured using Aqua Lytic BOD sensors and a spectrophotometer (DR 4000) respectively.

2.4 Monitoring land use pattern changes

Any significant changes in river banks, within the water bodies as well as the land use pattern changes in the catchments were monitored.

2.5 Assessment of site condition

Finally assessment of invertebrate composition at each site was performed referring to the score system given to each taxon in *Biological Monitoring Working Party (BMWP) Score Table* (Mason, 1996[1]) (table 2.1). Then the total score was divided by the number of families recorded in the site to derive Average Score Per Taxon (ASPT) value which is less sensitive to sample size and sampling effort. According the BMWP scoring system high ASPT scores indicate good water quality while low values indicate poor water quality.

Table 2.1 Biological Monitoring Working Party (BMWP) score system (Source: Mason 1996[1])

Invertebrate Families	**Score**
Siphlonuridae, Heptagenidae, Leptophlebidae, Ephemerellidae, Potamanthidae, Ephemeridae, Taeniopterygidae, Leuctridae, Capniidae, Perlodidae, Perlidae, Chloroperllidae, Aphelocheiridae, Phryganeidae, Molannidae, Beraeidae, Odontoceridae, Leptoceridae, Goeridae, Lepidostomatidae, Brachycentridae, Sericostomatidae	10
Astacidae, Lestidae, Agriidae, Gomphidae, Cordulegasteridae, Aeshnidae, Corduliidae, Libellulidae, Psychomyiidae, Philopotamidae	08
Caenidae, Nemouridae, Rhyacophildae, Polycentropidae, Limnephilidae,	07
Neritidae, Viviparidae, Ancylidae, Hydroptilidae, Unionidae, Corophiidae, Ganumaridae, Platycnemididae, Coenagriidae	06
Mesoveliidae, Hydrometridae, Gerridae, Nepidae, Naucoridae, Notonectidae, Pleidae, Corixidae, Haliplidae, Helodidae, Dytiscidae, Gyrinidae, Hydrophilidae, Clambidae, Helodidae, Dryopidae, Elminthidae, Chrysomelidae, Curculionidae, Hydropsychidae, Tipulidae, Simuliidae	05
Baetidae, Sialidae, Piscicolidae	04
Valvatidae, Hydrobiidae, Lymnaeidae, Physidae, Planorbudae, Sphaeriidae, Glossiphoniidae, Hirudidae, Erpobdellidae, Asellidae	03
Chironomidae	02
Oligochaeta (whole class)	01

In addition to this the trophic status of the reservoir sites was evaluated referring to the Mason (1996[1]) eutrophication survey guideline values given for water quality parameters for lakes and reservoirs (table 2.2). The relationship between the changes in water quality and populations of some organisms also assessed preferring to figure 2.3 in order to get a precise idea on the existing quality status of the water bodies assessed.

Table 2.2 Eutrophication survey guidelines for lakes and reservoirs (source: Mason 1996[1])

	Oligotrophic	Mesotrophic	Eutrophic
Total phosphorous (mg/l)	< 0.01	0.01-0.02	> 0.20
Total nitrogen (mg/l)	< 0.20	0.20 -0. 50	> 0.50
Secchi depth (m)	> 3.7	3.7 – 2	< 2
Hypolimnetic dissolved oxygen (% saturation)	> 80	10 – 80	< 10
Chlorophyll-a (mg/l)	< 4	4 – 10	> 10
Phytoplankton production (g Cm^{-2} d^{-1})	7 -25	75 - 250	350 - 700

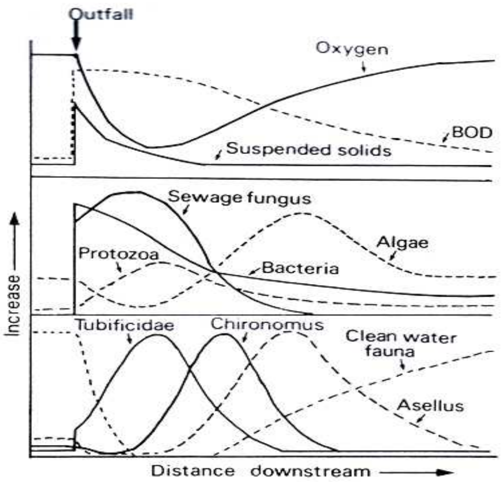

Figure 2.3 Changes in water quality and populations of organisms in a river below a discharge of an organic effluent (Adopted from Mason 1996[1]).

