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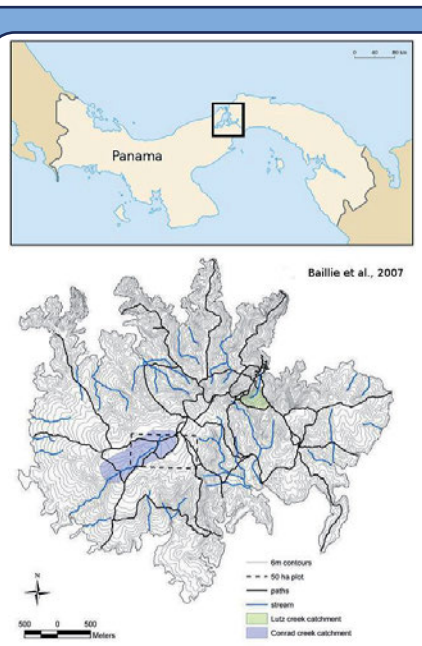
Throughfall as source and runoff transport of particular and dissolved reactive phosphorus in a tropical rainforest in central Panama

Anne Hartmann; person in support: Alexander Zimmermann

Introduction

- Phosphorus (P) is an important and limiting element for many biogeochemical processes
- P is transported in soluble and particulate forms
- study will concentrate on particulate phosphorus (PP) and dissolved reactive phosphorus (DRP) within a catchment in Panama
- characteristics of nutrient runoff are quite complex
- only a few studies have been undertaken to investigate P dynamics in tropical rainforest catchments
- suspended sediments concentration (SSC) and PP load are directly related

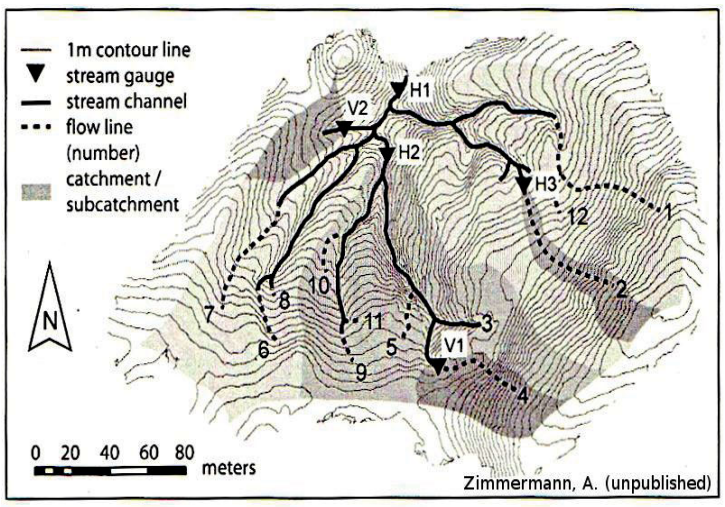


Study site

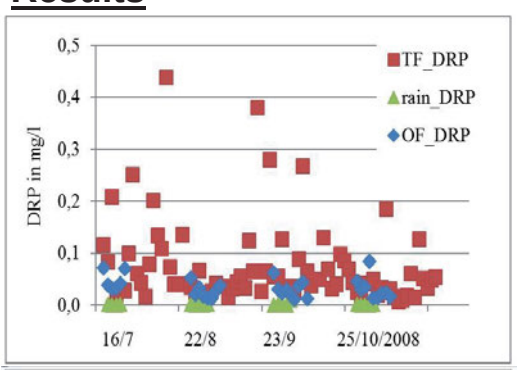
- 3.3 ha large Lutz Creek catchment (LC) on Barro Colorado Island (BCI), Panama
- climate is tropical, distinct wet and dry seasons
- total annual rainfall average: 2623 ± 458 mm
- steep slopes and the Caimito marine parent material in LC result in shallow and mottled clays
- all soils are fine textured
- total P in the surface soils ranges from 315 to 1114 mg $P*kg^{-1}$, amounts are declining with depth

