Available online at www.sciencedirect.com

ScienceDirect

Procedia Food Science 6 (2016) 339 – 343

Procedia Food Science

International Conference of Sabaragamuwa University of Sri Lanka 2015 (ICSUSL 2015)

Impacts of agricultural practices on water quality in Uma Oya catchment area in Sri Lanka

W.D.T.M Gunawardhana[a], J.M.C.K Jayawardhana[a], E.P.N Udayakumara[a]

[a]*Department of Natural Resources, Faculty of Appied Sciences, Sabaragamuwa University f Sri Lanka*

Abstract

Sustainability of global food production is highly depending on the quality of the environment. In many parts of the world increase of agricultural production heavily depend on intensive agricultural practices which are having negative impact on the environment. The impacts of agricultural practices on surface water quality is given special attention currently since the safe and ample supply of freshwater is fundamental to humans and for the sustainability of ecosystem function. Intensive agricultural practices in river catchments often pose threat to the ecological integrity of river ecosystems. Uma Oya watershed in the upper Mahaweli watershed in Sri Lanka is an intensively cultivated landscape. In most parts of the catchment previously forested lands have been cleared and converted to agricultural lands. However, the empirical evidence on quantitative assessment of such land use conversion impacts on stream ecological health is lacking in the context of river catchments in Sri Lanka. Therefore the present study was aimed at evaluating the agricultural land use impacts on stream physical habitat quality, water quality and macroinvertebrate indices in the Uma Oya catchment at different spatial scales. The relationship between catchment and site scale % agricultural lands, water quality and macroinvertebrate indices were evaluated using univariate and multivariate approaches. The results indicated that stream physical habitat quality, water quality parameters and macroinvertebrate indices are significantly ($p<0.05$) affected by catchment scale % agricultural land cover. Among the water quality variables that were tested NO_2-N, NH_3-N, PO_4-P and BOD_5 level in sites with higher percentage of agricultural land cover exceeded the drinking water quality standards during dry season. PO_4-P and BOD_5 level in those sites exceeded the proposed ambient water quality standards for inland waters in Sri Lanka for aquatic life and for irrigation purposes. Findings of the present study suggest that catchment scale interventions are crucial for the management of Uma Oya watershed and for the improvement of water quality and sustainable agricultural production.

Peer-review under responsibility of International Conference of Sabaragamuwa University of Sri Lanka 2015 (ICSUSL 2015).

Keywords: Agricultural practices; water quality; physical habitat quality; macroinvertebrate indices

Peer-review under responsibility of International Conference of Sabaragamuwa University of Sri Lanka 2015 (ICSUSL 2015).
doi:10.1016/j.profoo.2016.02.068

1. Introduction

Sustainability of global food production is highly depending on the quality of the environment. The need for increased food production to cater to increasing human population is challenged by issues related to sustainability of the world’s ecosystems on which food production depends on. In many parts of the world increase of agricultural production heavily depend on intensive agricultural practices which are having negative impact on the environment. The impacts of agricultural practices on surface water quality is given worldwide attention currently since the safe and ample supply of freshwater is fundamental to humans and for the sustainability of ecosystem function.

The Upper Mahaweli watershed area in Sri Lanka has undergone considerable land cover changes during the last few decades due to the anthropogenic influences. In most parts of the previously forested catchment, areas have been continuously cleared and converted into agricultural lands. Intensive agricultural practices in steep slopes in the catchment have used extremely high levels of pesticides (insecticides and fungicides) and fertilizers in order to maintain high yields and profits[1]. Evaluation of such land conversion impacts on stream ecological integrity is important for taking decisions in catchment management and for the adoption of sustainable agricultural practices. The present study was conducted in Uma Oya (fig. 1) catchment in upper Mahaweli watershed in Sri Lanka with the aim of testing the agricultural land use impacts under different spatial scales on river health in terms of physical, chemical and biological quality.

