

Determination of nitrogen pollution amount from livestock breeding in Turkey

Türkiye’de hayvancılık faaliyetlerinden kaynaklanan azot kirliliği miktarının belirlenmesi

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• Geliş tarihi / Received: 21.04.2021

• Düzeltilerek geliş tarihi / Received in revised form: 20.08.2021

• Kabul tarihi / Accepted: 04.09.2021

Abstract

Nitrogen (N) pollution is gradually increasing from agriculture production. Nitrogen pollution derived from agriculture has important components using overuse chemical fertilizers, excess amount formation of manure and incorrect manure management systems etc. Nitrogen compounds that take up with the soil, water and air with the nitrogen cycle cause various environmental problems. It is a critical issue that needs to be studied on, as the efficiency and production decrease will be encountered by decreasing the nitrogen rate in reducing nitrogen pollution. In this paper, the estimation of nitrogen pollution derived from livestock production in Turkey and aimed need to focus points to be considered. The nitrogen pollution load created by farm animals in 2019 is 1 062 004 tons N/year and 834 381 tons N/year in 2020 in Turkey. Cattle are the animal species that have the greatest effect on nitrogen excretion. Because the daily manure production amounts are higher than other types, and the moisture content is high. Therefore, processing and control are more difficult than other species. The integrated approach is needed to reduce elementary nitrogen formation due to the gradual formation of nitrogen from agricultural systems and intensive agriculture areas.

Keywords: Livestock animal, Manure, Nitrogen

Öz

Tarımsal üretimden kaynaklanan azot (N) kirliliği giderek artmaktadır. Tarımda azot kirliliğinin en önemli bileşenleri; kimyasal gübre kullanımı, doğal gübre oluşumu ile yanlış gübre yönetim sistemleridir. Azot döngüsü ile toprağa, suya ve havaya karışan azot bileşikleri çeşitli çevresel problemlere neden olmaktadır. Azot kirliliğinin azaltılmasında azot oranının düşürülmesiyle verim ve üretim düşüşüyle karşılaşılacağından üzerinde durulması gereken kritik bir konudur. Bu çalışmada, Türkiye’deki çiftlik hayvanlarından kaynaklanan gübre üretiminin neden olduğu azot kirliliği boyutunun belirlenmesi ve üzerinde durulması gereken noktaların ortaya konulması hedeflenmiştir. Türkiye’de 2019 yılında çiftlik hayvanlarının oluşturduğu azot kirlilik yükü 1 062 004 ton N/yıl iken 2020 yılında 834 381 ton N/yıl’dır. Azot atılımına en büyük etkide bulunan hayvan türü büyükbaş hayvanlardır. Çünkü günlük olarak gübre üretim miktarları diğer türlere göre daha fazladır ve nem içeriği yüksektir. Bundan dolayı işlenmesi ve kontrol altına alınması diğer türlere göre daha zor olmaktadır. Tarımsal sistemlerden ve yoğun tarım uygulanan alanlardan kaynaklanan azotun kademeli oluşması nedeniyle, elementer azot oluşumunun azaltılması için entegre bir yaklaşıma ihtiyaç bulunmaktadır.

Keywords: Çiftlik hayvanı, Gübre, Azot

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1. Introduction

Nitrogen pollution is on the way to becoming one of the most dangerous environmental problems in the world. Nitrogen pollution's the main source of in the world is the agricultural sector. Main sources of agricultural nitrogen pollution; excessive use of chemical fertilizers and not managing fertilizer and waste management systems correctly (Günel, 2019). It is possible to reduce the harmful effects caused by nitrogen by reducing the application of chemical fertilizers with nitrogen and reducing the feed protein content in animals. However, food production, efficiency and global food security should not be compromised. Although this problem is not sufficiently emphasized, it does not seem easy to develop and implement a nitrogen pollution prevention or reduction strategy.

Manure and faeces are the main sources of nitrogen pollution on livestock farms. The non-digestible part of the protein taken with the feed, that is, organic nitrogen, is thrown out with manure and feces. In animal feed, feeds with high protein content are generally preferred. However, high protein feeds do not always affect the yield in non-productive animals. Contrary, indigestible protein increases nitrogen excretion along with manure and feces. Nutrients that cannot be undigested by animals are excreted as urea ($\text{CO}(\text{NH}_2)_2$) in mammals and as uric acid ($\text{C}_5\text{H}_4\text{O}_3\text{N}_4$) in poultry through manure and feces as N (Yaylı and Kılıç, 2021). The hydrolysis of urea forms ammonia by urease enzymes in an anaerobic environment. Uric acid, on the other hand, is broken down by microorganisms and bacteria to form ammonia.