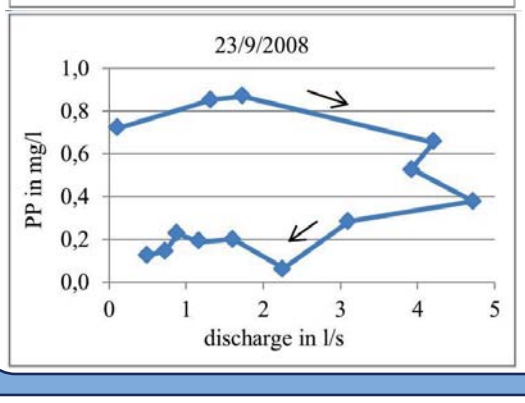
Methods

- in LC five measurement sites are permanently equipped with H- and V-flumes
- for this study data from H1 (catchment outlet) and from H3, which solely receives overland flow, were used
- water levels were recorded with a bubbler flow module to provide data to calculate discharge
- an Isco 6712 was used to take automatic water samples during rain events
- water samples were filtered and several P fractions were analyzed in Panama City
- precipitation was automatically measured with two Hobo tipping bucket rain gauges which have been installed 250 m away from H1 on a forest-free court
- this study investigated four events taking place in the rain season in the year 2008
- for analyzing the data Microsoft Excel 2010 was used



Results

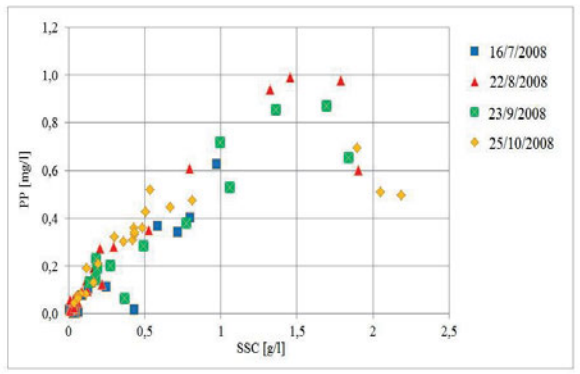




- throughfall (TF) water shows highest DRP concentration compared to rain water and runoff
- rain and thus TF water is connected with a peak of DRP concentration in the overland flow (OF)
- TP concentrations compose in average of 80 % PP at the catchment outlet
- plots of discharge against PP show clockwise hysteresis effects
- PP concentrations peak prior to discharge

Discussion

- water accumulates DRP probably by a leaching process from the leaves of trees and soils absorbed DRP
- leaching is most pronounced for highly soluble or not resorbed nutrients
- the clockwise hysteresis effects suggests a relation between SSC and PP which has been proved in many studies



- until SSC of about 1.5 g/l PP concentrations increase up to nearly 1 mg/l
- with further SSC increasing PP concentrations decrease
- one probably reason to explain this: Coarser particle add weight but relatively decrease P content compared to finer particles

Conclusion and outlook

- P dynamics in tropical rainforest catchments are influenced by several different processes
- leaching processes from the leaves of trees seem to be a major source of DRP
- PP dynamics are strongly connected to suspended sediments
- another factor influencing the amount of PP in runoff seems to be the grain size of suspended sediments
- for better understanding of these phosphorus dynamics further research in tropical rainforest catchments is necessary

References

Andrieux-Loyer F and Aminot A, 2001. *Phosphorus Forms Related to Sediment Grain Size and GeochemicalCharacteristics in French Coastal Areas*. Estuarine, Coastal and Shelf Science No. 52(5), pp. 617-629

Aström M, Aaltonen E K, Koivusaari J, 2004. *Changes in leaching patters on nitrogen and phosphorus after artificial drainage of boreal forest- a paired catchment study in Lappajärvi, western Finland*. Boreal Environment Research 10, pp. 67-78

