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A comparison between developed and developing countries in terms of urban land use change effects on nitrogen cycle: Paris and São Paulo metropolitan areas

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Urbanization is considered one of the most powerful and characteristic anthropogenic forces on Earth in the 21st century. Although, currently, cities occupy only about 2 percent of the Earth's land surface, they are home to over 50 percent of the world's population. While in cities of some developed countries, urban population might stabilize or even slightly decrease, its rate of growth in developing countries is faster than in the industrialized nations. Such increase is accompanied by growing energy production, increased food demand, expanding transportation and industrialization. Although agricultural production is by far the largest cause of the doubling in the amount of reactive nitrogen entering the biospheric cycle compared to pre-industrial conditions, nowadays more than half of the crops produced in rural areas are consumed in urban zones. Having in mind that there is a clear global trend towards urbanization and growing urban areas, the objective of this study was to compare major nitrogen fluxes between a mega city situated in a developing country (São Paulo Metropolitan Area - SPMA) in Brazil with one of the largest city of highly industrialized Europe (Paris Metropolitan Area - PMA). We make the first step in producing a detailed N mass balance for the SPMA and PMA in order to estimate the magnitude of major fluxes across the urban landscape and see how N cycling vary among urban system components. This effort may help to highlight differences between developing and developed areas and subsidize the formulation of public policies towards reduction of N related pollution of recipient systems. The N mass balance showed the SPMA as a net source of nitrogen, emitting in total about 93.5 Gg of N per year, or about 4750 g of N per capita. Most N inputs to the SPMA are directly related to food consumption, N in wastewater and landfills. These fluxes are quite amendable to management efforts to reduce N input to the receiver component of the urban ecosystem (rivers and soil). For example treated sewage effluent could be used as a source of N for some crops, especially vegetables. PMA is also a source of reactive nitrogen, emitting in total about 32 Gg of N per year, or about 3000 g of N per capita, being the major part attributed to the atmospheric emissions from transportation and energy. An important outcome of this study has been the identification of several key uncertainties regarding the N budget that require further research for either developed and developing regions studied. The following uncertainties of N cycling in an urban system need better understanding: the mechanisms of dry-deposition processes in urban systems with patchy vegetation; high NOx emissions and the increase in travel distance of smaller particles coming from modern engines; and complex patterns of air flow in the dense build-up areas. Urban soil N dynamics is very uncertain, while soil represents a major sink of N in natural ecosystems. Ultimately, the challenge is to integrate human choices and ecosystem dynamics into a multidisciplinary model of biogeochemical cycling in urban ecosystems, focusing as a first step on the quantitatively evaluating the mutual relationship between urban land-use changes and natural ecosystem from the standpoint of global N balance. To develop those schemes will require the construction of detailed ecosystem-level N balances, an in-depth understanding of the interplay of inputs, geographical and climatic factors, nonspecific management practices, and deliberate N management practices that control the fate of N in urban landscapes.