Failure to properly and planned manure management systems in livestock enterprises causes environmental pollution. Storing the manure without taking the necessary precautions and exposing it to rainwater causes the amount of N and K_2O in the manure to decrease. In incorrect storage and manure management systems, the leakage of N from the manure into the soil causes pollution in the surface and groundwater (Boyacı et al., 2011).

The most important nitrogen gases emitted by anthropogenic activities are nitrogen oxides (NO_x), nitrous oxide (N_2O), and ammonia (NH_3) (Behera et al., 2013). Nitrogen consists of different forms as a result of the microbial breakdown of manure in livestock animals. The main source of reactive nitrogen from manure and feces is the NH_3 and N_2O compounds. Reactive nitrogen can easily be displaced by the nitrogen cycle in air, water and

soil. Nitrogen fixation occurs when free nitrogen in the atmosphere is retained by bacteria and transforms into NH_4 form that plants can use (Karaşahin, 2014). Nitrification takes place by converting ammonium (NH_4^+) to nitrite (NO_2^-) by Nitrosomonas bacteria, and nitrite to nitrate (NO_3^-) with Nitrobacter. Nitrite is an intermediate product in nitrification and quickly turns into nitrate form. Denitrification processes take place by reducing nitrate and nitrite and turning them back into elemental nitrogen gas. In the denitrification process, N_2O is formed by the reduction of nitrate. N_2O greenhouse gas has a great potential for global warming (1 kg of N_2O gas is 298 kg CO_2 equivalent).

Some of the ammonia that microorganisms can not use in animals digestive systems is thrown out, and nitrogen loss occurs. Ammonia is a key component in the global nitrogen cycle and plays an important role (Ti et al., 2019; Erisman et al., 2007; Leip et al., 2015; Galloway et al., 2003). Ammonia can contribute to the greenhouse effect by contributing to soil acidification, water eutrophication, biodiversity loss and nitrous oxide formation when it returns to the earth through nitrogen accumulation through the nitrogen cycle (Erisman et al., 2007; Hou and Yu, 2020). Ammonia emissions from livestock farms are also the main source of particulate matter in the atmosphere (Dai et al., 2019). Nitrate (NO_3^-), an important component formed in the nitrogen cycle, causes it to become eutrophic by mixing in water resources. Nitrate, which is an output in livestock production, increases daily as an input in crop production and causes greater pollution, especially in water resources. There is a determining the pollution on the water resources caused by nitrates of agricultural origin and the prevention convenience Regulation on the Protection of Waters against Agricultural Nitrate Pollution in Turkey. According to this regulation, water resources' eutrophication potential containing more than 50 mg/L of nitrate is determined (Anonymous, 2016). Also, nitrogen compounds cause toxicological problems in underground and aboveground sources, apart from eutrophication, affecting the oxygen concentration and drinking water (Ardıç, 2013).

In this study, to determine the size of the nitrogen manure amount of pollution caused consisting of animal species from the agricultural sector in Turkey.

2. Materials and method

In this study, taking into account, the animal species in Turkey are intended to estimate the actual size of the nitrogen pollution arising from livestock operations and the determination of the points to be focused on.

Turkey seems a general upward trend in the presence of livestock animals in 2020 (Table 1). With the increasing demand for livestock products, the amount of manure created by the increase in livestock animals' number becomes difficult to manage (Chadwick et al., 2020).

Table 1. Livestock numbers (head/year) (TUIK, 2021)

Livestock animals	2019	2020	Change (%)
Culture breed cattle	3 793 401	1 245 275	-67.17
Culture hybrid cattle	3 121 495	1 039 112	-66.71
Calf-Heifer (Culture breed)	1 214 030	1 245 275	2.57
Calf-Heifer (Culture hybrid)	1 043 498	1 039 112	-0.42
Indigenous cow	664 597	644 800	-2.98
Bull	836 561	958 017	14.52
Calf-Heifer (indigenous)	218 841	213 112	-2.62
Bullock	14 074	19 775	40.51
Laying hen	120 725 299	121 302 869	0.48
Broiler	221 841 860	258 046 340	16.32
Turkey	4 541 102	4 797 793	5.65
Buffalo (female)	45 337	45 853	1.14
Buffalo (male)	110 802	117 935	6.44
Sheep	37 276 050	42 126 781	13.01
Goat	11 205 429	11 441 418	2.11

