Supporting Information

Direct Discharges of Domestic Wastewater are a Major Source of Phosphorus and Nitrogen to the Mediterranean Sea

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This document contains 26 pages, 3 figures and 14 tables.

1. Estimations of terms in Equation 1 (Section 2, main text)

P,N_{capita} – Annual per capita phosphorus and nitrogen loads in domestic wastewater

The annual per capita loads of P and N in domestic wastewater, P_{capita} and N_{capita}, are computed by considering the P and N contents of human excreta (Equation 2 in main text). For P, we also add the contributions of laundry and dishwasher detergents (Equation 3 in main text). The P_{capita} and N_{capita} values are estimated individually for each country along the Mediterranean; the resulting loads for year 2003 are given in Table S7.

The P and N loads associated with human excreta are related to the annual per capita protein supply to a country, as compiled by the Statistics Division of the Food and Agriculture Organization (FAO) of the United Nations [1]. Dietary protein contains 1.6 and 16% P and N, respectively [2]. The protein supply rates are corrected for the losses by retail businesses and households, along with human losses through sweat, blood and hair loss. Retail and household losses account for 17% of gross protein supply in Europe and 13% in North African and West and Central Asia, while 3% of P and N intake is lost on average through hair sweat and blood [2].

Domestic release of P from dishwashers (P_D) is estimated from the country's market exchange rate based gross national domestic product (GDP) expressed in 1995 U.S. dollars capita^{-1} yr^{-1}, using the equations presented by Van Drecht, et al. [3]. For countries with a GDP below US$10,000 capita^{-1} yr^{-1} households with dishwashers are rare, and we therefore assume that they contribute negligibly to the P loads in wastewater. For the other countries, we impose a maximum fraction of 80% of the population with access to dishwashers.

Inputs of P from laundry detergents (P_L) are also calculated with the equations of Van Drecht, et al. [3], which relate laundry detergent usage and the fraction of P-free laundry detergent to a country's GDP. However, for a number of countries the actual P-free laundry detergent usage is known, in which case we use the reported fractions [4]. In addition, for countries with GDP >US$33,000 capita^{-1} yr^{-1} laundry detergents are assumed to be P-free [3].

pop – Population

Populations of coastal cities were obtained directly from the UNEP-MAP surveys [5, 6]. Individual countries report permanent populations, population equivalents, or both. Population equivalent includes the increase in seasonal population due to tourism. When both permanent population and population equivalent are reported, permanent population is used in the analysis as this results in

better fits between observed and modeled P and N inputs (see section 3). Details of the population distribution per country and per region/basin are summarized in Table S2a.

f_c – Fraction of population connected to sewerage system

For each city, f_c is obtained directly from the available United Nations surveys [5, 6], or, if unavailable, the average f_c of the host country for the year closest to 2003 is imposed (Table S8). In case the permanent population is less than the population connected to the sewage network, the permanent population is used in the calculations, assuming f_c= 1.

$f_{P,N}$ – Fraction of P or N removed from wastewater stream in WWTP

We use the average retentions of P and N for the different types of wastewater treatment reported in Kristensen, et al. [7] (Table S9). These values are representative for Nordic countries. WWTPs in developing countries may have less efficient retentions [3]. Untreated wastewater and wastewater that has undergone pretreatment are assigned a retention of zero.

2. Gaza and Egypt

In addition to the coastal cities included in the two UNEP-MAP surveys [5, 6], we also estimate P and N sewage inputs to the MS from Northern Egypt and the Gaza Strip. According to Rasmussen, et al. [8], the El-Baqar drain releases 42.5×10^6 mol P yr^{-1} and 988.6×10^6 mol N yr^{-1} into Lake Manzella in the Nile Delta. Channels connect this coastal lake to the MS. The wastewater flowing through the El-Baqar drain mainly originates in East Cairo and is mostly untreated although some primary treatment may occur [9]. Around 40% of the water discharge from the drain is of commercial and domestic origin [9]. As a first approximation we therefore assume that domestic sewage inputs to the MS from Northern Egypt equal 40% of the total P and N inputs from the El-Baqar drain to Lake Manzella, that is, 17×10^6 mol P yr^{-1} and 395×10^6 mol N yr^{-1}.

The Gaza Strip, with a population of 1.221 million in 2003 [10], has three WWTPs [11]. Applying the network connectivity of the Palestinian Territory (54%) [11] yields 653,235 people connected to the sewage network. Two of the WWTPs operate reasonably well, serving 420,000 inhabitants and providing secondary treatment [11]. This implies that sewage effluent from an additional 233,235 people is probably discharged into the Mediterranean untreated. In total, we estimate that the Gaza strip discharges 7.1×10^6 and 104×10^6 mol yr^{-1} of P and N into the MS, respectively.

3. Model check

As a check on the empirical modeling approach we use to calculate direct wastewater P and N discharges into the MS, we compare our model-predicted input and output fluxes of P and N for

individual WWTPs to available measured values for WWTPs in Italy, Spain and Cyprus [12]. As can be seen in Figure S1, the predicted N and P inputs to WWTPs are in general agreement with reported values, with a Nash Sutcliffe efficiency, E, of 0.734 and 0.789 for P and N, respectively. Note that the uncertainties on the model-calculated input fluxes reflect to a large degree missing data on population size and connectivity to the sewerage system for WWTPs in Spain and Italy. The error bars on Figure S1 correspond to the high and low estimates obtained as outlined in Table S10.

The P and N discharge fluxes from WWTPs are calculated using the reported (not modeled) input fluxes to the WWTPs, and the average P and N retention efficiencies for the different types of wastewater treatment (Table S9). Note, however, that for many WWTPs in Spain and Italy the treatment type is not reported. In those cases, secondary treatment is assumed, as it is the most common treatment type in countries surrounding the MS. In addition, uncertainty still surrounds the proportion of treated to untreated wastewater for a given WWTP when connectivity to the sewage network is not reported. Despite the uncertainties associated with the missing data, good agreement between modeled and measured output fluxes is observed, with E of 0.328 and 0.862 for P and N, respectively.

4. Speciation of P and N in wastewater

Relatively little data exist on the chemical speciation of P and N discharged from WWTPs; here we use all available information although, at this stage, we cannot assess how representative our estimations are for WWTPs in the Mediterranean coastal region (Table S12). Average P speciation after primary, secondary and tertiary treatment are derived from detailed studies on 12 WWTPs across the United States [13]. Speciation of P in untreated sewage is calculated from measurements at WWTPs in South Africa and the Netherlands [14, 15]. For N, raw and primary treated N speciation are based on observations at South African WWTPs [14]. The predicted raw sewage N speciation is within the range reported for 3 WWTPs in France [16]. Secondary and tertiary N speciation are estimated from N discharges at the same WWTPs in France. The resulting, model-derived fluxes of individual P and N species in direct domestic wastewater discharges to the Mediterranean Sea are presented in Table S3.

5. Projections (2050)

Wastewater discharges for the year 2050 are projected using estimated changes in population growth, dietary habits and connectivity to the sewage system as described in the main text. A protein intake of 115 g capita^{-1} day^{-1} is assigned to all Mediterranean countries in 2050, which corresponds to the combined 2003 average value of France, Greece, Italy and Spain, that is, the

2003 EU countries bordering the MS [1]. According to Faostat, protein intake in these 4 countries increased steadily between 1960 and 1990, then stabilized at an average value of 115 g capita^{-1} day^{-1} by the turn of the century [1]. In comparison, per capita protein intake in SMCs increased at an approximate constant rate from 1960 to 2010, and will likely approach that of NMCs in the next few decades. Thus it is not unreasonable to assume that SMCs will exhibit a protein intake in 2050 similar to that reached in 2003 by the EU countries.