Campo J, Maass M, Jarumillo V J, Martínez-Yrízar A, Sarukhá J, 2001. *Phosphorus cycling in a Mexican tropical dry forest ecosystem*. Biogeochemestry 53, pp.161-179

lpg=PA193&dq=throughfall+phosphorus&source=bl&ots=q_NhnJ0AVt&sig=cKbo_Pbb0O8GEpAO_TmLM8gpVrU&hl=de&ei=f6wuTvnsMtSk-l2ojLDg&sa=X&oi=book_result&ct=result&resnum=10&ved=0CGo Q6AEwCQ#v=onepage&q=throughfall%20phosphorus&f=false

Collison A J C, 2001. *The cycle of instability: stress release and fissure flow as controls on gully head retreat*. DOI: 10.1002/hyp.150

Croat T B, 1978. *Flora of Barro Colorado Island*. *Stanford University Press*, p. 5. Available at: http://books.google.de/books?hl=de&lr=&id=Whc_ahfhFFoC&oi=fnd&pg=PA1&dq=Flora+of+Barro+Colorado +Island&ots=VnoQzWKoPy&sig=cvYis1t7778-YS6Ztm5CyOAql2c#v=onepage&q&f=false

Dieter, D., Elsenbeer, H., Turner, B.L., 2010. *Phosphorus fractionation in lowland tropical rainforest soils in central Panama*. Catena 82, 118–125, doi:10.1016/j.catena.2010.05.010.

Dietrich, W.E., Windsor, D.M., Dunne, T., 1982. *Geology, Climate, and Hydrology of Barro Colorado Island*, in: Leigh, E.G., Rand, S.A., Windsor, D.M. (Eds.), The Ecology of a Tropical Forest: Seasonal Rhythms and Long Term Changes. Smithsonian Institution, Washington DC., pp. 21–46.

Foster RB, Brokaw NVL, 1982. *Structure and history of the vegetation of Barro Colorado Island*. In: Leigh EG, Rand AS, Windsor DM. 1982 *The Ecology of a Tropical Forest: Seasonal Rhythms and Long Term Changes*. Smithsonian Institution Press, Washington DC, pp. 67-81

Fox, L.E. 1989.*Amodel for inorganic control of phosphate concentra tions in river waters*. Geochim. Cosmochim. Acta 53:417–428.

Froelich, P N, 1988. *Kinetic control of dissolved phosphate in natural rivers and estuaries: A primer on the phosphate buffer mechanism*. Limnol. Ocean. 33(4) 649-668.

Garbrecht J, Sharpley A N, 1992. Sediment-Phosphorus Relationships in Watersheds, U.S. Department for Agriculture, Agricultural Research service Durant, USA, 5th International Symposium on River Sedimentation, Karlsruhe, pp. 54-63

Godsey S, Elsenbeer H, Stallard R, 2004. *Overland flow generation in two lithologically distinct rainforest catchments*. Journal of Hydrology 295, pp. 276-290

Grimm, R., Behrens, T., Märker, M., Elsenbeer, H., 2008. *Soil organic carbon concentrations and stocks on Barro Colorado Island – Digital soil mapping using Random Forests analysis*. Geoderma 146, 102–113, doi: 10.1016/j.geoderma.2008.05.008.

Hejduk L, 2011. *Suspended sediment and phosphorus relations during floods in a small lowland catchment*. Geophysical Research Abstracts Vol. 13, EGU2011-9352

Hornbeck JW, Bailey SW, Buso DC, Shanley JB. 1997. *Streamwater chemistry and nutrient budgets for forested watersheds in New England: variability and management implications*. Forest Ecology and Management 93: 73–89.

Jahnke R A, 1992. *The Phosphorus Cycle*. In: *Global Biogeochemical Cycles*, edited by S. S. Butcher, et al., pp. 301–315. San Diego: Academic Press

Kenoyer, L.A., 1929. *General and successional ecology of the lower tropical rain-forest at Barro Colorado Island, Panama*. Ecology 10, 201–222.

