Nitrogen fluxes due to agricultural activities and wastewater management in Turkey

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Introduction and Problem Statement

Global nitrogen balance has been destroyed owing to increasing population and anthropogenic activities mainly food and energy production. The loss of reactive nitrogen (Nr) to the environment as well as its accumulation in the environmental reservoirs cause many adverse impacts on the ecosystems and human health (Vitousek et al., 1997; Galloway et al., 2004). Consequently, the earth is growing older in a faster manner. There is an urgent need to manage and control reactive nitrogen concentration in the ecosystems. As a developing country with growing population and depending on agricultural production and industrial activities as major economical driving forces, Nr management will be a challenging environmental issue for Turkey in the near future. In this study, we conducted a trend analysis of major N fluxes produced/consumed in two major anthropogenic sectors contributing to N-budget of Turkey; agricultural activities and wastewater management.

Methodology

An inventory of N-fluxes were established via constructing excel database for agriculture and wastewater sectors. Total utilized agricultural land was divided into three parts as; 1-total arable land, 2- total land under permanent crops and 3-land under permanent meadows and pastures. Sum of 1 and 2 were used as total crop cultivation land. A mass balance for soil due to agricultural activities is conducted and the residual nitrogen (N surplus) was calculated. Four different fertilization intensity analyses were conducted with respect to either only chemical fertilizer or sum of manure and chemical fertilizer applied over both of crop cultivation land and total utilized agricultural land. Total utilized agricultural land, crop production and livestock raising data used were obtained from Turkish Statistical Institute (TurkStat, 2019). Synthetic fertilizer consumption data is obtained from Ministry of Agriculture and Forestry. Data obtained from literature findings and reports published by OECD reports are used for determining the nitrogen uptake coefficient of each plant cultivated, nitrogen produced by each type of animal (OECD, 2007 and 2008). Wastewater sector included the flowrates of treated/untreated wastewater collected by municipal sewerage system, N content of untreated wastewater, the related N-treatment efficiencies for each type of treatment method and the corresponding flowrates of discharge to different environmental reservoirs from both treated and untreated wastewater in proportional with the flowrates. Municipal wastewater is subject to physical, biological and advanced treatment as well as natural treatment in Turkey. The N treatment efficiency values for each type of treatment method were determined according to literature data The residual nitrogen after treatment is distributed to the environmental reservoirs based on the flow rates for these reservoirs reported by Turkish Statistical Institute (TurkStat, 2019).

Results and Discussion

Results showed that total chemical fertilizer-N consumption followed a variable trend changing between 1104 and 1764 kilotons declining at the economic crisis years. Total N uptake by crops fluctuated between 872 - 2011 kilotons. Nitrogen fixation by legumes and free-living bacteria found to be 275 and 152 tons respectively as of year 2017 (Fig 1). Cattle breeding produced the highest amount of nitrogen (1270 kilotons at 2017) followed by sheep and goat farming (576 kilotons at 2017), poultry raising (140 kilotons at 2017) and other animals (11.4 kilotons at 2017) respectively (Fig 2). N uptake by cereals were highest among the other crop types (Fig 3). N surplus (for total utilized agricultural land) fluctuated between 9-32 kg/ha with a minimum residual N value of 337 kilotons (at 2011) and maximum value of 1282 kilotons (at 1993) (Fig 4).