The mitigation strategies considered are summarized in Table 2 of the main text. The 50% minimum wastewater recycling in scenarios B and H is a reasonable future, mid-century recycling rate for treated wastewater in Mediterranean countries: in the early 2000s, Cyprus, Israel, Libya, Syria and Lebanon already recycled over 88% of their treated wastewater, with other Mediterranean countries recycling up to 50% of treated wastewater [17]. An unknown fraction of the reused wastewater might enter the sea through agricultural runoff or submarine groundwater discharge. We have currently no basis to estimate what these fractions are for Mediterranean countries and therefore assume that re-used wastewater does not contribute P or N to the MS.

The legislation limiting P use in detergents (scenarios D, E and G) is based upon the 2012 EU amendment (Regulation (EU) 259/2012) to Regulation (EC) No 648/2004 [18], which states that all EU member countries should have no more than 0.5 g P per load in laundry detergent after July 2013 and no more than 0.3 g per load in dishwasher detergents by January 1, 2017. This results in an estimated reduction of P inputs in EU countries by 92% for laundry detergents and 82% for dishwasher detergents compared to pre-regulation inputs [19]. In scenarios D, E and G, these percent reductions are applied to the 2003 (baseline) laundry and dishwasher detergents in all Mediterranean countries (the baseline values are given in Table S7).

In scenarios C, E, F, G, H, and I (WWTP upgrades) we use the average P and N retentions given in Table S9. The WWTPs projected to be constructed are taken into account in the 2050 scenarios and are assigned the planned treatment level. If no treatment level is reported for a projected WWTP, secondary treatment is assumed.

FIGURE CAPTIONS

Figure S1: Observed total P (TP) and total N (TN) input fluxes to WWTPs (Panels A and B) and discharge fluxes from WWTPs (Panels C and D) [12] plotted against the modeled values using the approach followed in our study. Solid lines represent the 1:1 relationships. Error bars indicate maximum and minimum model estimated fluxes.

Figure S2: Estimated 2003 (baseline) direct TP discharges to the Mediterranean Sea associated with untreated and variably treated domestic wastewater. NMC = North Mediterranean countries, EMC = East Mediterranean countries, SMC = South Mediterranean countries.

Figure S3: Predicted impacts of imposing EU P legislation for laundry and dishwasher detergents on the 2003 (baseline) direct domestic wastewater discharges of TP to North Mediterranean Countries (NMC), East Mediterranean Countries (EMC), South Mediterranean Countries (SMC), and all Mediterranean Countries (Total).

TABLE CAPTIONS

Table S1: Model-estimated direct domestic wastewater discharges of a) TP and b) TN for Mediterranean regions, basins and individual countries in 2003 (baseline). Inputs from coastal cities with >10,000 inhabitants and 2000-10,000 inhabitants are given separately. Values in brackets are minimum and maximum estimations. Data availability assessments for cities with >10,000 inhabitants are provided. Units: 10^6 mol yr^{-1}. WMS = Western Mediterranean Sea, EMS = Eastern Mediterranean Sea..

Table S2: Model-estimated direct domestic wastewater discharges in 2003 (baseline) for a) TP and b) TN normalized to the corresponding sea surface area, coastal urban population, continental shelf volume and coastal administrative area. Results are shown for the entire Mediterranean Sea (MS), the Western (WMS) and Eastern Mediterranean Sea (EMS), regions (NMC, EMC, SMC), basins and individual countries.

Table S3: Estimated emissions of individual P and N species associated with direct discharges of domestic wastewater into the WMS, EMS, Adriatic Sea and Aegean Sea in 2003 (baseline), based on the total TP and TN loads estimated in this study and the average speciation percentages given in Table S12. DIP = Dissolved inorganic phosphorus, PIP = particulate inorganic phosphorus; DOP =

Dissolved organic phosphorus; NO_3 = nitrate plus nitrite; PON = particulate organic nitrogen, DON = dissolved organic nitrogen; NH_4 = ammonium.

Table S4: Regional TP and TN discharges into the Mediterranean Sea estimated in this study for 2003 (baseline) compared to values reported in the literature.

Table S5: Projected TP inputs to the Mediterranean Sea from direct domestic wastewater effluents in 2050 due to population growth, without (no mitigation) and with implementation of different mitigation measures. Units: 10^6 mol yr^{-1}.

Table S6: Projected TP inputs to the Mediterranean Sea from domestic wastewater effluents in 2050 due to the combined effects of population growth, dietary changes and increased connectivity of population to the sewage network, without (no mitigation) and with implementation of different mitigation measures. Bold headings identify scenarios included in Figure 4 in the main text. Units: 10^6 mol yr^{-1}.

Table S7: Gross per capita protein supply, and per capita P and N inputs to WWTPs (for P, see Equation 3 of the main text), in individual countries in 2003 (baseline).

Table S8: Average, country-specific fractions of the population connected to the sewage network (f_c), with treatment (f_t) and without treatment (f_u), in 2003. The values listed are applied in Equation 1 in the main text when, for a given coastal city, connectivity was not provided in the database. Wastewater discharges from inhabitants not connected to the sewage network (f_n) are assumed not to drain into the Mediterranean Sea.

Table S9: Relative retentions of P and N for each wastewater treatment type. Values in parentheses are minimum and maximum estimates.

Table S10: Upper and lower estimates for P and N emissions to the Mediterranean Sea associated with direct domestic wastewater discharges.

Table S11: Uncertainties assigned to parameters in Equations 2 and 3 of the main text to calculate average upper and lower uncertainty on the P and N input per capita to the sewerage network. The uncertainties are used to calculate average uncertainties on P,N_{capita} in Equation 1 of the main text.

Table S12: Input and ancillary information used in calculating the direct domestic wastewater P and N emissions from settlements with 2000-10,000 inhabitants in 2003, based on data from UNEP/MAP/MED-POL/WHO [6]

Table S13: Speciation of P and N in WWTP effluent after different treatment types, given as percentages of TP and TN, respectively. Numbers in brackets represent the observed range. DIP: dissolved inorganic phosphorus, PIP: particulate inorganic phosphorus, POP: particulate organic phosphorus, DOP: dissolved organic phosphorus, NO_3: nitrate plus nitrite, PON: particulate organic nitrogen, DON: dissolved organic nitrogen, NH_4: ammonium.

Table S14: Concentration of TP and annualized cost for each wastewater treatment type. TP concentrations are calculated using an untreated effluent TP concentration of 12 mg L^{-1} [20] and the P retention estimates for each treatment type in Table S9.

Table S15: Reported percentage of treated wastewater recycled in Mediterranean countries for the year closest to 2003 [17]. Values are used to calculate the additional recycling needed to have a minimum 50% recycling of treated wastewater in scenarios B and E of the main text.

FIGURES AND TABLES

Figure S1:

Inputs to WWTP

Phosphorus / Nitrogen
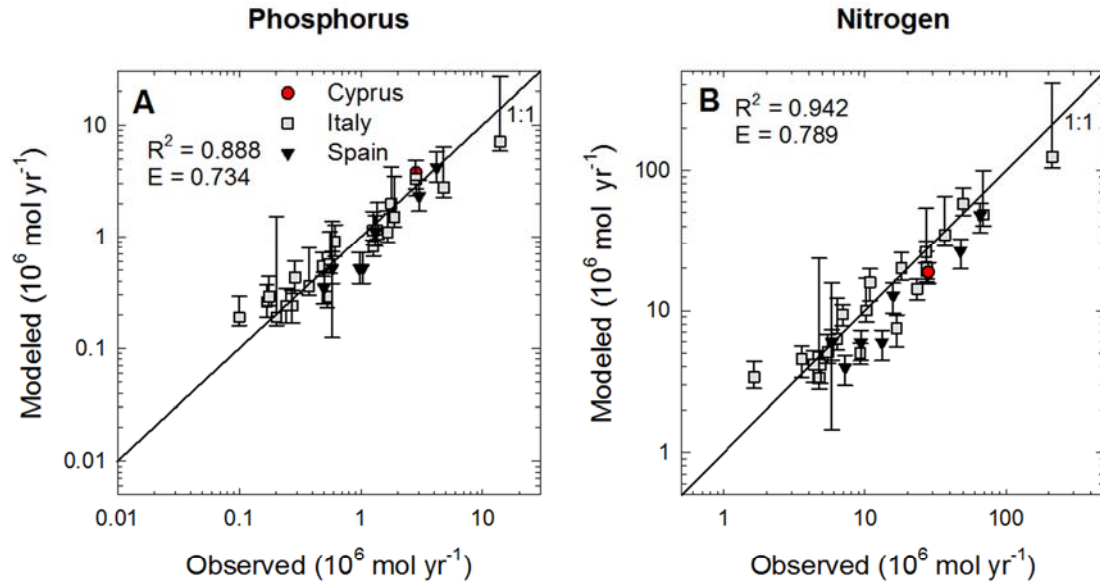
Discharges from WWTP

