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Mapping the Dispersion Pollution Load of Animal Waste and Investigating its Environmental Effects: The Case of Karaman

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ABSTRACT

Animal wastes are not stored correctly and are used haphazardly without control in agricultural lands. As a result, it causes many irreparable environmental pollution, especially water pollution. These wastes, which are described as diffuse pollution, cause pollution of both underground and surface water resources directly or indirectly and even make them unusable. In this research, waste generation as a result of animal breeding in Karaman province, its districts, neighborhoods and villages and the effects of animal wastes on environmental pollution were evaluated with distributed pollutant load calculations. In the study, the number of 1019277 ovine and 81368 bovine in Karaman in 2022 was used. The total nitrogen (TN) produced annually by the animals has been calculated as 1,723.23 tons/year, and the total phosphorus (TP) amount is determined as 124.23 tons/year. Additionally, for large ruminant animals, the annual total amount of dry manure is 130,305.77 tons, and for small ruminant animals, it is 41,984.27 tons. To prevent environmental pollution, these wastes should be stored in closed areas in compliance with standards, and processes such as composting, drying, and biogas production should be applied. By doing so, not only can environmental pollution be mitigated but also economic value can be obtained. The proper management and utilization of these wastes have high economic potential and can contribute to sustainable development, supporting the country's economy. In addition, this study is a source for researchers working in the field in calculating the pollution load of animal wastes and is thought to be a guide for decision makers and practitioners.

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Introduction

Human beings are consumptive beings and as a result of their consumption, they generate waste. The waste generated as a result of this consumption varies depending on people's consumption habits. With the increase in population, both consumption and waste generation have increased. One of the most important consumption products is animal-based foods (Kocaman et al., 2015; Singh and Rashid, 2017). Looking at the supply-demand balance, livestock farming has increased in our country, as in the rest of the world, in order to meet the increasing demand. This increase naturally leads to a rapid increase in animal-derived waste and its uncontrolled release into the environment, causing disruption of the environmental balance, significant environmental pollution, and threats to environmental health, such as bad odor, flies, insects, and pathogenic microorganisms (Karaman, 2006; Singh and Rashid, 2017). Animal wastes differ from urban and industrial wastes in terms of their polluting nature and content. While the majority of domestic and industrial wastes fall into the category of point source pollutants, animal-based wastes belong to the category of non-point source pollutants and have the capacity to pollute larger areas (Tırınk, 2021). Non-point source pollutants particularly make it difficult to identify the sources of water pollution (Eleroğlu and Yıldırım, 2011).

Indeed, animal waste, which is classified as non-point source pollution, can mix with groundwater or surface water, leading to the deterioration or unusability of water sources' quality (Aydın and Derinöz, 2013; Yetiş et al., 2018). In most livestock farms, especially those operated in small family-style (1-5 and 6-10 cattle) settings, appropriate manure storage areas are lacking, and solid manure is accumulated haphazardly in open environments, while the liquid portion of the manure is discharged into surface water bodies without proper treatment, resulting in water pollution (Boyacı et al., 2011). During the transportation process of these wastes, factors such as the characteristics and quantities of pollutants, as well as important factors like soil structure, land cover, and topography, play a role in their impact on water sources

