Mass Balance Models of Phosphorus and Nitrogen in Sediments and Water of the Lower Reaches of Tamiraparani River System

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Nutrient circulation through the global environment has grown dramatically (Vitousek, 1997). Delivery of water through rivers to receiving systems has increased greatly in the last half of the 20th century (Howarth, 1996). Natural and cultural sources of nutrients and their subsequent transformations influence the amount of their Wetlands serve as sinks, sources, or transformers of many inorganic and organic chemicals, including those of ecological and socio-economic importance such as nitrogen and phosphorus, carbon, sulfur, iron, and manganese. Measurement of concentrations of certain chemical substrates can provide rapid and inexpensive indicators of the rates of those processes. Simple measurements of biogeochemical processes within a wetland could serve as efficient indicators to infer on its environmental condition and surrounding landscape.

KEY WORDS: Nutrients, Wetlands, Nitrogen, Phosphorous, Concentrations, Biogeochemical Process.

1. INTRODUCTION

Wetlands are a key component of the landscape. Wetlands tend to occupy topographic low points in the landscape and are thus recipient of water and eroded materials from higher in the landscape. The influx of water and other materials gives each wetland its character, supports its internal processes, and in part determines wetland function and value (Kent, 2001). The importance of including all ecosystem service availability or nutrient-limiting conditions furthest from input points. Between these two extremes, there exists a gradient in quality and quantity of organic matter, nutrient accumulation, microbial and macrobiotic communities, composition, and biogeochemical cycles.

Nutrients: Water column nutrient concentrations are often used as indicators in aquatic systems and are useful indicators for determining downstream effects of impacted wetlands. Hydrologic inputs, nutrient concentrations in the water column of wetlands can change rapidly and can be highly variable. As water column nutrients are in direct contact with the microbial communities associated with periphyton, plant detritus, and soils, they change the composition and activities of these ecosystem communities. In most of the developed world, nutrients are major water pollutants (Smith, 2003).

Nitrogen flux in streams and rivers of any size is the cumulative result of processes that control the supply and transport of nitrogen in terrestrial and aquatic ecosystems. Nitrates are highly soluble and are transported easily in water, influenced by hydrological processes including flow paths and residence times of water throughout the watershed (Band, 2001).

Study Area: A preliminary survey of all the Tamiraparani river wetlands was carried out to have an assessment of the geographical characteristics of the wetlands, the factors which may influence water quality in the wetlands, the land use activities, wildlife, fisheries and anthropogenic activities. Tamiraparani is the most important perennial river among the 33 rivers in Tamilnadu. Tamiraparani river originates from the peak of Periyapothigai hill in the Western Ghats above Papanasam in the Ambasamudram Taluk. The river traverses irunelveliT and Thoothukudi districts before joining the Gulf of Mannar. It runs about 120 km traversing for about 80 km including 24 km in hills in Tirunelveli District and for about 40 km in Tuticorin district. It forms a delta in Punnakayal village before discharging into the Bay of Bengal. The delta is 140.93km^2 in area. Up to the hill slopes, the river flows with high velocity and then flows gently as it meanders up to the end of Tirunelveli district. River flows are highly modified through the presence of 8 headwater dams / *anicuts* and 11 main channel weirs. At a number of stations the seasonality of flows has also been affected with a distinct shift in seasonal flow peaks relating to irrigation diversions. The *anicuts*, canals and numerous small flood structures provide important habitats for plants, invertebrates, fishes and wildlife. When it reaches Thoothukudi, the plain. In the upstream area, the water users get unrestricted water and so the storage necessity is low. So the wetlands sizes are very minimum. As we go downstream, the flow needs to be regulated and so the check dams and the volume of wetlands need to be large enough. Tail end users are the most affected because of water scarcity and also the available water.

2. MATERIALS AND METHODS

Based on existing knowledge, Cetin (2001), created the model WETMOD capable of simulation scenarios of management drying cycles for selected wetlands. The WETMOD model (Cetin, 2001) is a generic wetland ecosystem model. Changes in the wetlands nutrient load is mostly the function of the ecosystem processing over the total available quantity of the nutrients in the wetland. So we supposed that the relationship is a simple equation. The bi-directional exchange between the wetland and the river $\Delta N_R/\Delta t$ [mg Day^{-1}] is computed as;

$$\Delta N_R/\Delta t = (C_R - C_W)\, f * R$$

Where, ΔN_R = Difference in concentration of nutrient; Δt = Calculation period; C_R = Concentration of nutrient in the river; C_W = Concentration of nutrient in the wetland; f = Flow rate for the individual wetland (fraction of canal flow); R = River flow rate.

When modeling, factor f is varied and the model performance with respect nitrate and phosphate can be tested.

The index D is derived as, $D = \Sigma$ (ABS) (M-E) / Σ E

M = modeled PO_4^-P or NO_3^-N values and E = measured or expected PO_4^- - P or NO_3^-- N values at the monitoring dates.