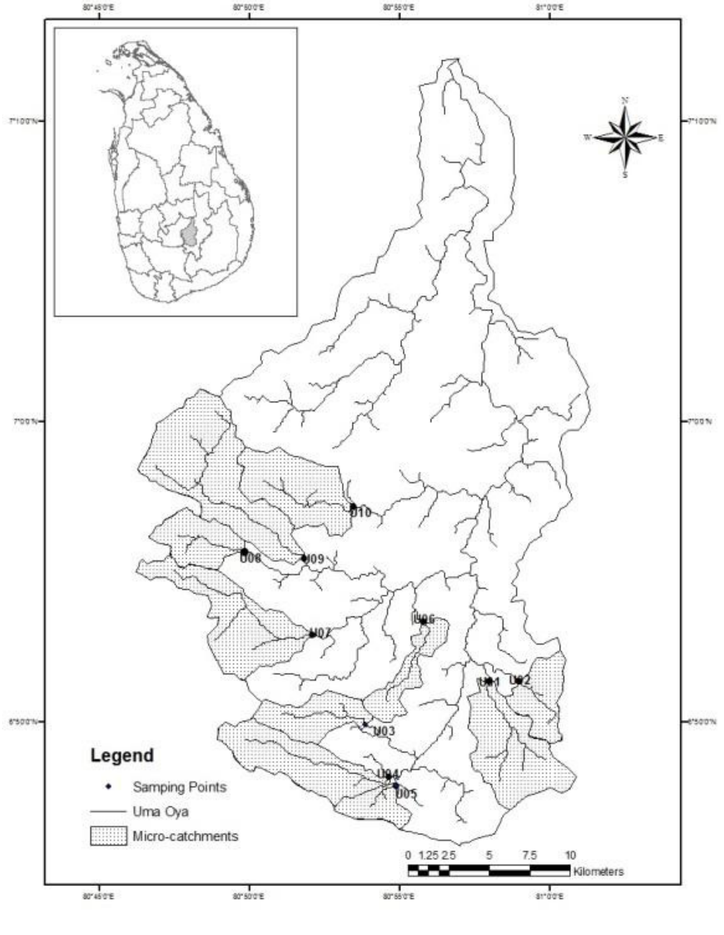

Fig.1. Sampling locations in the Uma Oya catchment

2. Methodology

Ten sub catchments within Uma Oya watershed with 2nd or 3rd order tributaries draining into Uma Oya were selected as sampling locations for the study (Fig. 1). The agricultural land percentages at catchment scale and site scale were evaluated by quantifying % of agricultural lands in whole sub-catchments and within riparian corridors extending 200m upstream of the sampling point (with 300 m lateral extension in each side) using Landsat TM Satellite images.

Water samples were collected monthly from 10 sampling locations covering10 sub catchments from August 2014 to January 2015. Electrical conductivity (EC), pH, temperature, Biochemical Oxygen Demand (BOD5), Total Dissolved Solids (TDS), Total Solids (TS), Total Suspended Solids (TSS) , Nitrite-N, Nitrate-N, Ammonia-N, Phosphate-P, Sulphate, Fluorite Iron, Magnisium and Sodium were measured following APHA (2005) procedures. Riparian Quality Index (RQI) and Channel Physical Habitat Quality Index (CQI) were developed for each sampling location to evaluate the riparian and channel habitat quality in each sampling reach using the criteria of Rapid Bio Assessment Protocols for use in streams and wadeable rivers [2].

Macroinvertebrate samples were collected from study stream reaches using a suber sampler in September (dry period) and December (rainy period) 2014 respectively. The macroinvertebrate families were identified and biotic indices such as family richness, % EPT taxa (Ephemeroptera: Plecoptera: Trichoptera), % Chironomids were calculated since they are universally used metrics to track water-quality changes effectively [3].

Standard Multiple Regression analysis was conducted in order to explore the effect of agricultural land impacts at catchment and site scale to channel physical habitat quality, water quality and macroinvertebrate indices. Principal Component Analysis (PCA) was also conducted in order to identify patterns of variation of sites based on stream physical habitat quality, water quality, and catchment land use at different spatial scales and in different seasons

3. Results and discussion

Results of the multiple regression analysis are presented in the Table 1. It indicated that % agricultural land cover was having a significant ($p<0.05$) negative impact on RQI, CQI and water quality. The increase of catchment scale % agricultural lands were having significant ($p<0.05$) negative impact on water quality by increasing the levels of temperature, TS, TDS, TSS, Conductivity, BOD_5, NO_3-N, NO_2-N, NH_3-N, Mg levels in stream.