(Lenzi and Di Luzio, 1997; Akdoğan et al., 2015). When these wastes are not properly stored, they can contaminate surface water sources, and when accumulated in permeable soil areas, they can infiltrate downwards, reaching groundwater sources and causing contamination (Atılgan et al., 2006; Karaman, 2006; Boyacı et al., 2011; Yağlı and Yıldız, 2019). Additionally, animal manure is traditionally used in agricultural fields to improve soil fertility. These wastes contain high levels of nutrients such as nitrogen (N), phosphorus (P), and potassium (K), which provide essential minerals for plant growth, improve the overall structure of the soil, alter the population of microorganisms, and enhance water-holding capacity (Konca and Uzun, 2012). However, improper storage of these wastes on the soil surface or excessive application as fertilizer can result in the leaching of these elements into surface water sources, promoting the growth of algae and causing eutrophication in surface water bodies. This, in turn, reduces oxygen levels, leads to fish stress, and decreases fish populations. Moreover, excessive application of manure can lead to soil compaction and crust formation, negatively affecting the physical properties of the soil (Çayır et al., 2012). Furthermore, the direct application of animal wastes to agricultural fields without proper treatment reduces product quality and disrupts the beneficial properties of soil structure (Yağlı and Yıldız, 2019). Medications and antibiotics are also administered to animals for treatment purposes or to support the growth and protection of animals raised for food. Some of these administered drugs can be metabolized, while others are excreted through feces and urine (Konca and Uzun, 2012; Akdoğan et al., 2015). The manure of animals treated with antibiotics can lead to the proliferation of resistant bacterial species in soil, surface water, and groundwater, posing threats to the environment and human health. These wastes not only contribute to soil and water pollution but also have negative impacts on air quality, thus affecting climate change. Animal manure releases gases such as water vapor (H_2O), carbon dioxide (CO_2), ammonia (NH_3), hydrogen sulfide (H_2S), carbon monoxide (CO), and hydrogen (H_2) into the atmosphere. Moreover, the decomposition of organic matter in manure by anaerobic bacteria results in the release of methane (CH_4) gas. Additionally, the nitrogen (N_2) in manure leads to the formation of nitrous oxide (N2O) during nitrification and denitrification processes. These two gases, in particular, are significant contributors to greenhouse gas emissions, which are known to contribute to global climate change (IPCC, 1996). In the current era, where global warming is an undeniable threat, greenhouse gas emissions play a significant role in the formation of global climate change (Ersoy, 2017). Therefore, it is crucial to take necessary precautions to protect the environment from pollution until these wastes are applied to the land. Practices such as composting, drying, and biogas production applied to animal manure can minimize environmental harm and enable more effective use of organic fertilizers in fields. Ultimately, these practices reduce unpleasant odors, eliminate pathogenic microorganisms, and result in significant reductions in the weight and volume of manure (Karaman, 2006). The aim of this study is to determine the amounts of waste and pollutant loads, specifically total nitrogen (TN) and total phosphorus (TP) concentrations, resulting from animal production in the province, districts, neighborhoods, and villages of Karaman. In this study, the numbers of cattle and small ruminants (sheep and goats) in Karaman province for the year 2022 were determined on a neighborhood and village basis. Then, the TN and TP concentrations resulting from the waste generated by these animals were calculated. Subsequently, the daily amounts of dry manure produced by these animals were determined to evaluate the environmental pollution aspect.

Materials and Methods:

Materials

In this study, data on the number of animals in villages and neighborhoods were obtained from the provincial agriculture and forestry directorate of Karaman province to determine the amount of animal waste. The coordinates of Karaman province, districts, neighborhoods, and villages were marked using the ArcMap 10.5 program. The distribution of animal numbers according to the districts of Karaman province was analyzed. The amounts of dispersion pollutant load and dry manure that could be generated from animal waste were calculated.

The study area is located in Karaman province, which is in the Central Anatolia region of our country, between 37°-11' north latitude and 33°-13' east longitude. Karaman province is surrounded by Mersin and Antalya to the south, and Konya province to the west, north, and east. The surface area of Karaman province is 8,851 km², and the elevation of the provincial center from sea level is 1,033 m. It has a total of 6 districts, 10 townships, and 154 villages, with one being the central district. The northern part of Karaman province is covered with steppe vegetation, while the southern part is covered with forest. Two-thirds of the terrain is mountainous. The provincial center is located in a plain, just south of the Taurus Mountains' extensions (ÇŞB, 2022). The total surface area of Karaman is 885,100 hectares, of which 39% is agricultural land, 23% is meadow pasture land, 27% is forest land, and 11% is other areas. Plant production is carried out on 346,848 ha of our province. Of these areas where plant production is conducted, 62% is allocated to field crops, while 15% is fallow areas. Fruit cultivation is carried out on 8.7% of agricultural lands, viticulture on 1.4%, and vegetable cultivation on 3.9% (TOB, 2022; URL-1). Agriculture and animal husbandry constitute the main livelihood source in the region.

Assumptions made in the study: The production of animal manure and the unit loads of nitrogen (N) and phosphorus (P) released into the environment can vary greatly depending on the feeding habits, types of nutrients, and frequency of water intake of the animals (Kocabey, 2019). In order to calculate the amounts of dispersion pollutants originating from animal waste in Karaman province and its districts, some assumptions were made based on the literature. Estimated unit loads resulting from dispersion pollutants are given in Table 1 according to the values predicted in the literature (Yontar, 2009; Biçer, 2011; Derin et al., 2019; ÇŞB, 2016; Tırınk, 2021). The total amount of dispersion pollutants originating from animal waste in Karaman province was calculated using the following equation (Equation 1).

