Runoff Nitrogen Speciation and Concentration Dynamics from Agricultural Fields to Indian River Lagoon

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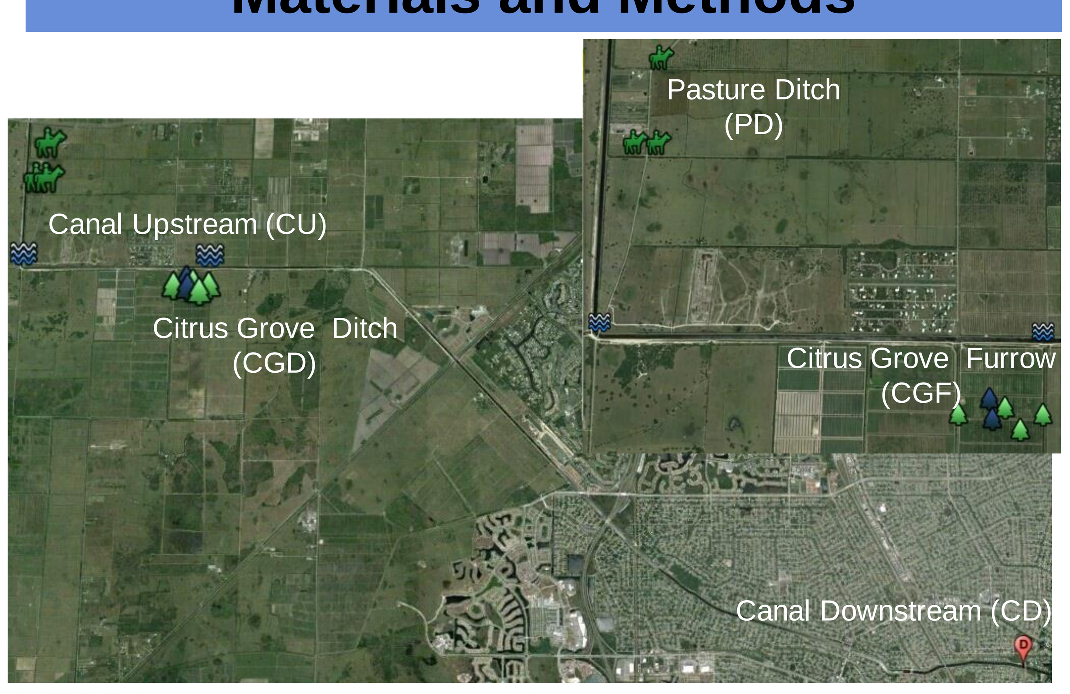
Introduction

Eutrophication of Indian River Lagoon (IRL) has been a major public concern in the last decade. The acceleration of water quality degradation is suspected to associate with nitrogen (N) in Stormwater from agricultural fields and urban area. Especially during the rainy season, increased runoff water carries N and other nutrients from agricultural fields to the surface water systems. Nitrogen in runoff water may consist of different forms including organic N (ON), Dissolved N (DN), particulate N (PN), NH_4-N and NO_3-N. Not all the forms are equally available to plants including algae. In addition, waterway biology and chemistry affect the speciation and bioavailability of nitrogen. St. Lucie Estuary Restoration program has proposed a target of 30% reductions in total N input (Chamberlain and Hayward, 1996). Therefore, an understanding of nitrogen speciation and concentration dynamics in runoff waters from agricultural fields to discharge points is important to develop best management practices (BMPs) in south Florida.

Objectives

To determine the bioavailability change of N in stormwater during the transport from its origin to destination and to relate N bioavailability to speciation dynamics and other water quality parameters.

Materials and Methods



Water samples were monthly collected from 12 sites from fields-Citrus Grove Furrow (CGF), waterways-Citrus Grove Ditch (GCD), Pasture Ditch (PD) and Canal Upstream (CU) to the Discharge point- Lower part of the Canal Downstream(CD) during the 04/2013 to 03/2014 period.