3. Results

3.1 Results of bio monitoring

The invertebrate taxa recorded at the study sites in the Dambagastalawa Oya micro-catchment during the study period are given in table 3.1. Majority of them were aquatic insects of which one genus of Trichopterans (caddis flies) of the family Hydropsychidae was found to more prolific in the down stream site studied at Agra valley. They were less dominant in the upstream sites studied in Pattipola forest area. The Ephemeropterans (May flies) were found in all upstream sites studied and none of them were recorded at the down stream site (site 5) and the reservoir sites. The Odonates (Damsel and dragonflies) were predominantly recorded at site 3 and site 5. There was a single record of Plecopterans (stone fly) in the reference stream site studied at the Piduruthalagala mountain peak.

The Chironomid larvae were recorded from all the riverine sites studied with relatively low abundance (<0.5 individulas/m^2). Its density was very high in the reservoir sites (average value was 208 individuals/m^2 in 2008) where occasional records of huge colonies of *Hydra* were found. The population density of *Hydra* was found to show negative relationship (r = 0.88) with monthly rainfall experienced in 2008 (figure 3.1). In addition to these the larval forms of several other invertebrate taxa such as hemipterans (water bugs/boatmen/striders), coleopterans (beetles) and Platyhelminthes (flat worms) as well as crabs and molluscs were occasionally recorded.

The highest invertebrate generic richness (13) was recorded at the stream sites studied in Pattipola forest area. The second most diverse site (5) was the down stream site studied at Agara valley. The lowest invertebrate diversity (3) was recorded at the Ambewela reservoir sites. The Average Score Per Taxon (ASPT) of the upstream sties were 6.8 and 7. It was 8.2 (out of 10) at the reference stream site studied at the Piduruthalagala peak. The ASPT was 4.57 in the down stream site (site 5). However, significantly lower ASPT values 3.5 and 2.5 respectively recorded at the sluice gate and at the uppermost outlet of the Ambewela reservoir indicating an associated ecological risk in it.

Table 3.1 different invertebrate taxa recorded at the study sites at Dambagastalawa micro-catchment in 2007 and 2008 and calculated values for site generic richness and site ASPT (abundance: + less, ++ moderate, +++ high and – not recorded).

	Study site					
TAXA	**Site 1 (upstream)**	**Site 2 (upstream)**	**Site 3 (reservoir)**	**Site 4 (reservoir)**	**Site 5 (downstream)**	**Reference site**
PLECOPTERANS						
Perlidae						
Neoperla sp.	-	+	-	-	-	+
EPHEMEROPTERANS						
Hepatagenidae						
Heptagenia sp.	-	+++	-	-	-	++
Baetidae						
Baetis sp.	++	+++	-	-	-	+
Choroterpes sp.	+	+++	-	-	-	+
TRICHOPTERANS						
Hydrosphychidae						
Cheumatopsyche sp.	-	+++	-	-	+++	-
Helicopsyche sp.	+	+++	-	-	-	+
Molannidae						
Molanna sp.	-	-	-	-	-	+
ODONATES						
Gomphidae						
Anisogomphus sp.	+	-	-	-	-	+
Libellulidae						
Trithemis sp.	+	++	-	-	++	+
Lestidae						
Lestes sp.	+	-	++	-	+	+
HEMIPTERANS						
Naucoridae						
Naucoris sp.	+	-	-	-	-	+
Notonectidae						
Anisops sp.	-	-	-	-	-	+
Gerridae						
Gerris sp.	-	-	-	-	-	+
Rhagodotarsus sp.	-	-	-	-	-	+
Gyrinidae						
Aulonogyrus sp.	+	+	-	-	-	+
Dytiscidae						
Cybister sp.	+	-	-	-	-	-
LEPIDOPTERANS	+	+	-	-	-	-
DIPTERANS						
Simuliids	+	+	-	-	+	+
Chironomids	+	+	+++	+++	+	-
CNIDARIANS						
Hydra sp.	-	-	+++	+++	-	-
CRUSTACEANS						-
Crab	+	+	-	-	-	-
PLATYHELMINTHES						
Planarian	-	+	-	-	+++	-
MOLLUSKS	-	-	-	-	++	-
Generic richness	**13**	**13**	**03**	**03**	**07**	**15**
ASPT value	**6.8**	**7**	**3.5**	**2.5**	**4.57**	**8.2**

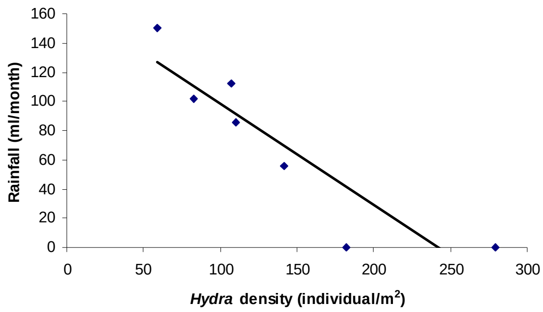

Figure 3.1 relationship between *Hydra* population density and monthly rainfall in the Ambewela reservoir in 2008 (r = 0.888).