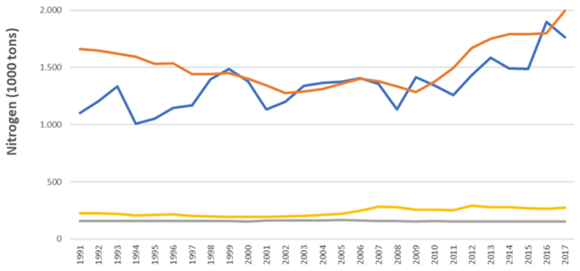

Figure 1. Nitrogen input to soil due to agricultural activities

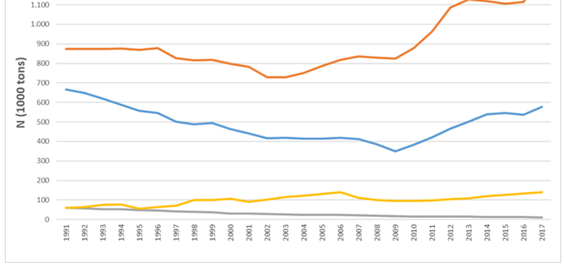

Figure 2. Nitrogen Excreted in Manure by Livestock Groups

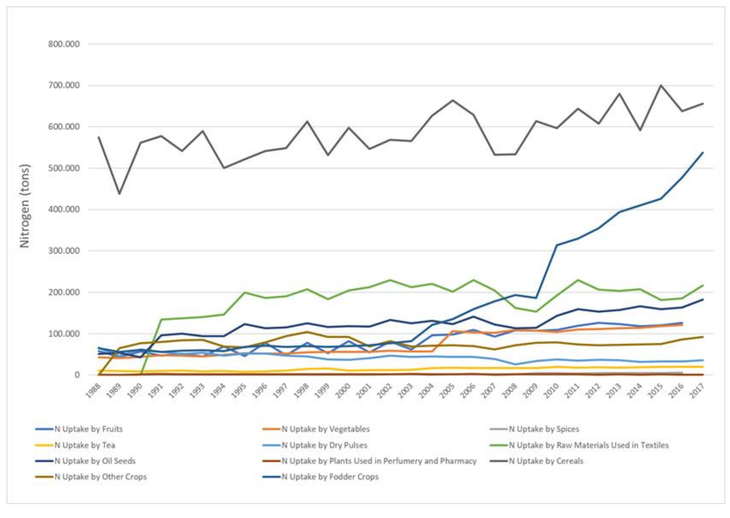

Figure 3. Nitrogen uptake by different crop types

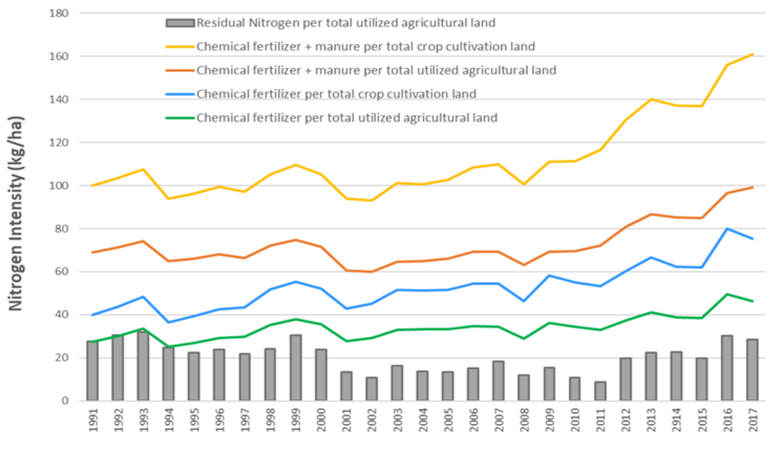

Figure 4. Nitrogen fertilization intensities with respect to agricultural land

Municipal wastewater treatment ratio followed an increasing trend and reached to almost 88 % at 2018 from 19% at 1994 and the total N (sum of treated and untreated) discharged to environmental reservoirs due to wastewater management doubled (from 60 to 114 kilotons). Almost half of the total 114269 tons of residual N in municipal wastewater was discharged to rivers (54966 tons) and 38% was discharged to sea. The amount of total N discharged to rivers increased ~1.5 folds while total N discharged to seas increased by ~2 folds from 1994 to 2018 (Fig 5).

The relative amounts of treated and untreated wastewater N changed considerably during this time period; although the ratio of untreated wastewater was 86% in total wastewater at 1994, the ratio of treated wastewater N increased up to 94% whereas the ratio of untreated wastewater decreased to 4%. Analyzing the final destination of the residual N for treated and untreated N separately, majority of the treated wastewater is discharged to sea followed by rivers with an increasing trend and their amount became almost equal at 2018. On the other hand, majority of the untreated wastewater is discharged to rivers followed by seas with a decreasing trend (Figures 6 and 7).

Figure 5. Total N discharged to receiving bodies via wastewater

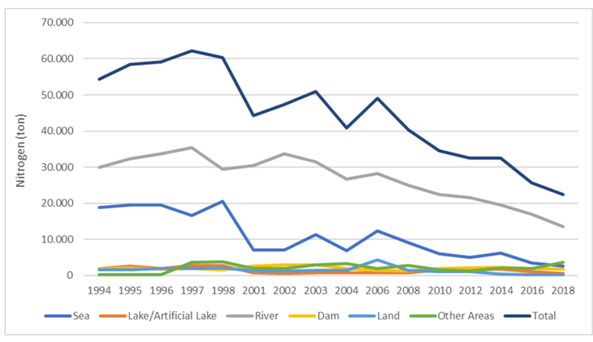

Figure 6. Total N discharged to receiving bodies via untreated wastewater

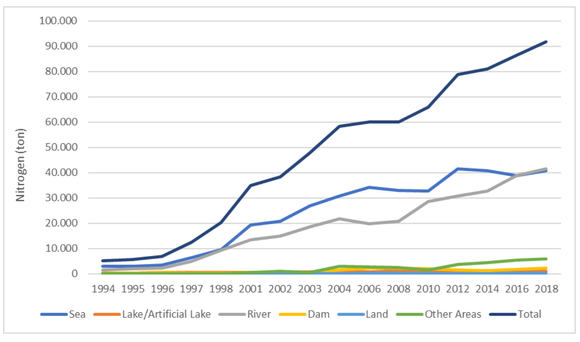

Figure 7. Total N discharged to receiving bodies via treated wastewater

Conclusion and Recommendations

- Food production is one of the major sources of Nr in the environment. It is crucial and possible to establish a balance in between Nr emissions, livestock breeding and synthetic fertilizer use by improving nutrient use efficiencies (NUE) in both crop production and livestock breeding having positive effects on economy and environment.

- Although amount of wastewater Nr is much less compared to agricultural Nr production, it threatens the aquatic ecosystems where local Nr concentrations are high. Time dependent increase of wastewater discharge and nitrogen release to the inland waters must be evaluated not only for the risk of eutrophication and population shifts among species, but for the potential contribution to global warming, since CH_4 and N_2O emissions are also affected from these increases. Advanced wastewater treatment methods must be included in the typical treatment processes in addition to organic materials oxidation and also recycling of nitrogen from wastewater systems needs to be enhanced.

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