According to animal species, there were obtained from the Pasture Regulation necessary reference values for nitrogen conversion coefficients (Table 2). Bovine animal unit (BBHB) is the reference value initially established according to each type of animals nutritional or feed needs. Culture breed dairy cow was taken as a bovine unit. According to regulation, it is taken as a basis that 2.5% of dry grass or 10% of green grass will be fed to animals daily live weight (Mera Yönetmeliği, 1998). According to these reference values, animal species average amount of nitrogen excretion per year is given in Table 2. Poultry manure contains

higher dry matter (DM) and N, while cattle manure is rich in organic matter (OM) and organic carbon (OC) (Kılıç et al., 2014). The nitrogen pollution per unit of poultry is higher than other livestock animal species. Because in poultry, feeds with high nutritional value are given to produce abundantly in a short time. The non-digestible part is thrown away with the manure, and its nitrogen content is high (İnal et al., 1996; Özdemir and Sezer, 2013; Görmüş, 2018). However, more nitrogen excretion occurs, especially due to the high daily manure amounts of cattle.

Table 2. Annual nitrogen amount consisting of bovine unit values and animal manure by animal species

Livestock animals	BBHB conversion coefficient	kg N / yıl.BBHB
Laying hen	0.004	85
Broiler	0.0025	85
Turkey	0.02	85
Süt sığırı		
Culture breed cattle	1	
Calf-Heifer (Culture breed)	0.6	
Culture hybrid cattle	0.75	70
Calf-Heifer (Culture hybrid)	0.45	
Indigenous cow	0.5	
Calf-Heifer (indigenous)	0.3	
Sheep	0.1	70
Goat	0.08	70
Buffalo		
Buffalo (male)	0.9	70
Buffalo (female)	0.75	
Bullock	0.6	70
Bull	1.5	70

3. Discussion and conclusion

According to the calculations made, it is seen that the N excretions of bovine animals and ovine are more than poultry (Table 3). The reason for this is that the daily manure amount of cattle is higher. Daily manure production of dairy cattle is 43 kg, beef cattle 29 kg, sheep 2.40 kg, goat 2.05 kg, broiler 0.19 kg, laying hen 0.13 kg and turkey 0.38

kg (Yağlı and Koç, 2019). Nitrogen excretion from livestock was 1 062 004 tons N/year in 2019 and 834 381 tons N/year in 2020. It is observed that this decrease in the rate of nitrogen excretion with fertilizer decreases with the decrease in the number of cattle. It is observed that this decrease in the rate of nitrogen excretion with manure decreases with the decrease in the number of cattle.

Table 3. Nitrogen excretion by livestock animal species (tons/year)

Livestock animals	2019	2020
Broiler	47 141	54 835
Laying hen	41 047	41 243
Turkey	7 720	8 156
Sheep	260 932	294 887
Goat	62 750	64 072
Culture breed cattle	265 538	87 169
Calf-Heifer (Culture breed)	50 989	52 302
Culture hybrid cattle	163 878	54 553
Calf-Heifer (Culture hybrid)	32 870	32 732
Indigenous cow	23 261	22 568
Calf-Heifer (indigenous)	4 596	4 475
Buffalo (male)	6 981	7 430
Buffalo (female)	2 380	2 407
Bull	87 839	100 592
Bullock	591	831

Manure management systems are critical in reducing nitrogen excretion, which increases with the increase in the number of livestock animals. According to Figure 1, it is seen that most of the nitrogen pollution is caused by cattle. Manure, especially in large enterprises and facilities, emerges as a significant problem. Bovine manure contains macro and micronutrients, and stable organic nitrogen in the barn decomposes slowly. Approximately 40-50% of nitrogen continues to decompose in the first year, 12-15% in the second year, 5-6% in the third year and less in other years (Çayır et al., 2012).

Livestock is rich in nitrogen, phosphorus and potassium, which increase crop yield and soil fertility. Beef manure and pig manure have a high moisture content (> 85%), while poultry, sheep and goats have relatively lower moisture content (70%). Solid manure has a higher nutrient density. It is easier to process, transport and use. Therefore, poultry, sheep, and goat manure have higher values than pig and cattle manure (Li, 2020).

When nitrogen pollution in poultry was examined, it was observed that more nitrogen was formed in broiler chickens. Because broiler chickens are bred in litter, they mix as of manure, excrement and litter. Since laying hens are generally cultivated in caged systems without litter, the

manure is in pure form without litter (Özdemir and Sezer, 2013).

It is seen that the highest N load occurs in the Eastern Anatolia region when nitrogen pollution caused by livestock farms is examined by region in 2020 (Table 4). Bovine and ovine livestock breeding is the animal species with the highest nitrogen pollution in the Eastern Anatolia region. There are limited economic activity areas since much cannot be cultivated due to the climatic conditions in this region. It is made mostly in the form of cold-enduring cattle and sheep pasture livestock.