3.2 Results of chemical monitoring

Table 3.2 some physio-chemical parameters of water at the study sites average for the enter study period (AL -Average for lake).

Water quality parameter	Site 1	Site 2	Site 3	Site 4	AL	Site 5
Water Temperature (ºC)	16.30	17.20	19.97	18.40	19.19	19.20
pH	7.06	6.83	7.36	6.56	6.96	6.30
DO (mg/l)	7.63	7.33	5.05	4.30	4.68	7.40
BOD (mg/l)	4.00	4.40	7.60	9.00	8.30	7.70
EC (mS/l)	32.90	28.80	26.66	28.20	27.43	35.57
Ammonia (mg/l)	0.10	0.07	0.20	0.25	0.23	0.20
Nitrite (mg/l)	0.09	0.10	0.11	0.12	0.12	0.01
Nitrate (mg/l)	0.96	1.00	0.50	1.35	0.92	1.528
Phosphate (mg/l)	0.04	0.03	0.05	0.75	0.40	1.067
Turbidity (NTU)	0.96	1.53	5.38	6.77	6.08	6.23
TSS (mg/l)	2.38	3.67	4.96	3.25	4.11	459.9
TDS (mg/l)	15.80	12.68	11.52	13.08	12.3	16.49
Chlorophyll- a content (mg/l)	8.10	8.45	21.28	10.99	16.135	-

The average values for some water quality parameters measured during the study period are given in table 3.2. The highest values for nitrite (0.12 mg/l), Chlorophyll-*a* content (21.28 µg/l), turbidity (6.77 NTU), ammonia (0.25 mg/l) and BOD (9.00 mg/l) were recorded at the reservoir sites where the lowest DO value (4.3 mg/l) was recorded. More down stream site studied at Agra valley recorded the highest values for EC (35.57 mS/l), nitrate (1.528 mg/l), phosphate (1.067 mg/l) and TSS (459.9 mg/l).

3.3 Identified causes for low down of ecological integrity

The identified causes for deterioration of ecological integrity of the study sites are given in table 3.3. According to table 3.3 it is clear that Ambewela reservoir area and the down stream studied are encountering more impacts that are leading to a rapid water quality depletion.

Table 3.3 identified causes for low down of ecological integrity of the Dambagastalawa micro-catchments during the study period (possible effects are given parentheses).

Identified causes	Study site				
	Site 1	Site 2	Site 3	Site 4	Site 5
Converting tea/grass land or forest area into annual crops (*soil erosion, high siltation and habitat loss*)	-	-	+++	+++	+++
Excessive use of agrochemicals and fertilizer (*loading of organic pollutants, heavy metals and other toxic compound*)	-	-	++	++	++

Adding of effluent from dairy farms and unwanted vegetable matters (*loading of organic substances in excess, harmful microbs and pathogen*)	-	-	+++	+++	++
Dumping waste due to eco-tourism (*loading bio and non bio degradable substance*)	+	+	+	-	+
Dumping waste/tea dust (*loading bio degradable substance*)	-	-	-	-	++
Sand mining (*habitat damage*)	-	-	-	-	+
Mixing of house hold sewage/drainage channel	-	-	-	-	+
Cleaning river bankers for crop farming (*eroding of bankers and soil erosion*)	-	--	+	+	+

(Severity: + low, ++ moderate and +++ high)

4. Discussion

The present study showed that few genera of Ephemeropterans, Plecopterans and Trichopterans (EPT) are predominately colonized in the upstream sties studied in the Dambagastalawa Oya micro-catchment. They are well known good water quality indicatives in tropical streams (Chessman, 1995). Due to presence of EPT insects, high generic richness and high ASPT values it is logical to conclude that the streams assessed are of good quality water as well as of good ecological integrity. This is in agreement with the results of parallel chemical monitoring studies since most of water quality parameters measured are within approval ranges for good quality water. However, the comparatively elevated level of nitrate at the site 2 (1.0 mg/l) might be due to decomposition of large amount of leaf debris as the stream flows through natural forest reserve and planted forest areas. At present these upstream sites are still not having any obvious impact to deplete sustainability except for non bio-degradable waste such as plastic containers and bottles that come through eco-tourism industry.

