ScienceDirect

Applied Geochemistry

Volume 22, Issue 1, January 2007, Pages 175-191

A review of land–sea coupling by groundwater discharge of nitrogen to New England estuaries: Mechanisms and effects

J.L. Bowen [1], K.D. Kroeger [2], G. Tomasky, W.J. Pabich [3], M.L. Cole [4], R.H. Carmichael [5], I. Valiela

https://doi.org/10.1016/j.apgeochem.2006.09.002

Get rights and content

Abstract

Hydrologists have long been concerned with the interface of groundwater flow into estuaries, but not until the end of the last century did other disciplines realize the major role played by groundwater transport of nutrients to estuaries. Mass balance and stable isotopic data suggest that land-derived NO_3, NH_4, and dissolved organic N do enter estuaries in amounts likely to affect the function of the receiving ecosystem. Because of increasing human occupancy of the coastal zone, the nutrient loads borne by groundwater have increased in recent decades, in spite of substantial interception of nutrients within the land and aquifer components of watersheds. Groundwater-borne nutrient loads have increased the N content of receiving estuaries, increased phytoplankton and macroalgal production and biomass, decreased the area of seagrasses, and created a cascade of associated ecological changes. This linkage between land use and eutrophication of estuaries occurs in spite of mechanisms, including uptake of land-derived N by riparian vegetation and fringing wetlands, “unloading” by rapid water removal, and direct N inputs to estuaries, that tend to uncouple the effects of land use on receiving estuaries. It can be expected that as human activity on coastal watersheds continues to increase, the role of groundwater-borne nutrients to the receiving estuary will also increase.

Section snippets

Background

Awareness of the importance of transport of materials by freshwater flow through rivers and streams to receiving coastal waters has existed as long as the history of natural science, but knowledge about the role of subsurface flows has a more recent history. Interest in the interaction of groundwater and coastal waters emerged early. Key features of flow through aquifers were identified in pioneering work by Darcy (1856), and by Baden Ghijben, 1888–1889, Herzberg, 1901, who interpreted vertical …

Nutrient transport by groundwater

The magnitude of land-derived nutrient transport by groundwater is set by the concentrations of nutrients near-shore, attenuation processes along flowpaths, and by groundwater flow rates. Of course, to some extent the impact of these exports are mediated by the ambient concentrations in the receiving waters, but in general, groundwater holds considerably higher concentrations of solutes than receiving estuaries. Here the forms of N dissolved in groundwater are focussed on because N is the …

Concentrations

The relative area of diverse types of land covers and biogeochemical processes that occur during groundwater transport greatly alter not only the magnitude but also the composition, or chemical form, of N loads delivered from land to receiving waters (Kroeger, 2003, Kroeger et al., 2006b). On Cape Cod (and elsewhere, Fig. 1), the primary land use change in recent decades has been conversion of forested and agricultural land to residential uses (Bowen and Valiela, 2001a). This conversion to …

Effects on nitrogen concentrations in water of receiving estuaries

Nitrogen concentrations in receiving estuaries are directly related to both groundwater N concentration and within-estuary processing in the Waquoit Bay estuaries (Valiela et al., 2000a). Groundwater, the predominant transport mechanism in the Waquoit Bay system, delivers N-rich water to the receiving estuaries (Fig. 6, solid points). The composition of N compounds in groundwater depends on land use mosaics on the watersheds.

Nitrate is the dominant form of N in groundwater entering Childs River …

Modifications to degree of coupling between land and estuary

The mass balance and isotopic evidence, and the field measurements clearly argue that there are powerful couplings between land and open waters. In specific settings, it may be that diverse mechanisms work to uncouple receiving waters from the influence of land-derived N loads. Below three of these features: riparian and wetland fringes, and water residence times, are briefly discussed. …

Acknowledgements

Part of the work we review was supported by the LMER initiative of NSF, EPA Region 1, and by NOAA. We also gratefully acknowledge support from The Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET), WHOI and MIT Sea Grant Programs, and from the USGS Water Resources Program at the University of Massachusetts. …

Recommended articles

References (131)

B. Ataie-Ashtiani *et al.*
Tidal effects on sea water intrusion in unconfined aquifers
J. Hydrol. (1999)

K.C. Beck *et al.*
Organic and inorganic geochemistry of some coastal plain rivers of the southeastern United States
Geochim. Cosmochim. Acta (1974)

R. Benner *et al.*
Abundance, size distribution, and stable carbon and nitrogen isotopic compositions of marine organic matter isolated by tangential-flow ultrafiltration
Mar. Chem. (1997)

H.J. Bokuniewicz
Groundwater seepage into Great South Bay, NY
Estuar. Coast. Shelf Sci. (1980)

J.L. Bowen *et al.*
Historical changes in atmospheric nitrogen deposition to Cape Cod, Massachusetts, USA
Atmos. Environ. (2001)

M.J. Bowman
Nutrient distributions and transport in Long Island Sound

Estuar. Coast. Mar. Sci. (1977)

R.H. Carmichael *et al.*
Changes in the shell and soft tissue growth, tissue composition, and survival of quahogs, *Mercenaria mercenaria*, and softshell clams, *Mya arenaria*, in response to eutrophic-drived changes in food supply and habitat
J. Exp. Mar. Biol. Ecol. (2004)

A. Evgenidou *et al.*
Response of growth and density of a population of *Geukensia demissa* to land-derived nitrogen loading to Waquoit Bay, Massachusetts
Estuar. Coast. Shelf Sci. (2002)

W.S. Gardner *et al.*
Stability and composition of terrestrially derived dissolved organic nitrogen in continental shelf surface waters
Mar. Chem. (1978)

E.D. Goldberg
Emerging problems in the coastal zone for the twenty-first century
Mar. Poll. Bull. (1995)

View more references

Cited by (96)

Submarine groundwater discharge impacts on coastal nutrient biogeochemistry ↗
2021, Nature Reviews Earth and Environment

Marine ecological processes ↗
2016, Marine Ecological Processes

Groundwater - the disregarded component in lake water and nutrient budgets. Part 2: Effects of groundwater on nutrients ↗
2015, Hydrological Processes

Transient groundwater dynamics in a coastal aquifer: The effects of tides, the lunar cycle, and the beach profile ↗
2013, Water Resources Research

Microbial nitrogen cycling at the saltwater-freshwater interface ↗
2010, Hydrogeology Journal

Aerial infrared imaging reveals large nutrient-rich groundwater inputs to the ocean ↗
2008, Geophysical Research Letters

View all citing articles on Scopus ↗

1 Present address: The Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA 02543, USA.

2 Present address: US Geological Survey, Woods Hole Science Center, Woods Hole, MAA 02543, USA.

3 Present address: P.O. Box 3814, Hailey, ID 83333, USA.

4 Present address: Save The Bay, Narragansett Bay, Providence, RI 02908, USA.

5 Present address: Dauphin Island Sea Lab, 101 Bienville Blvd., Dauphin Island, AL 36528, USA.

View full text