Figure S2:

Figure S3:

Table S1a:

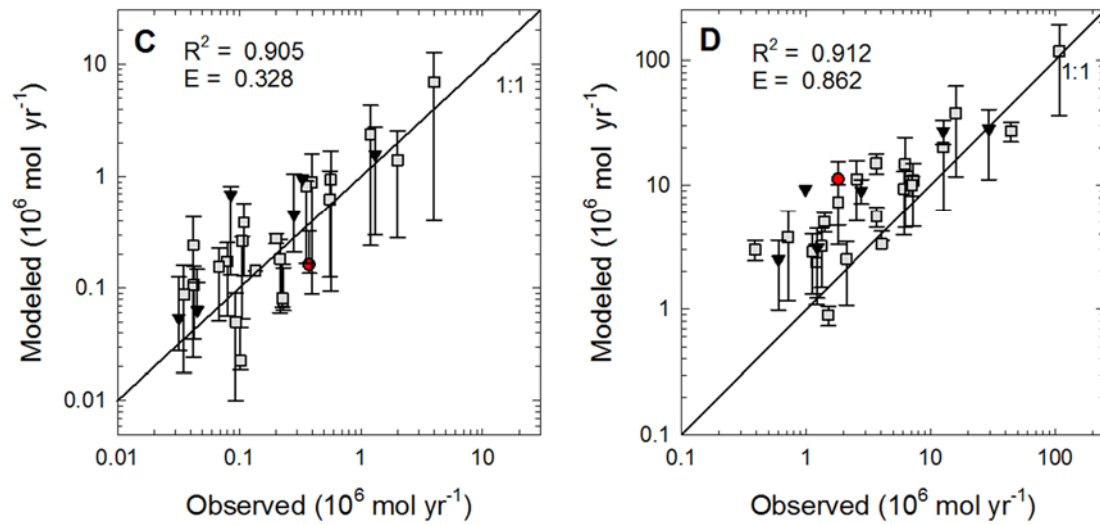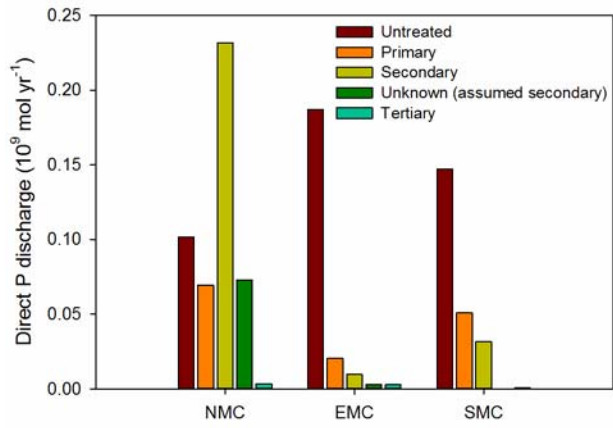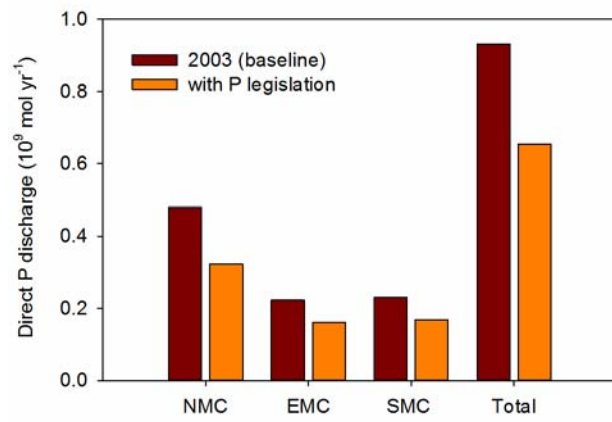| Region/basin /country	Cities with population>10000			Cities with population 2000-10000	Total P	Data availability for cities with population>10000
	Treated	Untreated	Total			
WMS	214	87	301 (124-689)	51 (14-101)	353 (138-789)	
EMS	215	169	384 (209-658)	195 (89-291)	579 (298-949)	
NMC	316	56	372 (120-866)	107 (33-202)	479 (153-1068)	
EMC	35	53	89 (63-145)	134 (69-178)	222 (132-323)	
SMC	78	147	225 (150-366)	5 (1-11)	230 (150-347)	
Adriatic	26.3	11.2	37 (20-110)	38.0 (10.8-70.8)	75 (30-181)	
Aegean	85.7	12.0	98 (25-147)	6.7 (3.7-9.5)	104 (29-156)	
Alboran	17.2	33.7	51 (27-123)	3.7 (0.8-8.5)	55 (27-131)	
NW Med	140.8	13.7	154 (55-373)	19.3 (5.3-35.1)	174 (60-408)	
SW Med	17.9	24.6	42 (24-88)	1.3 (0.5-2.4)	44 (24-90)	
Tyrrhenian	38.0	15.3	53 (18-105)	27.1 (7.3-54.6)	80 (26-160)	
Ionian	16.3	5.1	21 (6-44)	13.3 (3.7-27.5)	35 (9-72)	
Central	6.9	42.2	49 (35-69)	8.4 (5.1-11.3)	58 (40-80)	
N Levantine	23.6	48.4	72 (54-116)	127.6 (65.3-169.7)	200 (119-285)	
S Levantine	56.3	50.3	107 (70-172)	0.7 (0.0-1.9)	107 (70-174)	
Albania	0.0	2.3	2.3 (1.8-3.0)	0.4 (0-0.5)	2.6 (1.8-3.5)	Medium: No data on connection to sewage network in 25% of cases
Algeria	10.3	37.0	47.3 (30.9-66.0)	nd	47.3 (30.9-66.0)	Medium: No information on connection to sewage network in approximately 20% of cases
Cyprus	0.0	0.0	0.0	0	0	Good: All wastewater is recycled
Croatia	6.5	5.5	12.0 (9.8-18.3)	7.5 (2.7-10.0)	19.5 (12.5-28.3)	Good
Egypt	48.7	45.6*	94.3* (62.9-152.4)	0.7 (0.0-1.8)	95.0 (62.9-154.2)	Medium: No discharge location stated for untreated wastewater
France	74.9	0.0	74.9 (40.1-119.4)	4.9 (0.7-6.5)	79.8 (40.8-125.8)	Good: Population equivalent rather than permanent population reported
Gaza	3.4	3.7	7.1 (3.6-11.6)	nd	7.1 (3.6-11.6)	n/a
Greece	88.5	14.6	103.1 (25.5-151.3)	0.4 (0.2-1.5)	103.5 (25.7-152.8)	Medium: Population equivalent rather than permanent population reported. Treatment type missing in 4% of cases. No data on where wastewater discharged in 30% of cities
Israel	4.1	0.0	4.1 (2.1-6.4)	0 (0-0.1)	4.1 (2.1-6.5)	Good: Wastewater mostly reused
Italy	63.3	17.8	81.1 (24.5-226.1)	79.2** (21.8-162.1)	160.3 (46.2-388.2)	Poor: Connection to sewage network is not reported in ~27% of cases. No treatment type stated when WWTP is present in ~47% of cases. No information on where wastewater is discharged
Lebanon	7.5	33.6	41.1 (33.6-67.2)	111 (56.5-147.6)	152.1 (90.1-214.8)	Good
Libya	0.8	28.6	29.3 (23.1-38.9)	0.2 (0.1-0.4)	29.6 (23.2-39.4)	Medium: Some wastewater recycled. No data on where wastewater discharged in 70% of cities
Malta	0.0	3.7	3.7 (3.1-5.0)	7.0 (4.9-9.3)	10.7 (7.9-14.3)	Good
Morocco	0.2	18.0	18.2 (14.9-24.4)	2.3 (0.2-6.1)	20.5 (15.0-30.5)	Good
Monaco	0.5	0.0	0.5 (0.1-1.3)	nd	0.5 (0.1-1.3)	Good
Montenegro	nd	nd	nd	1.7 (0.2-2.3)	1.7 (0.2-2.3)	n/a
Slovenia	0.6	0.7	1.3 (1.1-2.0)	0.3 (0.1-0.5)	1.6 (1.2-2.4)	Good
Spain	81.5	11.5	93.1 (14.1-339.4)	5.8 (2.5-9.8)	98.8 (16.7-349.1)	Poor: No data given on connection of population to sewage system or where water is discharged. Permanent population and population equivalent given
Syria	0	11.0	11.0 (9.0-14.6)	3.9 (1.7-5.1)	14.8 (10.8-19.7)	Medium/Good: Location of discharge of treated water not given in 43% of cases
Tunisia	18.0	18.0	35.9 (17.7-54.2)	1.8 (0.2-2.4)	37.8 (18.0-56.6)	Medium: No data on f_c in approximately one third of cases Large portions of wastewater recycled as well as discharged to sea
Turkey	20.4	4.9	25.3 (15.0-45.0)	19.1 (10.7-25.4)	44.4 (25.7-70.4)	Medium: Population missing for 5 cities. Treatment type missing for 17% of cites with a WWTP
Total	**429**	**256**	**685 (333-1347)**	**246 (103-391)**	**932 (435-1738)**	