3. RESULTS AND DISCUSSION

The effect of nutrient retention or release by the three wetlands, Seidunganallur, Velloorkulam and Kadambakulam has been analysed using regular sampling and using mass balance approach. In our study, the total nitrate and phosphate transported from the river water through Marudur Melakkal canal in 2007 was 4408.1 kg and 4750.1 kg respectively and in 2008 it was 4321.6 kg nitrate and 6450.9 kg phosphate. The total quantity of nitrate and phosphate in the surface water of Tamiraparani through Srivaikundam South Main canal during 2007 was 10905.6 kg and 9341.4 kg respectively. Kadambakulam wetlands received 80% of the water and so the quantity of nitrate and phosphate received was 8724.5 kg and 7473.2 kg respectively.

Water quality characteristics of Lower Reaches of Tamiraparani River and its Wetlands: During the present study, the surface water pH varied from 6.4 to 7.7. Comparatively higher pH values were obtained in Kadambakulam wetlands during Oct 2007. The value of pH did not show much seasonal variation. It varied from 6.4 to 7.4 at Seidunganallur, at Velloorkulam from 6.5 to 7.6 and from 6.4 to 7.4 at Kadambakulam wetland. This narrow range pH may be due to the buffering capacity of the aquatic system.

Nutrient Concentration: In Melakkal Canal water the maximum nitrate concentration was found to be 5.7 mgL^{-1} and minimum 1.1 mgL^{-1} during the study period 2007-08. For Seidunganallur, it was 6.1 mgL^{-1} and 0.8 mgL^{-1} and for Velloorkulam, it was 6.6 mgL^{-1} and 0.1 mgL^{-1} during 2007 and 2008. Similarly, the maximum phosphate concentration for Melakkal Canal was found to be 8.5 mgL^{-1} and minimum 1.1 mgL^{-1} For Seidunganallur wetland, it was 5.4 mgL^{-1} and 1.0 mgL^{-1} the maximum and minimum respectively and for Velloorlkulam it was 5.2 mgL^{-1} and 0.6 mgL^{-1}. In the Marudur-Seidunganallur wetland system, the nitrate concentration in the canal inflow was found to be sinusoidal during 2007 and pulsating with an annual variation in 2008. During March and April of 2007 and 2008, the phosphate values were found to be low 0.6 and 2.3 mgL^{-1}. The relative behavior of the wetland is whether it is flow dependent or nutrient concentration dependent. Considering the Marudur wetland system, during 2008, the nutrient concentration in inflow was characterized by a sharp nitrate concentration peak of 1.1 mgL^{-1} in June to 5.7 mgL^{-1} in August 2008. The initial peak nitrate concentration diminished slightly from 3.2 to 2.8 mgL^{-1} and again the peak concentration diminished from 4.9 to 1.0 mgL^{-1}. The same effects were also observed and documented by (Tate, 2000; Gannon, 2005).

Due to the combination of dilution and flushing effects and fluctuations in inflow rates, the concentration of nutrients in sediments and surface waters varied extensively. In Srivaikundam – Kadambakulam wetland system, the fluctuation in the nutrients concentration was minimum throughout the period except May and October 2008. Soil phosphate concentration ranged between 4.05 mgL^{-1} and 8.0 mgL^{-1} and nitrate concentration between 6.7 mgL^{-1} and 1.7 mgL^{-1}. Phosphate concentration to the Kadambakulam wetland seemed to be high throughout the study period and may be due to the runoff from the agricultural lands fed by Marudur Melakkal system.

Water Flow: In the two years of study period, the water storage in the wetland system fluctuated almost daily. This corresponds to a pulse of nutrients driven in or out of the wetland with respect to the velocity of water flowing in to the wetland. In Marudur wetland systems, twice the water flow was stopped rendering the wetland completely dry and then rose, filling the wetland once again. During the study period, Seidunganallur wetland experienced the flow variation on three occasions. It is obvious from the data, that the Kadambakulam wetland remained flooded for 330 days out of 365 days in both the years of 2007 and 2008. However the flow was comparatively low during March, May-September and high in January, February, April, October-December 2007 and again low in March, April, July – September and high in January, February, May, October-December of 2008.August 2008. In Srivaikundam SMC canal, monthly discharge ranged from 78 to 591 m^3 during 2007 and 102 to 550 m^3 in 2008. Here peak flow, 662m^3 occurred during November 2007 and 550 m^3 during February 2008. In 2007, the flow rate slowly and steadily declined from a peak of 591m^3 in November to base flow condition of nil in August 2008. Inflows are ~10 times larger during the south-west monsoon than in summer. This leads to shift in wetlands flushing regime. During summer the exchange flows become the dominant flushing mechanism. During the monitoring period, no flow condition was experienced by the Seidunganallur and Velloorkulam wetlands for thrice, from April 2007 to June 2007, September 2007 and in August 2008. Kadambakulam did not face no flow condition throughout the study period. High flow continued from November to February in all the wetlands. The first part of the period may be to fill the wetlands by the seasonal rain water and the second half for the downstream agricultural requirement. Reflooding happened in Seidunganallur and Velloorkulam.

To conclude, the relative concentration of nutrients shows the exchange rate between the canal and the wetlands; and the pulsation trend state the dynamic behavior of surface waters. The relative load of the nutrients enter through the canal into the wetland show the cyclic behavior of the wetland whether it is flow dependent or nutrient concentration dependent.

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