Subsamples of water were filtered through 0.45 µm membrane filter for measuring concentrations of NH_4-N, NO_3-N and total Kjeldahl N (TKN). Both unfiltered and filtered TKN samples were digested with acidified cupric sulfate and potassium sulfate before being analyzed. NH_4-N, NO_3-N and TKN were analyzed by using a discrete auto-analyzer (EasyChem, Systea Scientific, Italy) following EPA methods (EPA 350.1, EPA 353.2 and EPA 351.3 respectively)

TN = unfiltered TKN + NO_3-N

PN = unfiltered TKN - filtered TKN

ON = unfiltered TKN - NH_4-N

DN = filtered TKN + NO_3-N

Statistical method: One-way ANOVAs with LSD and Pearson's correlation coefficient were performed by SPSS18.0 software package (SPSS, Chicago, IL, USA)

Results and Discussion

Table 1, Physical properties of water samples at different sites

	pH	EC (µS cm^{-1})	Turbidity (NTU)	Solids (mg L^{-1})
CGD	7.2±0.5b	976±391b	4.2±3.8b	24.9±13.3a
PD	7.6±0.9a	1115±546b	3.5±3.0b	23.4±14.9ab
CU	7.7±1.0a	1242±594b	3.7±3.2b	20.2±14.4ab
CD	7.8±1.1a	4335±1666a	2.5±3.0b	26.9±15.1ab
CGF	6.9±1.2c	588±1545b	6.7±3.7a	17.5±14.7b

Mean values followed by different letters within the same column are significantly different at *P*<0.05

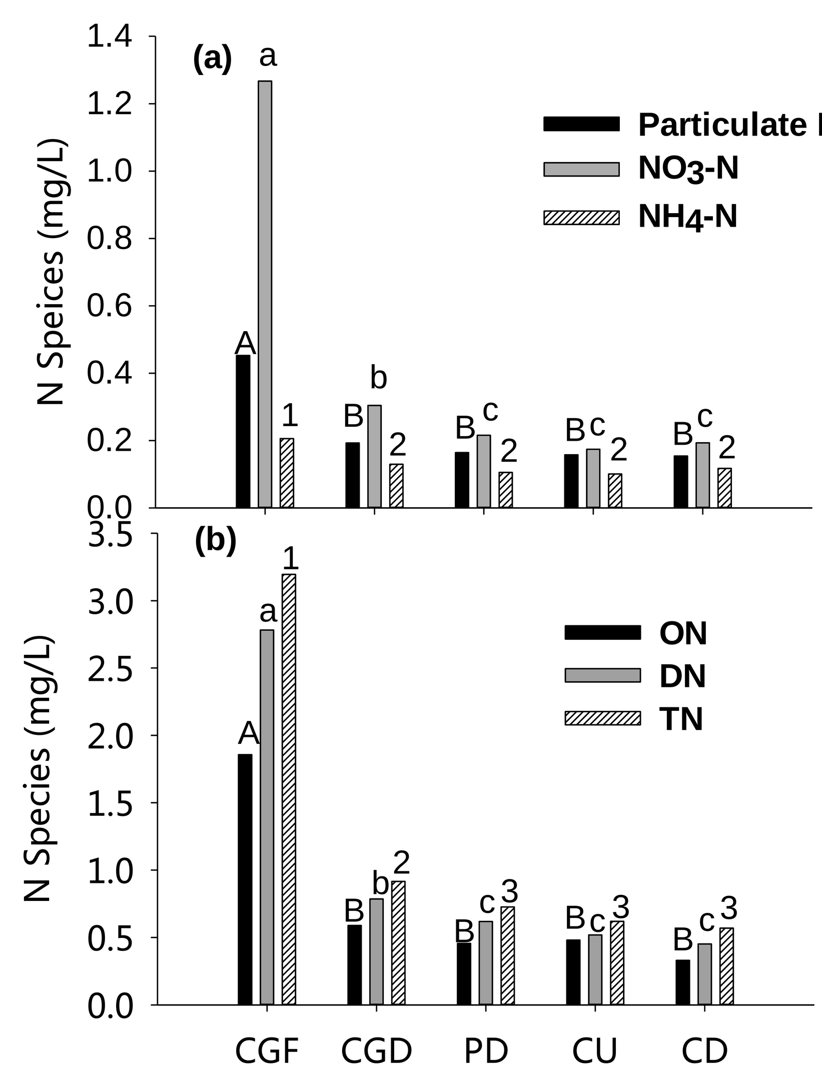


Fig. 1 N species concentrations in water samples from different sampling sites. Different letters and numbers indicate significant differences among the N species concentrations (one-way ANOVA, P<0.05)