Table.1 Regression coefficients (r^2) for significant ($p<0.05$) stream physical habitat quality index and water quality variables (n=60) for percentage agricultural land use categories in the micro catchments

	Spatial scale	**Physical Environment**		**Water quality**												**Macro-invertebrate Indices**	
		RQI	CQI	Temperature	pH	TS	TDS	TSS	Conductivity	BOD_5	NO_3-N	NO_2-N	NH_3-N	Cd	Mg	Taxa richness	Total abundance
% Agricultural lands	Model (r^2)	0.49	0.30	0.14	0.12	0.13	0.30	ns	0.25	ns	0.17	ns	ns	ns	0.17	0.50	0.41
	Catchment scale	-	- 0.42	0.41	- 0.29		0.51				0.26				0.39	- 0.70	- 0.70
	Site scale	- 0.49	- 0.23	ns	ns		ns		0.02		Ns	ns	ns	ns	ns	ns	ns

It also indicated the catchment scale % agricultural lands are having significant ($p<0.05$) negative effects on macroinvertebrate Family richness and Taxa abundance and no impact on % Chironomidae and % EPT at both spatial scales.

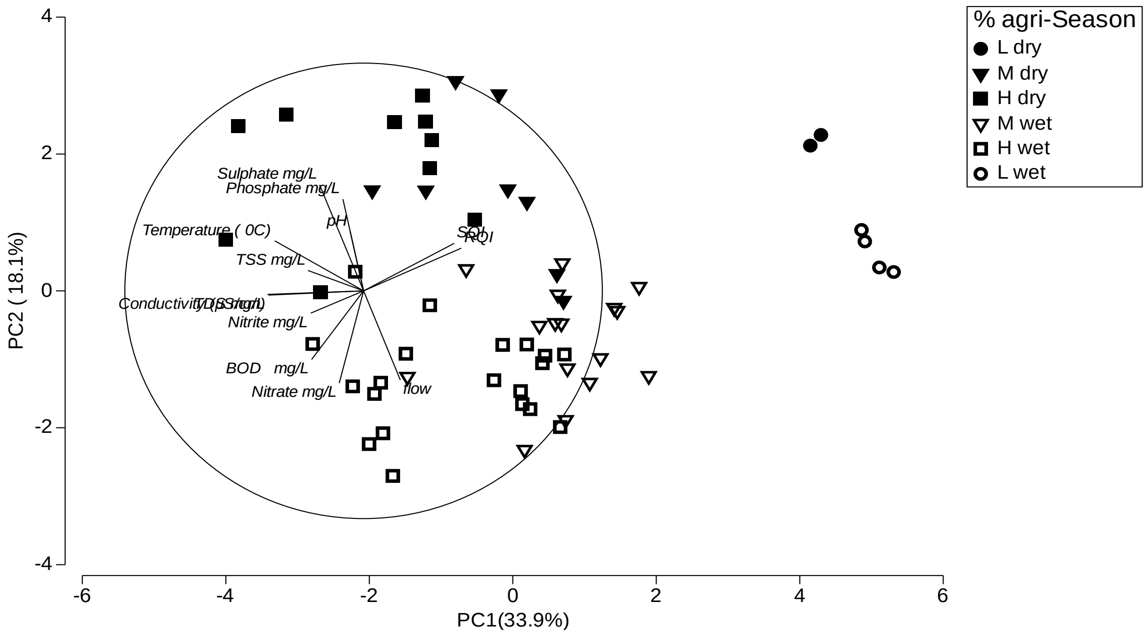

Fig. 2. PCA plot indicating site variation based on stream physical habitat and water quality (Thee letters in the legend indicate level of % agricultural land cover and corresponding season; % agricultural lands: L=Low; M=Medium; H=High; Season: W= Wet season; D= Dry season) (n=60)

PCA analysis of stream physical habitat, water quality and % agricultural land use is depicted in the figure 2. The PC axis 1 represented 33.9 % of the data variability. Vector loading to principal component axis indicated that SQI, RQI, TDS, temperature and conductivity are highly correlated with PC1 axis suggesting the main variables driving the separation of sites along the PC1 axis. Sites with low % agricultural land at both spatial scales were grouped together in the positive side of the PC1 and they were associated with improved RQI and CQI. Sites with higher % agricultural lands at both spatial scales were grouped in the negative side of the axis and they were associated with increased temperature, conductivity and TDS.