As a result of this study, Turkey's nitrogen pollution potential can be projected for 2021 using the obtained values. According to TUIK's data, livestock animals' numbers showed an average annual increase of 5.1% in the last 10 years (Table 5). It is seen that there is an increase in all animal species except a bullock. Livestock animal numbers are expected to reach approximately 472 520 269 in 2021.

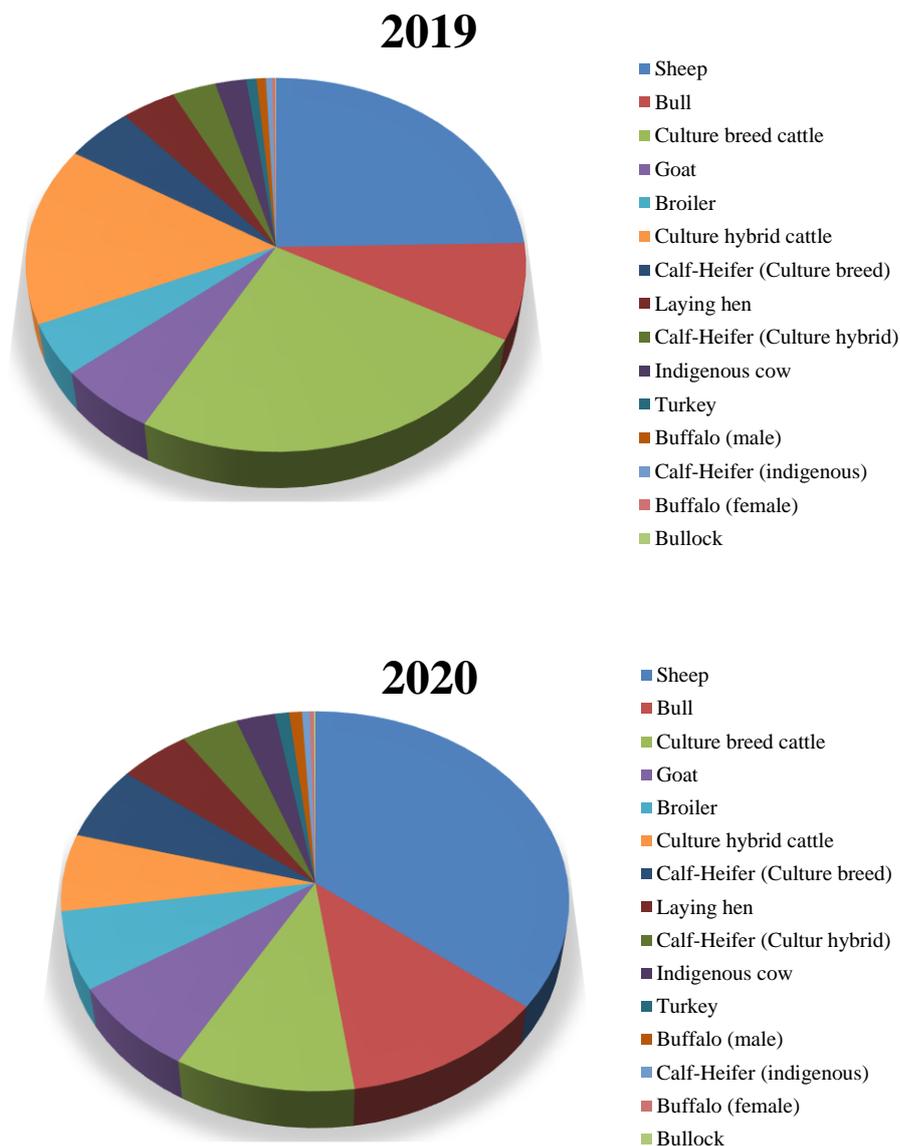


Figure 1. Contributions of N pollution by livestock animal

Table 4. Nitrogen pollution by regions (tons N/year)

	Mediterranean	Aegean	Black Sea	Southeastern Anatolia	Marmara Region	East Anatolia	Central Anatolia
Sheep	23 647	31 455	13 980	53 255	34 794	78 043	59 713
Goat	18 633	7 594	2 421	16 365	5 358	9 616	7 134
Cattle	33 077	70 529	60 933	39 262	56 065	91 211	81 479
Buffalo	177	633	3 072	884	2 259	1 326	1 166
Bullock	47	105	884	158	48	111	21
Bull	5 475	9 285	10 850	18 032	9 591	26 854	20 505
Laying Hen	2 242	14 169	3 311	3 217	7 998	1 699	8 608
Broiler	6 032	14 913	2 710	136	27 009	1 652	2 383
Turkey	78	3 533	163	624	2 927	586	245
Toplam	89 409	152 214	98 322	131 933	146 050	211 099	181 253