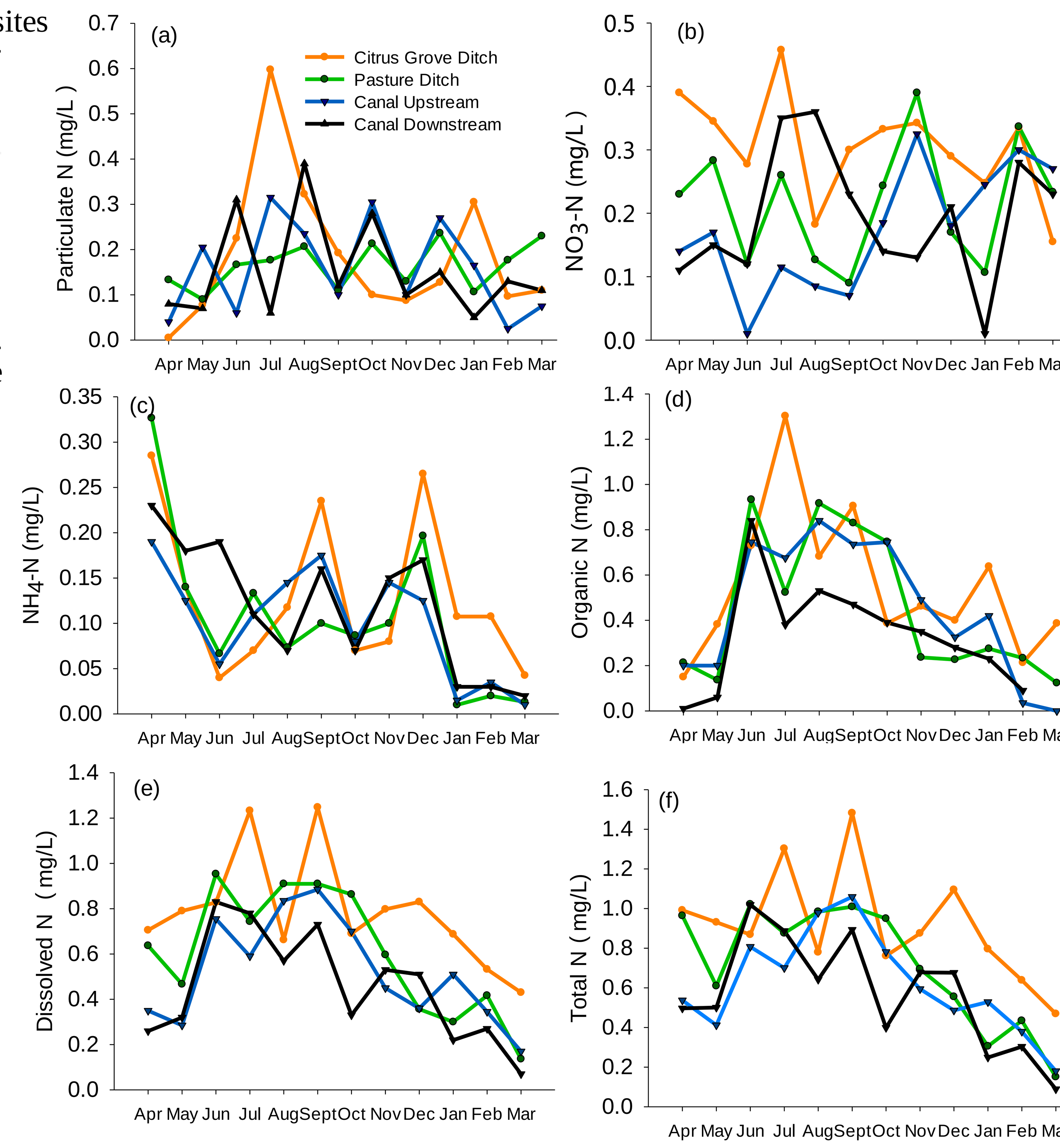


Fig.2 Monthly change of N species at different sites

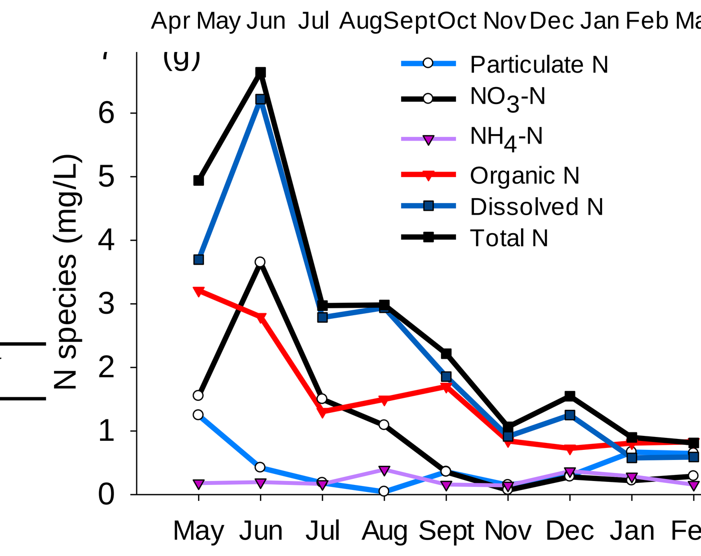


Table 2 Correlations between water physical properties and N species at Ditch and Canal sites