nd= no data; *Includes additional 17.0 x 10^{6} mol yr^{-1} not calculated from UNEP/MAP/MED-POL/WHO [5] data;** includes data from cities > 10,000 inhabitants; n/a = not applicable . Good quality indicates that the data is complete for the purposes of this study.

Table S1b:

Region/basin/country	Cities with population >10000			Cities with population 2000-10000	Total N	N:P effluent
	Treated	Untreated	Total			
WMS	3219	1340	4559 (2964-9100)	889 (348-1506)	5448 (3312-10606)	15.5
EMS	3804	2683	6487 (4365-10122)	3108 (1513-4093)	9595 (5877-14215)	16.6
NMC	4823	787	5610 (3479-11823)	1846 (722-3031)	7455 (4201-14854)	15.6
EMC	831	811	1642 (1095-2358)	2063 (1116-2415)	3705 (2212-4773)	16.7
SMC	1370	2425	3795 (2755-5041)	87 (22-153)	3882 (2777-5194)	16.9
Adriatic	554	163	717 (433-1934)	649 (232-1037)	1366 (665-2972)	18.1
Aegean	1483	161	1645 (951-2330)	130 (69-177)	1775 (1021-2506)	17.0
Alboran	261	516	777 (516-1604)	58 (22-111)	835 (538-1715)	15.3
NW Med	1982	190	2172 (1440-4711)	315 (130-524)	2487 (1570-5234)	14.3
SW Med	268	378	646 (460-1127)	19 (12-30)	665 (472-1157)	15.2
Tyrrhenian	708	256	964 (548-1659)	497 (184-840)	1461 (732-2500)	18.2
Ionian	281	72	352 (168-645)	254 (93-438)	607 (261-1082)	17.5
Central	138	631	769 (605-971)	103 (64-121)	872 (669-1092)	15.1
N Levantine	416	737	1153 (908-1611)	1959 (1053-2292)	3111 (1961-3903)	15.6
S Levantine	933	918	1851 (1300-2631)	13 (1-28)	1864 (1301-2659)	17.4
Albania	0.0	35.7	36 (30-42)	5.6 (0.1-6.6)	41 (30-49)	15.9
Algeria	169.4	574.2	744 (526-905)	nd	744 (526-905)	15.7
Cyprus	0.0	0.0	0.0	0	0	nd
Croatia	85.6	67.7	153 (127-200)	93.1 (34.2-109.0)	246 (161-308)	12.6
Egypt	824.7	851.1*	1676* (1166-2382)	11.9 (0.6-25.3)	1688 (1167-2408)	17.8
France	1014.9	0.4	1015 (776-1418)	67.5 (18.5-109.4)	1083 (794-1527)	13.6
Gaza	51.8	52.3	104 (79-153)	nd	104 (79-153)	14.7
Greece	1276.4	186.7	1463 (990-2012)	37.1 (8.9-78.8)	1500 (999-2091)	14.5
Israel	53.8	0.0	54 (41-75)	0 (0-0.9)	54 (41-76)	13.3
Italy	1304.1	310.9	1615 (811-3884)	1462.1** (542.7-2490.2)	3077 (1354-6374)	19.2
Lebanon	120.6	510.8	631 (524-900)	1689.4 (889.3-1976.6)	2321 (1423-2877)	15.3
Libya	19.5	430.1	450 (360-529)	3.9 (2.0-5.5)	454 (362-534)	15.3
Malta	0.0	41.6	42 (34-49)	77.6 (54.6-90.7)	119 (89-139)	11.1
Morocco	19.5	282.1	302 (241-361)	39.6 (8.1-84.2)	341 (249-446)	16.7
Monaco	7.6	0.0	8 (5-21)	nd	8 (5-21)	16.5
Montenegro	nd	nd	nd	25.5 (2.9-29.9)	26 (3-30)	14.8
Slovenia	10.0	11.7	22 (18-28)	4.5 (2.0-6.3)	26 (20-34)	16.4
Spain	1124.5	131.9	1256 (687-4170)	72.7 (58.3-110.1)	1329 (746-4280)	13.4
Syria	0	166.8	167 (138-195)	58.4 (26.7-68.4)	225 (165-263)	15.2
Tunisia	336.7	287.4	624 (462-864)	32.0 (11.3-37.4)	656 (473-902)	17.4
Turkey	604.4	81.4	686 (313-1035)	315.5 (190.5-369.2)	1001 (504-1404)	22.6
Total	**7023**	**4023**	**11046 (7329-19222)**	**3997 (1860-5599)**	**15043 (9190-24821)**	**16.1**

nd = no data; *Includes additional 395.4 x 10^6 mol yr^{-1} not calculated from UNEP/MAP/MED-POL/WHO [5] data;** includes data from cities > 10,000 inhabitants

Table S2a:

Region/ basin/ country	Wastewater discharge of P to MS (10^6 mol yr^{-1})	% treated	Normalized to sea area (10^{-3} mol m^{-2} yr^{-1})	Population in database (10^3 inhabitants)[a]	Normalized to population (mol capita^{-1} yr^{-1})	Coastline length (km)[b]	Normalized to coastline length (10^3 mol km^{-1})	Continental Shelf Volume (km^3)[c]	Normalized to continental shelf volume (10^3 mol km^{-3} yr^{-1})	Coastal region administrative area (10^3 km^2)[b]	Normalized to coastal region administrative area (10^3 mol km^{-2} yr^{-1})
MS	**932 (435-1738)**	**53**	**0.37**	**76003**	**12.3**	**45807**	**20**	**42.2**	**22**	**1136**	**0.8**
WMS	353 (138-789)	71	0.42	28006	12.6	n/a	n/a	12.5	28	n/a	n/a
EMS	579 (298-949)	42	0.35	47997	12.1	n/a	n/a	29.7	19	n/a	n/a
NMC	479 (153-1068)	79	n/a	37221	12.9	34239	14	29.1	16	460	1.0
EMC	222 (132-323)	16	n/a	19313	11.5	5833	38	1.4	154	152	1.5
SMC	230 (150-347)	36	n/a	19468	11.8	5735	40	11.7	20	524	0.4
Alboran	55 (27-131)	38	0.72	4822	11.3	n/a	n/a	n/a	n/a	n/a	n/a
NW Med.	174 (60-408)	90	0.69	12474	13.9	n/a	n/a	6.2*	33 **	n/a	n/a
SW Med.	44 (24-90)	44	0.16	3324	13.2	n/a	n/a	2.5*	29 **	n/a	n/a
Tyrrhenian	80 (26-160)	69	0.33	7386	10.9	n/a	n/a	3.8	21	n/a	n/a
Adriatic	75 (30-181)	59	0.58	6382	11.8	n/a	n/a	10.1	7	n/a	n/a
Ionian	35 (9-72)	71	0.19	3251	10.7	n/a	n/a	3.9	9	n/a	n/a
Central	58 (40-80)	15	0.09	6007	9.6	n/a	n/a	6.3	9	n/a	n/a
Aegean	104 (29-156)	82	0.52	9732	10.7	n/a	n/a	5.1	20	n/a	n/a
N Levantine	200 (119-285)	12	1.80	12139	16.4	n/a	n/a	4.3***	71***	n/a	n/a
S Levantine	107 (70-174)	53	0.25	10485	10.2	n/a	n/a	4.3***	71***	n/a	n/a
Albania	2.6 (1.8-3.5)	0	n/a	307	8.5	418	6.2	n/a	n/a	7.8	0.3
Algeria	47.3 (30.9-66.0)	22	n/a	4290	11.0	1200	39.4	n/a	n/a	47.0	1.0
Cyprus	0	100	n/a	474	0	782	0	n/a	n/a	9.3	0
Croatia	19.5 (12.5-28.3)	33	n/a	1165	16.7	5835	3.3	n/a	n/a	26.2	0.7
Egypt	95.0 (62.9-154.2)	52	n/a	5226	18.2	955	99.5	n/a	n/a	114.8	0.8
France	79.8 (40.8-125.8)	100	n/a	5860	13.6	1703	46.8	n/a	n/a	46.2	1.7
Gaza	7.1 (3.6-11.6)	47	n/a	1221	5.7	55	129.1	n/a	n/a	0.4	19.6
Greece	103.5 (25.7-152.8)	86	n/a	7972	13.0	15021	6.9	n/a	n/a	101.0	1.0
Israel	4.1 (2.1-6.5)	100	n/a	3685	1.1	179	22.7	n/a	n/a	19.9	0.2
Italy	160.3 (46.2-388.2)	71	n/a	14048	11.4	7375	21.7	n/a	n/a	165.8	1.0
Lebanon	152.1 (90.1-214.8)	5	n/a	7931	19.2	225	675.8	n/a	n/a	4.9	31.1
Libya	29.6 (23.2-39.4)	3	n/a	4081	7.2	1770	16.7	n/a	n/a	274.9	0.1
Malta	10.7 (7.9-14.3)	0	n/a	418	25.7	180	59.6	n/a	n/a	0.3	34.0
Morocco	20.5 (15.0-30.5)	12	n/a	1706	12.0	512	40.0	n/a	n/a	42.0	0.5
Monaco	0.5 (0.1-1.3)	100	n/a	35	13.1	4	114.6	n/a	n/a	0.002	229.3
Montenegro	1.7 (0.2-2.3)	0	n/a	84	20.7	294	5.9	n/a	n/a	6.5	0.3
Slovenia	1.6 (1.2-2.4)	54	n/a	94	17.0	47	34.0	n/a	n/a	1.0	1.5
Spain	98.8 (16.7-349.1)	88	n/a	6764	14.6	2580	38.3	n/a	n/a	95.5	1.0
Syria	14.8 (10.8-19.7)	0	n/a	813	18.3	183	81.1	n/a	n/a	4.2	3.5
Tunisia	37.8 (18.0-56.6)	52	n/a	4164	9.1	1298	29.1	n/a	n/a	45.7	0.8
Turkey	44.4 (25.7-70.4)	46	n/a	5663	7.8	5191	8.6	n/a	n/a	122.6	0.4

[a]This study [b]Plan-Bleu [21]; [c]Laruelle, et al. [22]; n/a = not applicable;*Includes Alboran Sea; **Total discharges to Alboran Sea split equally between NW and SW Med.;
***Calculated for N Levantine and S Levantine together

Table S2b:

Region/ basin/ country	Wastewater discharge of N to MS (10^6 mol yr^{-1})	% treated	Normalized to population (mol $capita^{-1}$ yr^{-1})	Normalized to sea area (10^{-3} mol m^{-2} yr^{-1})	Normalized to coastline (10^3 mol km^{-1} yr^{-1})	Normalized to continental shelf volume (10^3 mol $km^{-3}yr^{-1}$)	Normalized to coastal region administrative area (10^3 mol km^{-2} yr^{-1})
MS	15043 (9190-24821)	55	198	6	328	356	6.0
WMS	5448 (3312-10606)	71	195	6	n/a	436	n/a
EMS	9595 (5877-14215)	46	200	6	n/a	323	n/a
NMC	7455 (4201-14854)	80	200	n/a	218	256	7.3
EMC	3705 (2212-4773)	22	192	n/a	635	2573	11.0
SMC	3882 (2777-5194)	38	199	n/a	677	332	3.3
Alboran	835 (538-1715)	38	173	11	n/a	n/a	n/a
NW Med.	2487 (1570-5234)	89	199	10	n/a	470 *	n/a
SW Med.	665 (472-1157)	43	200	2	n/a	435 *	n/a
Tyrrhenian	1461 (732-2500)	71	198	6	n/a	380	n/a
Adriatic	1366 (665-2972)	66	214	10	n/a	136	n/a
Ionian	607 (261-1082)	74	187	3	n/a	156	n/a
Central	872 (669-1092)	19	145	1	n/a	138	n/a
Aegean	1775 (1021-2506)	85	182	9	n/a	347	n/a
N Levantine	3111 (1961-3903)	13	256	28	n/a	1152**	n/a
S Levantine	1864 (1301-2659)	51	178	4	n/a	1152**	n/a
Albania	41 (30-49)	0	135	n/a	99	n/a	2.4
Algeria	744 (526-905)	23	173	n/a	620	n/a	7.1
Cyprus	0	100	0	n/a	0	n/a	0
Croatia	246 (161-308)	35	212	n/a	42	n/a	4.3
Egypt	1688 (1167-2408)	50	323	n/a	1767	n/a	6.6
France	1083 (794-1527)	100	185	n/a	636	n/a	10.6
Gaza	104 (79-153)	50	84	n/a	1892	n/a	129.5
Greece	1500 (999-2091)	88	188	n/a	100	n/a	6.7
Israel	54 (41-76)	100	15	n/a	301	n/a	1.2
Italy	3077 (1354-6374)	73	219	n/a	417	n/a	8.4
Lebanon	2321 (1423-2877)	5	293	n/a	10315	n/a	214.3
Libya	454 (362-534)	5	111	n/a	256	n/a	0.7
Malta	119 (89-139)	0	285	n/a	662	n/a	170.2
Morocco	341 (249-446)	17	200	n/a	666	n/a	3.7
Monaco	8 (5-21)	100	216	n/a	1891	n/a	1707.6
Montenegro	26(3-30)	0	305	n/a	87	n/a	1.8
Slovenia	26 (20-34)	55	279	n/a	558	n/a	11.3
Spain	1329 (746-4280)	90	196	n/a	515	n/a	6.3
Syria	225 (165-263)	0	277	n/a	1231	n/a	24.3
Tunisia	656 (473-902)	56	158	n/a	505	n/a	6.5
Turkey	1001 (504-1404)	60	177	n/a	193	n/a	3.7

n/a = not applicable; *Total discharges to Alboran Sea split equally between NW and SW Med.; **calculated for N Levantine and S Levantine together

Table S3:

	Phosphorus				Nitrogen			
	DIP	PIP	POP	DOP	NO_3	PON	DON	NH_4
	10^6 mol yr^{-1} (%TP or TN)							
WMS	150.2 (42.6)	70.2 (19.9)	94.0 (26.7)	38.2 (10.8)	1123.4 (20.6)	319.1 (5.9)	582.2 (10.7)	3423.4 (62.8)
EMS*	176.5 (44.2)	99.1 (24.8)	91.8 (23.0)	31.6 (7.9)	353.5 (5.5)	507.9 (7.9)	899.5 (13.9)	4691.4 (72.7)
Adriatic	32.4 (42.9)	16.2 (21.5)	19.3 (25.5)	7.6 (10.0)	288.5 (21.1)	83.0 (6.1)	150.0 (11.0)	844.7 (61.9)
Aegean	41.6 (39.9)	18.2 (17.4)	30.7 (29.5)	13.8 (13.2)	666.5 (37.6)	83.3 (4.7)	157.2 (8.9)	867.9 (48.9)
Total	400.7 (43.0)	203.7 (21.9)	235.8 (25.3)	91.2 (9.8)	2431.9 (16.2)	993.1 (6.6)	1788.9 (11.9)	9827.4 (65.3)

*excluding Adriatic and Aegean Seas

Table S4:

Area	Population (million)	P emitted (10^6 mol yr^{-1})	N emitted (10^6 mol yr^{-1})	Reference
Gulf of Lions	2.07 1.5	TP:38.8 (22.2-62.3) TP:22.1 (17.7-26.5)	TN:525(406-733) TN:606 (485-727)	This study [23]
Aegean	9.7 10	DIP: 41.6 DIP: 96	NO_3: 667 NO_3:398	This study [24]
West Istrian coast of former Yugoslavia	0.370 0.275	TP: 6.30 (5.1-9.5) TP: 12	TN: 85.1(71-110) TN: 94	This study [25]
Malaga	0.562-0.978 nd	DIP: 3.8 (0.52-10.8) DIP: 1.5-5.6	NO_3:38.1 (24.4-85.6) NO_3:0.3-2.1	This study [26]

nd = no data; *Note: only Malaga reports direct effluent data.

Table S5:

	Baseline (2003) population	2050 population (% increase)	Baseline P discharge (2003)	2050 P treatment options														
				No mitigation	All WWTPs operational: no treat upgrades	50% treated waste-water re-used	Min tertiary treatment in eutrophic areas	Detergent legislation in all countries	Min tertiary treatment in eutrophic areas + detergent legislation	No treatment to primary + all WWTPs operational	Upgrade primary to secondary + all WWTPs operational	Upgrade secondary to tertiary+ all WWTPs operational	No treatment to secondary + all WWTPs operational	Upgrade primary to tertiary+ all WWTPs operational	Min secondary treatment + all WWTPs operational	Min secondary treatment +WWTPs operational + detergent legislation	Min secondary treatment +WWTPs operational + wastewater re-used	Min tertiary treatment + all WWTPs operational
Regional	*10³ inhabitants*									*10⁶ mol yr⁻¹*								
WMS	28006	41564 (48%)	353	506	478	380	466	346	321	442	452	246	416	398	390	262	229	49
EMS	47997	88861 (85%)	579	1091	1046	955	732	787	531	873	991	823	747	876	692	498	398	91
NMC	37221	42576 (14%)	479	549	539	366	423	364	284	511	514	230	490	461	465	307	263	59
EMC	19313	39472 (104%)	222	452	452	428	392	330	288	341	440	431	261	414	249	182	133	36
SMC	19468	48378 (148%)	230	597	533	541	383	438	280	463	490	407	412	399	369	271	231	45
Country																		
Albania	307	816 (166%)	2.6	6.9	6.9	6.9	6.9	5.1	5.1	4.9	6.9	6.9	3.5	6.9	3.5	2.6	1.7	0.4
Algeria	4290	9047 (111%)	47.3	99.7	91.7	89.5	99.7	72.3	72.3	73.7	85.9	82.9	60.7	73.6	54.8	39.8	27.9	6.6
Cyprus	474	870 (84%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Croatia	1165	1543 (32%)	19.5	25.8	25.8	21.5	24.4	15.4	14.5	20.9	23.3	25.8	17.2	17.9	14.7	8.7	7.3	1.8
Egypt	5226	15933 (205%)	95.0	289.6	282.5	257.3	78.7	214.8	58.4	246.3	245.3	254.4	220.1	167.4	182.9	135.6	123.9	21.9
France	5860	7763 (32%)	79.8	105.6	105.6	64.4	69.9	65.2	43.1	105.6	88.7	63.0	105.6	53.3	88.7	54.8	54.0	10.6
Greece	7972	9177 (15%)	103.5	119.2	117.1	72.9	41.6	74.1	25.8	113.4	117.1	26.1	110.8	117.1	110.8	68.8	60.3	14.2
Israel	3685	6162 (67%)	4.1	6.8	6.8	6.8	3.3	4.0	1.9	6.8	5.7	4.2	6.8	3.3	5.7	3.3	5.7	0.7
Italy	14048	13403 (-5%)	160.3	153.0	147.6	101.2	144.1	125.5	118.3	137.4	142.5	64.6	130.1	131.7	125.0	102.5	64.8	15.9
Lebanon	7931	13894 (75%)	152.1	266.4	266.4	266.4	210.4	189.8	149.9	192.9	262.5	266.4	139.7	254.3	135.9	96.8	72.6	16.3
Libya	4081	9440 (131%)	29.6	68.4	36.6	68.4	68.4	48.3	48.3	35.9	36.5	7.3	35.4	36.1	35.2	24.8	18.7	4.4
Malta	418	528 (26%)	10.7	13.6	11.2	13.6	13.6	7.4	7.4	8.6	11.2	9.1	6.8	11.2	6.8	3.7	3.4	0.8
Morocco	1706	4327 (154%)	20.5	51.9	34.9	50.7	51.9	38.0	38.0	31.5	34.9	14.8	29.1	34.9	29.1	21.3	16.4	3.9
Monaco	35	51 (45%)	0.5	0.7	0.7	0.3	0.7	0.5	0.5	0.7	0.7	0.1	0.7	0.7	0.7	0.5	0.3	0.1
Slovenia	94	125 (32%)	1.6	2.1	2.1	1.5	0.5	1.6	0.4	1.8	1.8	2.1	1.6	1.1	1.3	1.0	0.6	0.2
Spain	6764	8160 (21%)	98.8	119.2	119.2	80.8	118.0	67.3	66.6	115.2	118.8	29.5	112.3	117.9	111.9	63.1	70.1	15.1
Tunisia	4164	9631 (131%)	37.8	87.3	87.3	74.9	84.4	65.1	62.9	75.3	87.3	47.5	66.6	87.3	66.6	49.6	43.8	8.4
Turkey	5663	13097 (131%)	44.4	102.7	102.7	80.5	102.7	78.8	78.8	86.7	95.5	88.0	75.2	80.3	68.0	52.2	35.0	14.0
Syria	813	2596 (219%)	14.8	47.4	47.4	47.4	47.4	33.7	33.7	33.6	47.4	47.4	23.7	47.4	23.7	16.8	11.8	2.8
Gaza	1221	3723 (205%)	7.1	28.5	28.5	26.9	28.5	23.7	23.7	21.2	28.5	25.6	16.0	28.5	16.0	13.2	8.0	1.9
Montenegro	84	140 (67%)	1.7	2.9	2.9	2.9	2.9	2.0	2.0	2.1	2.9	2.9	1.4	2.9	1.4	1.0	0.7	0.2
Total	***76003***	***130425 (72%)***	***932***	***1598***	***1524***	***1335***	***1198***	***1132***	***852***	***1315***	***1443***	***1069***	***1163***	***1274***	***1082***	***760***	***627***	***140***

Table S6:

	Baseline P discharge (2003)	No mitigation (Scenario A)	All WWTPs operational: no treatment upgrades	50% treated waste-water re-used (Scenario B)	Min tertiary treatment in eutrophic areas (Scenario C)	Detergent legislation in all countries (Scenario D)	Min tertiary treatment in eutrophic areas + detergent legislation (Scenario E)	No treatment to primary + all WWTPs operational	Upgrade primary to secondary + all WWTPs operational	Upgrade secondary to tertiary+ all WWTPs operational	No treatment to secondary + all WWTPs operational	Upgrade primary to tertiary + all WWTPs operational	Min secondary treatment + all WWTPs operational (Scenario F)	Min secondary treatment+ WWTPs operational + detergent legislation (Scenario G)	Min secondary treatment+ WWTPs operational +50% treated wastewater re-used (Scenario H)	Min tertiary treatment + all WWTPs operational (Scenario I)
Regional								10^6 mol yr^{-1}								
WMS	353	636	586	498	597	462	437	533	560	313	495	504	468	334	271	59
EMS	579	1395	1318	1238	1088	1064	836	1093	1255	1039	931	1122	867	658	494	114
NMC	479	633	608	435	512	440	361	573	582	261	547	529	521	360	292	67
EMC	222	586	586	555	540	453	417	442	572	555	337	543	323	250	172	45
SMC	230	813	710	746	634	634	495	613	660	535	542	553	491	383	301	61
Country																
Albania	2.6	14.5	14.5	14.5	14.5	11.1	11.1	10.3	14.5	14.5	7.2	14.5	7.2	5.6	3.6	0.9
Algeria	47.3	151.1	141.1	138.3	151.1	117.9	117.9	111.0	133.8	129.8	89.3	118.5	82.0	63.9	41.6	9.8
Cyprus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Croatia	19.5	34.8	34.8	29.2	33.3	23.9	22.9	27.9	31.5	34.8	23.0	24.5	19.7	13.5	9.8	2.4
Egypt	95.0	336.1	327.9	298.7	160.4	261.3	124.7	285.9	284.7	295.3	255.4	194.3	212.3	165.0	143.8	25.5
France	79.8	102.3	102.3	62.8	68.1	64.9	43.2	101.9	86.1	61.6	101.6	52.2	85.4	54.2	51.9	10.3
Greece	103.5	116.5	114.5	71.4	46.5	73.6	29.4	110.8	114.5	26.4	108.1	114.5	108.1	68.3	58.9	14.5
Israel	4.1	6.4	6.4	6.4	3.1	3.8	1.8	6.4	5.4	3.9	6.4	3.1	5.4	3.1	5.4	0.6
Italy	160.3	218.6	198.4	150.5	206.2	182.2	171.9	187.7	193.1	73.9	180.0	181.9	174.6	145.6	90.3	22.7
Lebanon	152.1	331.9	331.9	331.9	288.7	255.3	222.1	240.4	327.0	331.9	174.1	316.9	169.3	130.2	90.4	20.3
Libya	29.6	146.6	84.2	146.6	146.6	114.4	114.4	78.9	84.0	27.6	75.0	83.5	74.8	58.4	39.0	9.5
Malta	10.7	13.6	11.2	13.6	13.6	7.5	7.5	8.7	11.2	9.2	6.8	11.2	6.8	3.8	3.4	0.8
Morocco	20.5	67.8	45.6	66.2	67.8	52.8	52.8	41.1	45.6	19.8	37.8	45.6	37.8	29.5	21.3	5.2
Monaco	0.5	0.7	0.7	0.3	0.7	0.5	0.5	0.7	0.7	0.1	0.7	0.7	0.7	0.5	0.3	0.1
Slovenia	1.6	2.3	2.3	1.7	1.2	1.8	0.9	2.0	2.0	2.3	1.8	1.2	1.4	1.1	0.7	0.2
Spain	98.8	125.9	125.9	87.1	124.6	71.7	70.9	120.3	125.5	35.2	116.2	124.6	115.8	65.9	72.2	15.6
Tunisia	37.8	111.6	111.6	96.3	107.8	87.7	84.7	95.7	111.6	62.4	84.1	111.6	84.1	66.1	55.1	10.7
Turkey	44.4	124.2	124.2	95.9	124.2	97.7	97.7	105.6	116.3	100.6	92.1	99.8	84.2	66.3	43.7	15.9
Syria	14.8	61.2	61.2	61.2	61.2	47.4	47.4	43.4	61.2	61.2	30.6	61.2	30.6	23.7	15.3	3.7
Gaza	7.1	62.4	62.4	59.8	62.4	48.4	48.4	45.7	62.4	57.9	33.7	62.4	33.7	26.1	16.9	4.0
Montenegro	1.7	3.4	3.4	3.4	3.4	2.5	2.5	2.4	3.4	3.4	1.7	3.4	1.7	1.3	0.8	0.2
Total	***932***	***2032***	***1904***	***1736***	***1685***	***1526***	***1273***	***1627***	***1814***	***1351***	***1426***	***1625***	***1336***	***992***	***764***	***173***

2050 P treatment options

Table S7:

Country	Gross 2003 Protein Supply (kg capita^{-1} yr^{-1})	P_{diet} (kg capita^{-1} yr^{-1})	P_L (kg capita^{-1} yr^{-1})	P_D (kg capita^{-1} yr^{-1})	P_{capita} (kg capita^{-1} yr^{-1})	$N_{diet}=N_{capita}$ (kg capita^{-1} yr^{-1})
Albania	35.7	0.46	0.18	0	0.64	4.58
Algeria	31.0	0.42	0.18	0	0.60	4.18
Croatia	27.6	0.35	0.28	0	0.63	3.54
Egypt	34.3	0.46	0.18	0	0.64	4.63
France	42.9	0.55	0.23	0.18	0.97	5.50
Gaza	63.7	0.31	0.18***	0***	0.50	3.14
Greece	42.7	0.55	0.26	0.14	0.95	5.47
Israel	45.6	0.62	0.36	0.13	1.10	6.15
Italy	41.1	0.53	0	0.14	0.67	5.27
Lebanon	30.9	0.42	0.19	0	0.61	4.17
Libya	27.9	0.38	0.18**	0**	0.55	3.76
Malta	41.5	0.53	0.42	0.11	1.06	5.32
Monaco	nd	0.55*	0	0.26	0.81	5.50*
Montenegro	nd	nd	nd	nd	0.64****	4.27****
Morocco	32.1	0.43	0.18	0	0.61	4.33
Slovenia	36.5	0.47	0	0.18	0.65	4.68
Spain	41.1	0.53	0.36	0.13	1.02	5.27
Syria	29.5	0.40	0.18	0	0.58	3.98
Tunisia	33.3	0.45	0.17	0	0.62	4.49
Turkey	37.3	0.50	0.17	0	0.67	5.03

nd= no data; *Used estimate for France as protein supply not reported; ** Calculated using average of North African countries; ***Calculated using Syrian values; ****average of Albania, Croatia and Slovenia.

Table S8:

Country	Year	Connected (f_c)	Connected with treatment (f_t)	Connected without treatment (f_u)	Not connected (f_n)
Algeria[a]	2008/2009	0.86	0.53	0.33	0.14
Albania[b]	2002	0.597	0.573	0.024	0.403
Croatia[a]	2008	0.442	0.273	0.169	0.558
Cyprus[c]	2003	0.23	0.23	0	0.77
Egypt[d]	nd	0.538	nd	nd	0.538
France[c]	2004	0.82	0.80	0.02	0
Greece[c]	2007	0.85	0.85	0	0.18
Italy[a]	1999/2005	0.94	0.69	0.25	0.06
Israel[a]	2007	0.938	0.910	0.028	0.062
Libya[e]	nd	0.743	0.598	0.145	0.257
Malta[c]	2003	1.0	0.36	0.64	0
Monaco[a]	2009	1.0	1.00	0	0
Morocco[a]	2000/2005	0.872	0.80	0.072	0.128
Slovenia[c]	2003	0.47	0.26	0.21	0.53
Spain[c]	2006	0.96	0.91	0.05	0.04
Syria[d]	nd	0.71	0.16	0.55	0.29
Tunisia[a]	2008	0.559	0.525	0.034	0.441
Turkey[c]	2003	0.67	0.30	0.37	0.33

nd = no data; [a] UNstat [27]; [b] average of Eastern countries [28]; [c] Eurostat [29]; [d] WHO [11]; [e] Average of North African countries.

