



Quantification of phosphorus (P) and nitrogen (N) inputs associated with direct discharge of domestic wastewater into the Mediterranean Sea

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Both treated and untreated wastewater is discharged directly into the Mediterranean Sea (MS), either at the surface or through submarine pipes. The direct discharge of wastewater poses a potential threat to the vulnerable ecosystems of the MS. Of particular concern are algal blooms within the coastal zone linked to the associated inputs of the nutrient elements phosphorus (P) and nitrogen (N). These inputs are not accounted for in current P and N budgets for the MS, however. Here, we use an empirical modeling approach to quantify P and N fluxes associated with household wastewater discharged directly into the MS by coastal towns and cities of more than 2000 inhabitants. Variables for each city include the population size, the percentage of population connected to the sewage network, and the type of wastewater treatment. The resulting best estimates for the inputs in 2003 are: $0.93 (0.52-1.46) \times 10^9 \text{ mol P yr}^{-1}$ and $14.6 (10.4-22.7) \times 10^9 \text{ mol N yr}^{-1}$. These fluxes are on the same order of magnitude as P and N inputs discharged by rivers into the MS; they should therefore be included in the nutrient budgets. The predicted total N:P ratio of the wastewater inputs is 15.7:1, which is close to the Redfield ratio and lower than the unusually high N:P ratios found in the water column of the MS. Inputs of P and N from wastewater may become increasingly important in the future as river nutrient loads decrease due to reduced freshwater discharge and the implementation of best management practices in agriculture. Model projections indicate that by 2050, P inputs along the African coast could increase by 147% in response to population growth – if no mitigation strategies are put in place. In comparison, the projected increase for the northern Mediterranean countries is only 14%. Improvements in sewerage and wastewater treatment facilities along the southern border of the MS basin should therefore be a priority.