	PN	NO_3	NH_4	ON	DN	TN
PN						
NO_3	.091					
NH_4	-.116	.084				
ON	.585**	-.034	-.089			
DN	.214*	.328**	.246**	.805**		
TN	.165	.316**	.471**	.708**	.971**	1
pH	.108	-.164	-.204*	-.044	-.211*	-.241**
EC	-.166	-.124	.159	-.330**	-.308**	-.241**
Tu§	.082	-.047	.111	.204*	.202*	.211*
So§	-.174	.204*	.229*	-.370**	-.173	-.097

Table 3 Correlations between water physical properties and N species at Furrow sites

	PN	NO_3-N	ON	DN	TN
PN					
NO_3-N	-.134				
ON	.621**	.153			
DN	-.068	.932**	.435*		
TN	.165	.884**	.575**	.974**	
pH	-.100	.488**	.235	.515**	.479**
EC	.285	.184	.653**	.356	.400*
Tu§	.780**	-.027	.414*	-.012	.162

* and ** indicate significant correlation at P< 0.05 and P<0.01 level, respectively

§ Tu and So represent Turbidity and Solid

- The concentration of N species in water samples from 12 sites increased in the following sequence: PN<NH_4-N<NO_3-N<ON<DN<TN (Fig. 1). All N species showed their highest value at the furrow sites. For PN, NH_4-N and ON, their concentrations showed no significant difference from ditch sites to Canal Downstream. For NO_3-N, ON and TN, their concentrations showed higher values at citrus grove ditch than other non ditch and canal sites (Fig. 1). NO_3-N conc. at all ditch and canal sites ranged from 0.07 to 0.47 mg/L, much higher than the reference condition for surface water (0.015 mg/L)(EPA). Mean TN conc. at all the sites were between 0.57 to 1.10 mg/L. Only the data from Citrus Grove sites exceeded the reference condition for surface water (0.74 mg/L). 79-88% of TN is in dissolved form. They are highly available to plant and microorganisms. The percentage of PN, NH_4-N and NO_3-N in TN were 19-33%, 12-20% and 28-41% respectively. NO_3-N had a significant positive relationship with DN and TN (Table 2).
- Different N species varied differently in the period (Fig. 2). Even the same N, they showed different temporal variations at different sites. PN was highest in Citrus Grove Dutch while it was much lower at the Canal Downstream in July (Fig. 2a). NO_3-N values in Pasture and Canal Upstream varied in a similar trend (Fig. 2b). NH_4-N values in Citrus Grove and Pasture ditches showed a similar variation pattern (Fig. 2c). ON values in Pasture and Canal downstream changed similarly (Fig. 2d). DN and ON changed in the same way at all sites (Fig. 2e, 2f, 2g) . In Citrus Grove Furrow, ON and PN reached the highest value in May, NO_3-N, DN and TN reached the highest value in June (Fig. 2g) .
- Only at ditch and canal sites, NH_4-N correlated with DN, TN, solid and pH (Table 3); PN correlated with DN; DN correlated with EC and turbidity and NH_4-N and ON correlated with Solid. Only in furrow, pH correlated with NO_3-N and Solid correlated with PN. A positive relationship existed among ON,TN and DN

Conclusions

Nitrogen concentration decreased from furrow sites to ditch sites, but their values were not significantly different in pasture ditches and canal.

Different N species showed different spatial variation pattern and they correlated with different water physical properties.

References

Chamberlain, R. and Hayward, D. (1996), Evaluation of Water Quality And Monitoring in the St. Lucie Estuary, Florida. Journal of the American Water Resources Association, 32: 681–696.

EPA, (2000), Ambient Water Quality Criteria Recommendations, Rivers and Streams in Nutrient Ecoregion XII, United States Environmental Protection Agency, EPA 822-B-00-021,