Table S9:

	% P retained	% N retained
Untreated	0	0
Pre-treatment	0	0
Primary	29 [a] (10-30) [a b]	25 [a] (10-25) [a b]
Secondary	50 [a] (45-90) [a b]	45 [a] (35-55) [a b]
Tertiary	94 [a] (88-95) [a b]	60 [a] (45-83) [a b]

[a] Kristensen, et al. [7]; [b] Van Drecht, et al. [3]

Table S10:

	High estimate	Low estimate
Pop^t	Population equivalent (if stated)**	Permanent population (if stated)
f_c*	• Increase f_c by 10%*** • Increase untreated fraction of f_c by 10%***	• Decrease f_c by 10%**** • Decrease untreated fraction of f_c by 10%****
f_R	Minimum in range for each treatment type (Table S9)	Maximum in range for each treatment type (Table S9)
Treatment type*	Primary	Tertiary

*when none stated in UNEP/MAP/MED-POL/WHO [5, 6]; **Population equivalent includes population connected to sewage system when greater than population; *** to a maximum of 100%; ****to a minimum of 0%.

Table S11:

Parameter	Uncertainty (+/-)%
Protein supplied	10*
Retail losses	10
N fraction of protein	5*
N:P protein	5
f_H	5
P_L	15**
P_D	15**

*[2]; **If no P in detergent in original calculation assume 0.17 and 0.1 kg P capita^{-1} yr^{-1} for upper uncertainty of P_L and P_D (lowest non-zero value reported)

Table S12:

Country	No. of settlements	Population	Treatment Facilities	Predominant treatment type	Discharge outlet	Calculation	P estimate (10^6 mol yr^1)	N estimate (10^6 mol yr^{-1})
Albania	3	17,200	None	None	Direct (surface)/cesspools	P,N$_{capita}$* pop*100% connectivity	0.4	5.6
Croatia	83	368,042	51% settlements served by WWTP	Pretreatment	Submarine outfalls	P,N$_{capita}$ *pop*100% connectivity	7.5	93.1
Cyprus	24	106,958	33% settlements served by WWTP	Tertiary	Treated: re-used Untreated: septic tanks	n/a	0	0
Egypt	12	65,458	17% settlements served by WWTP	Secondary	Treated: sea by canals Untreated: soil	P,N$_{capita}$ * pop*100% connectivity*(1-secondary f$_R$	0.7	11.9
France	77	762,100	Almost all settlements have WWTP, only 41% of settlements discharge to sea	Secondary	Submarine outfalls/direct (surface)	P,N$_{capita}$ * pop*100% connectivity*(1-secondary f$_R$)*0.41	4.9	67.5
Greece	178	764,580	31% settlements served by WWTP, 42% no treatment, 23% WWTP under construction	Tertiary	Treated: Direct (surface)/submarine outfall. Untreated: septic tanks	P,N$_{capita}$ * pop*100% connectivity*(1-tertiary f$_R$)*0.31	0.4	37.1
Israel	8	44982	100% settlements served by WWTP	Secondary	Water mainly reused	n/a	0	0
Italy	117	652,231	79% of settlements served by WWTP, 3% WWTP under construction.	Primary	nd	P,N$_{capita}$ * pop*100% connectivity*(1-primary f$_R$)	10.0	184.2
Italy > 10,000 pop	123	5,392,791		Secondary	nd	(P,N$_{capita}$ * pop*av. country connectivity to treatment*(1-secondary f$_R$) + (P,N$_{capita}$ *pop*av. country connectivity to no treatment)	69.2	1278.0
Lebanon	13	5,675,000	3 settlements have WWTP, remainder: projected to have WWTP.	None	nd	P,N$_{capita}$ *pop*100% connectivity	111.0	1689.4
Libya	15	19497	27% settlements served by WWTP	Primary	Submarine outfalls	P,N$_{capita}$ *pop*100% connectivity*(1-primary f$_R$)	0.2	3.9
Malta	42	204221	14% settlements served by WWTP, 86% WWTP under construction	None	Untreated: submarine outfalls/direct (surface)	P,N$_{capita}$ * pop*100% connectivity	7.0	77.6
Montenegro	9	83808	None	None	Submarine outfalls	P,N$_{capita}$ (average of Albania, Croatia and Slovenia)* pop*100% connectivity	1.7	25.5
Morocco	38	232748	74% settlements served by WWTP, 5% WWTP under construction	Secondary	nd	P,N$_{capita}$ * pop*100% connectivity*(1-secondary f$_R$)	2.3	39.6
Slovenia	5	18045	100% settlements served by WWTP	Primary	Submarine outfalls/ estuaries	P,N$_{capita}$ * pop*100% connectivity*(1-primary f$_R$)	0.3	4.5
Spain	76	351654	95% settlements served by WWTP.	Secondary	Submarine outfall/ re-used	P,N$_{capita}$ * pop*100% connectivity*(1-secondary f$_R$)	5.8	72.7
Syria	53	205776	None	None	Submarine outfalls/direct (surface)	P,N$_{capita}$ * pop*100% connectivity	3.9	58.4
Tunisia	26	181229	92% settlements served by WWTP	Secondary	Direct (surface)	P,N$_{capita}$ * pop*100% connectivity*(1-secondary f$_R$)	1.8	32.0
Turkey	192	878242	81% settlements not served by WWTP	None	Submarine outfalls	P,N$_{capita}$ * pop*100% connectivity	19.1	315.5

nd= no data; n/a = not applicable

Table S13:

	Untreated [a,b]	Primary [c,*]	Secondary [c]	Tertiary [c]
Phosphorus				
DIP	44	49 (21-64)	40 (1.3-90)	10 (1.3-73)
PIP	27	23 (8-57)	15 (0.6-70)	22 (3-70)
POP	22	21 (3-39)	31 (0.2-81)	37 (7-79)
DOP[†]	7	7 (1-15)	14 (1.3-52)	31 (3-86)
	Untreated	Primary [d]	Secondary [b]	Tertiary [b]
Nitrogen				
NO_3	0[d] (0-1)[b]	0	36 (0.7-91)	75.5 (75-76)
PON	16[d] (13-18)[b]	6.5	4 (2-7)	3.5(3.5-4.0)
DON	9[d] (6-26)[b]	10.5	8 (5-11)	6 (3-8)
NH_4	75[d] (60-75)[b]	83	52 (0.3-81)	15 (13-17)

[a] Lopez-Vazquez, et al. [15]; [b] Servais, et al. [16]; [c] Gu, et al. [13]; [d] Rössle [14] *Calculated from raw sewerage P values in Metcalfe & Eddy Inc [30] [†] Acid hydrolysable P is considered as DOP

Table S14:

	mg TP L^{-1}	Cost € m^{-3}
Primary	8.52	0.23[ab]
Secondary	6	0.35[a]
Tertiary	0.72	0.50[a]

[a] Hidalgo and Irusta [31] [b] Somlyódy and Shanahan [20]

Table S15:

Country	% of treated wastewater recycled	Year
Albania	ns	n/a
Algeria	3.1	2012
Croatia	ns	n/a
Cyprus	95	2005, 2007
Egypt	28.6	1993, 1996
France	10.9	2008
Greece	4.8	2003, 2007
Israel	87.8	2004, 2007
Italy	2.2	2004, 2006, 2007
Lebanon	50	1991
Libya	100	2008
Malta	100	1993
Monaco	ns	n/a
Morocco	0.3	2008, 2010
Slovenia	ns	n/a
Spain	11.2-15.7	2002, 2004, 2006
Syria	100	2009, 2012
Turkey	3	2004
Tunisia	23	2003

ns = not stated; n/a = not applicable

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