Table 5. Change rate of livestock numbers in the last 10 years

Livestock animal	Sheep	Goat	Cattle	Buffalo	Bullock	Bull	Laying Hen	Broiler	Hen
Change (%)	6.3	6.3	4.4	8.7	-2.9	7.2	5.6	4.8	5.4

As a result of the projection made by predicting that this increase will continue in 2021, the nitrogen pollution expected to occur according to livestock

animal species in 2021 is given in Figure 2. The expected livestock numbers are predicted to cause 1 061 762 tons N/year nitrogen pollution.

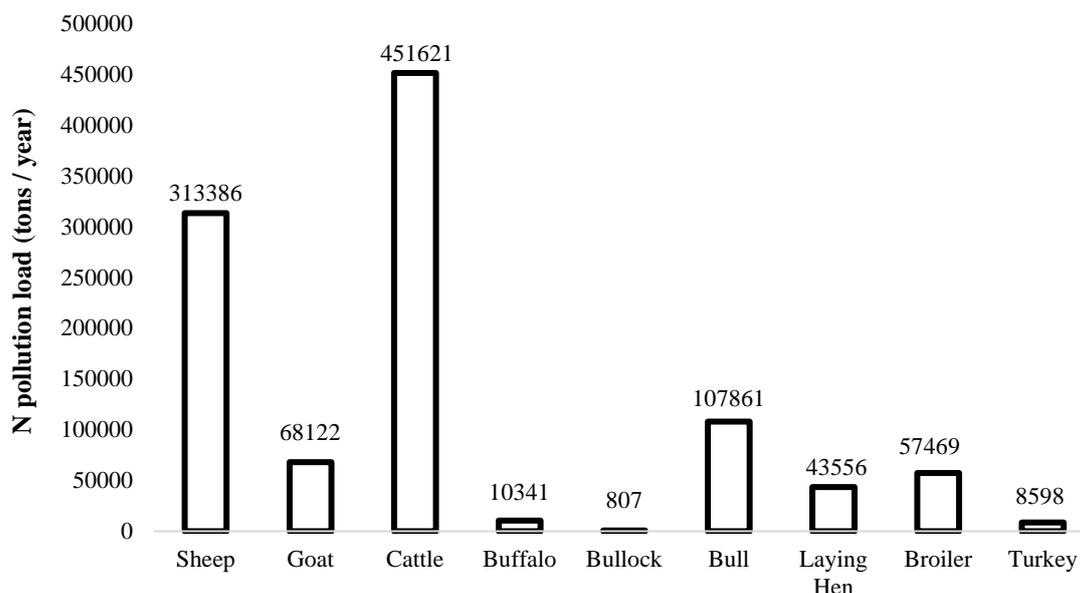


Figure 2. N pollution load projected for 2021 (tons/year)

In this study, the amount of nitrogen pollution discharged with manure from farm animals has been estimated from the general livestock animal numbers. Manure is in on into the atmosphere in the form of nitrogenous compounds by microbial breakdown in intensive livestock facilities. It also causes diffuse pollution by infiltrating ground and surface waters through runoff and leakage from pastures and agricultural lands. According to Turkish Environmental Legislation, livestock farms should be at least 500 m and an average of 1000 m away from residential areas. It should be at least 300 m away from lakes and water sources, at least 100 m away from irrigation and drainage channels, and at least 30 m from sanitary installations that provide water (Karaman, 2005; Parlakay et al., 2015; Yüksel and Şişman, 2015). Manure contains large amounts of N in organic form and is converted to inorganic form by mineralization, posing a serious risk to the environment. Manure is applied to the soil by spreading it once, so compared to chemical fertilizer, the N content is more mixed into ground and surface waters (Soyer and Yılmaz, 2020). Nitrogen excretion rates may vary according to the practices in the enterprises, the age, gender, breed, yield, and ration composition of the livestock. There is needed an integrated approach to reduce the formation of reactive nitrogen due to the gradual formation of nitrogen from agricultural systems and areas with intensive agriculture. In manure management practices, improvement

studies should be carried out at all stages such as housing, storage of manure, processing and application to the field. Manure storage areas and silos bottom must be well insulated so that manure does not leach with ground and surface waters. Directing the manure from animal production to biogas production will not only provide energy gain but also have positive environmental effects (Kayışoğlu and Göncü, 2020). Thus, considering that it will effectively reduce nitrogen emissions by converting the methane gas content of the manure into energy, it is thought to be one of the effective methods.

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