Maguire, R.O., A.C. Edwards, and M.J. Wilson. 1998. *Influence of cultivation on the distribution of phosphorus in three soils from NE Scotland and their aggregate size fractions*. Soil Use Man age. 14:147–153.

McDowell R, Sharpley A, Folmar G, 2001. *Landscape and Watershed Processes- Phosphorus Export from an Agricultural Watershed:Linking Source and Transport Mechanisms*. Published in J. Environ. Qual. 30:1587–1595

Neal C, Reynolds B, Neal M, Hughes S, Wickham H, Hill L, Rowland P, Pugh B, 2003. *Soluble reactive phosphorus levels in rainfall, cloud water, throughfall, stemflow, soil waters, stream waters and groundwaters for the Upper River Severn area, Plynlimon, mid Wales*. *Science of the Total Environment*, Volume: 314-316, pp. 99-120

Neill C, Deegan L A,Thomas S M, Haupert C L, Krusche A V, M. Ballester V M, Victoria R L, 2006. *Deforestation alters the hydraulic and biogeochemical characteristics of small lowland Amazonian streams*. Hydrol. Process. 20, 2563–2580. doi: 10.1002/hyp.6216

Rowland A P, and Haygarth P M, 1997. *Determination of total dissolved phosphorus in soil solutions*. J. Environ. Qual. 26:410-415

Saunders T J, McClain M E, Llerena C A, 2006. *The biogeochemistry of dissolved nitrogen, phosphorus, and organic carbon along terrestrial-aquatic flowpaths of a montane headwater catchment in the Peruvian Amazon*. Journal of Hydrological Processes no. 20, pp. 2549–2562. doi: 10.1002/hyp.6215

Sharpley A N, Daniel T C, Edwards D R, 1993. Phosphorus Movement in the Landscape. J. Prod. Agric., Vol. 6, no. 4, pp. 492-500

Sharpley, A.N., W.J. Gburek, G. Folmar, and H.B. Pionke. 1999. *Sources of phosphorus exported from an agricultural watershed in Pennsylvania*. Agric. Water Manage. 41:77–89.

Stone M, Mulamoottil G, Logan L, 1995. *Grain size distribution effects on phosphate sorption by fluvial sediment: implications for modelling sediment phosphate transport*. Journal des Sciences Hydrologiques, Vol. 40

Stutter M I, Langan s J, Cooper R J, 2007. *Spatial contributions of diffuse inputs and within-channel processes to the form of stream water phosphorus over storm events*. Journal of Hydrology (2008) 350, 203– 214

Turner B L and Haygarth P M, 2000. *Phosphorus Forms and Concentrations in Leachate under Four Grassland Soil Types*. Soil Sci. Soc. Am. J. 64:1090-1099

Vincent A G, Turner B L, Tanner E V J, 2010. *Soil organic phosphorus dynamics following perturbation of litter cycling in a tropical moist forest*. Eur. J. Soil Sci. 61, pp. 48–57

Woodring, W., 1958. *Geology of Barro Colorado Island*, Canal Zone, Smithsonian Miscellaneous Collections, 135.

Zhang Z, Fukushima T, Onda Y, Gomi T, Fukuyama T, Sidle R, Kosugi K, Matsushige K, 2007. *Nutrient runoff from forested watersheds in central Japan during typhoon storms: implications for understanding runoff mechanisms during storm events*. Journal of Hydrological Processes no. 21, 1167–1178 (2007), doi: 10.1002/hyp.6677

Zimmermann A, Francke T, Elsenbeer H, unpublished (submitted 2010). *Forests and erosion: Views from a study on suspended sediment dynamics in an overland flow-prone rainforest catchment*

Zimmermann A, Zimmermann B, Elsenbeer H, 2009. *Rainfall distribution in a tropical forest: Spatial and temporal patterns*. Water Resour. Res. 45, W11413, doi:10.1029/2008WR007470