PC2 axis represented 18.2% of the data variability and parameters such as water flow, NO_3-N, PO_4-P and Sulphate were mainly responsible for the separation of sites along PC2. The separation of sites along the PC2 axis is mainly attributed to the seasonal effects.

Physical habitat and water quality of streams are often related to processes that occur across the terrestrial landscape. The magnitude of these land use impacts on stream health may depend upon the spatial scale that they are measured[4]. Results of the present study indicated that % agricultural lands at catchment scale negatively affect the water quality and stream habitat quality. Among the water quality variable that were tested NO_2-N, NH_3-N, PO_4-P and BOD_5 level in sites with higher percentage of agricultural land cover exceeded the drinking water quality standards during dry season rather than the wet season. Further, PO_4-P and BOD_5 level in those sites exceeded the proposed ambient water quality standards for inland waters in Sri Lanka for aquatic life and for irrigation purposes. During the dry period, agricultural practices were predominantly conducted using irrigated water and runoff from the crop lands carry high amount of sediments from land preparation activities, fertilizer, residues of pesticides, herbicides, and ions contributing to deteriorated water quality. The low flow of the streams during the dry period may also contribute to the concentration of nutrients and ions in those sites during dry period. During the rainy period a substantial amount of organic loads, nutrients such as NO_2-N enters the streams from the agricultural lands and lack of riparian cover along the streams in agricultural areas may have further enhanced the deterioration of water quality and these may lead to arising various environmental and health issues that resulted from exceeding ambient water quality standards.

Macroinvertebrate biotic indices reflect long-term impacts to stream health hence these indices are essential to have holistic view of the ecological integrity of streams impacted by catchment disturbances[5]. CQI reflects the habitat diversity within channels and improved habitat diversity within channel support divers communities and increased the species richness[2]. The present study indicated that % agricultural lands deteriorate the riparian vegetation and channel quality as reflected in the reduced RQI and CQI. Increased sedimentation of riverbed, water flow regulation impacts may have contributed to reduced channel quality Index and habitat diversity for biota in study stream reaches. It is possible that lowered macroinvertebrate family richness and abundance values reported in agricultural sites may have attributed to the degraded habitat quality and water quality associated with sites with higher agricultural practices.

The findings of the present study indicated that increase of % agricultural lands negatively affect the stream ecological integrity and water quality of the study catchment. Mechanisms such as better soil management practices in agriculture, forest cover restoration projects, riparian vegetation and channel quality restoration efforts are some of the essential steps needed to upgrade the stream ecological health in the Uma Oya catchment. Such catchment management efforts are essential for the sustainability of agricultural production and preservation of water quality in the study catchment.

Acknowledgements

Authors acknowledge the National Research Council of Sri Lanka Grant No.13-160 for funding the research.

References

1. Bandara. DGVL , Thiruchelvam S. Factors affecting the choice of soil conservation practices adopted by potato farmers in Nuwara Eliya district, Sri Lanka, *Tropical Agricultural Research and Extension*. 2008;11:49-54.
2. Barbour. MTJ, Gerritsen BD, Snyder ,Stribling. JB, Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: *Periphyton, Benthic Macroinveretebrates and Fish*, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water, Washington, D.C; 1999.
3. Wallace. JBJW, Grubaugh.,Whiles MR. Biotic indices and stream ecosystem processes: results from an experimental study. Ecological applications. 1996; p. 140-151.
4. Sponseller RE, Benfield, Valett. H. Relationships between land use, spatial scale and stream macroinvertebrate communities. *Freshwater Biology*. 2001; 46(10):1409-1424.
5. Kroll. SA, Llacer CN, de la Cruz Cano.M. & de las HerasIbáñez. J. The influence of land use on water quality and macroinvertebrate biotic indices in rivers within Castilla-La Mancha (Spain). Limnetica. 2009; 28(2):203-214.