Nevertheless, the present bio- monitoring results showed a severe depletion in quality of water in Dambagastalawa Oya at its middle reaches where the river has given rise to the Ambewela reservoir. The reservoir sites recorded periodically intensified colonies of *Hydra* and a steady population of *Chironomid* larvae which taxa are among the well known indicatives of poor water quality (MaCafferty, 1981). This condition seems to be attributed by organic pollutants loading into the reservoir. According to the cause and effect studies (table 3.3), nearby dairies are critical problem to the reservoir as they bring plenty of organic waste due to intensified livestock rearing and the over wintering of animals in confined building, as well as the increased use of silage to feed them. The drainage canal systems of particular dairies directly connect to the reservoir and they transport plenty of unpleasant odor organic matters into the reservoir routinely. Of the waste effluents the silage seems to be a main contributor for its pollution condition as it can be 200 times as strong as settled sewages (Mason 1996[1]). In generally (see figure 2.3), when organic discharges load into a water body initially its oxygen level decreases and BOD level increases due to microbes activities to decompose the organic matter releasing large quantities of nitrates and phosphates that are stimulating massive algal growth (Mason 1996[1]). Therefore, it leads to increase BOD level, decrease DO and some deviation in other water quality parameter such as pH and conductivity from the accepted standards. Hence, decrease level of DO (4.30 mg/l), increase level of BOD (9.00 mg/l), nitrate (1.35 mg/l), phosphate (0.75 mg/l) and chlorophyll-*a* content (21.28 mg/l) in the reservoir sites are due to organic pollution. Above values exceed the meso-trophication indicative levels (Table 2.2).

In addition to animal farm wastes the Dambagastalawa catchments frequently encountered residues of different agrochemicals such as weedicides, fungicides, insecticides etc. that apply to potato, vegetables and flowering plants in the riparian areas. These probably increase level of toxic compound in water. In addition to agrochemicals, farmers constantly use crop manure in excess. This excess amount or sometimes all (if it is raining at the applying time) washed away into a nearby water bodies contributing to increased nutrient levels. The nitrogen and phosphorous are the two nutrients most implication in eutrophication (Mason 1996[1]). According to Mason (1996[2]) the most important sources of nutrients include phosphorous containing detergent, agricultural run-off and leaching of artificial fertilizers, the washing of manure from intensive farming units into water, the felling of forests which causes increasing erosion and run-off. The present study showed that the Ambewela reservoir is experiencing all these sources and have integrated to develop periodic eutrophic condition in the reservoir. Hence, the reason for huge colonies *Hydra* and *Chironomid* is obvious as the reservoir water does not get diluted in relative low rainy season and leads nutrient level to go up. The condition is favoured by *Hydra* and *Chironomid* build huge colonies that can live in extremely polluted waters (Dash 2001).

The pollution condition in downstream site studied is of significant as there was no any record of EPT insects except *Hydropsia* sp. which taxon has given low score in BMWP system. It means it is found in low quality waters. In addition to *Hydropsia* sp. some other poor quality indicative invertebrates such as Simuliid dipterans and Plannarians were also recorded. Most of them live in cases or possess external respiratory organs that are adaptive radiation to cope with rapid chemical environmental changes or rapid run off (Chessman 1995). Therefore, presence of large colonies of such invertebrates, relative low generic richness and relatively low ASPT value at the downstream site indicate lowering of water quality in the Dambagastalawa Oya at this reach too. The stream bed was of thick sediment layer of grass particles. This condition might be attributed to silage effluent encounters from Ambewela area. Although water gets diluted at this run, there is no sufficient purification process to bring river water into a good quality as the river encounter additional threats at this stretch. Furthermore, the landscape changes due to encroachment, illegal cultivation of tea and annual crops and converting of tea plantation into annual crop are attributing to elevated levels of turbidity, TSS and TDS due to high siltation. Thereby water becomes more turbid, unpleasant and undrinkable. Now it has already depleted the drinking and bathing water quality. Since the Dambagastalawa river catchment is a victim of several impacts returning to pristine conditions is a big challenge.

According to Dash (2001) the good quality water is highly significant to build sustainable aqua environments. If the catchments are facing chronic stress condition due to depletion of quality of water probably on organic pollution, it would cause hazards to human health, harm to living resources and ecological systems, damage to structure or amenity, or interference with legitimate uses of the environment. Since the studied catchment water is of significant use, it is extremely necessary bring the quality of water into a manageable level that depends on its local geology and ecosystem, as well as human uses. Therefore, action should be taken to protect geo-environment as well as to minimize the up loading of organic pollution from the reservoir area. Otherwise it will be a swerving menace to sustain good aqua environments in the Ambewela valley as well as Agra/Bopathtalawa valleys.

5. Conclusion

The uppermost reaches of the Kotmale river; the Dambagastalawa Oya micro-catchment is experiencing a severe water quality depletion trend clearly signifying eutrophic condition mainly on agricultural based activities. Therefore, actions should immediately be taken to bring the catchments into manageable levels. Otherwise we may face irreversible loss of sustainability of them with many adverse effects on water uses of downstream areas.

Acknowledgements

We are very thankful to all staff members of Environment Studies Division and Mr. Janaka P. Kumara of Inland Aquatic Resources and Aquaculture Division of NARA, Sri Lanka for their assistance given through out this research project.

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