$$Q_T = Q_{YK} \times A_{CH} \times Y_U \times 365/1000 \quad (1)$$

Here, QT represents the annual total dispersion pollutant load (kg/number of animals/year), QYK represents the dispersion pollutant load varying according to the type of pollutant (kg/ton/number of animals/day), ACH represents the live animal weight according to the animal species (kg); in the literature, these values are taken as 500 kg for BBH, 45 kg for KBH, and 2 kg for KH. The assumptions in Table 1 were obtained using the annual N and P amounts per animal based on these live weights in the literature. Y_U represents the percentage of dispersion pollutants that can reach the receiving environment, assuming that 15% for N and 5% for P can reach the receiving environment (Özalp, 2009; ÇŞB, 2016; Hacısalihoğlu, 2022; Haksevenler and Ayaz, 2021). This value is determined considering the transportation processes and losses of N and P. The calculation of TN load (Equation 2) is as follows:

$$QTN = QT \times NCH/1000 \quad (2)$$

is calculated as. Here, QTN represents the annual total nitrogen load (kg/year), and NCH represents the number of live animals (count). The calculation of TP load (Equation 3) is as follows:

$$QTP = QT \times NCH/1000 \quad (3)$$

is calculated as. Here, QTP represents the annual TP load (kg/year).

After calculating the potential diffuse pollutant loads resulting from animal waste in Karaman province and its districts, the amount of dry manure that can be collected in this province has been estimated. To calculate this manure amount, certain assumptions were made based on the literature, and the range of values predicted in the literature is presented in Table 2 (Köttner, 2002; Omer and Fadalla, 2003; Koçer et al., 2006; Avcıoğlu et al., 2013; Aktaş et al., 2015; Ilgar, 2016; Salihoğlu et al., 2019; Hacısalihoğlu, 2022; Haksevenler and Ayaz, 2021). The total amount of manure resulting from animal waste in Karaman province is calculated using the following equation (equation 4).

$$TYGM = ACH \times YCHA \quad (4)$$

Here, TYGM represents the total daily amount of fresh manure (kg/animal/day), ACH denotes the live animal weight (kg) according to the animal species. The literature suggests that this value ranges from 135-800 kg for BBH, 30-75 kg for KBH, and 1.5-12 kg for KH. YCHA represents the percentage of live animal weight according to the animal species (%). The literature suggests that this value ranges from 5-6% for BBH, 4-5% for KBH, and 3-4% for KH. The amount of fresh manure in animals can vary based on their weight, species, age, gender, feeding type, and climatic conditions of the region they are in. However, in this study, Equation 1 and literature values are considered, assuming that the production of fresh manure will be 27 kg/day for BBH, 2.48 kg/day for KBH, and 0.26 kg/day for KH. The calculation of the collected fresh manure in animal shelters takes into account the duration of animals staying in the shelter. The total available amount of dry manure is calculated using Equation 5.

$$TGM = TYGM \times YKG \times YKM \quad (5)$$

is calculated as. Here, TGM represents the total available amount of dry manure in tons per day, and YKG is the percentage of usable manure (%) based on the animal species. The values used in this study are 65% for BBH, 13% for KBH, and 99% for KH. YKM represents the percentage of dry matter (%) in the animal waste, which varies according to the animal species. In this study, the values used are 15% for BBH, 33% for KBH, and 50% for KH (Tırınk, 2021). The annual total amount of dry manure is calculated using Equation 6.

$$TYGP = TKYGM \times NCH \times 365/1000 \quad (6)$$

It is calculated with the equation. In this equation, NCH is the number of animals.

For the GIS-based mapping of diffuse pollution using the acquired animal population data and the calculated values of dry manure and diffuse pollutant loads, density distribution maps were created using the Kernel Density tool in ArcMap 10.5. The coordinates of the study area were entered into the program to generate the maps (Çakır et al., 2019).

Table 1. Distributed pollutant load acceptances by animal breeds

	Distributed Load Coefficients	BBH	KBH	KH
TN	QYK (kg/ton number of animals/day)	0.3	0.42	0.52
	YU (%)	15	15	15
	QT (kg/number of animals/year	8.213	1.035	0.057
TP	QYK (kg/ton number of animals/day)	0.1	0.06	0.22
	YU (%)	5	5	5
	QT (kg/number of animals/year)	0.913	0.049	0.008

BBH= cattle, KBH= ovine animals, KH= poultry

Table 2. Waste generation acceptances according to animal breeds

Acceptance Parameters	BBH	KBH	KH
Livestock Weight (kg)	135-800	30-75	1.5-12
Wet Fertilizer Formation (%)	5-6	4-5	3-4
Wet Fertilizer amount (kg/day)	6-48	1.2-3.75	0.045-0.48
Availability (%)	25-65	13	99
Dry Matter Content (%)	5-25	30-36	10-90

BBH= cattle, KBH= ovine animals, KH= poultry

Findings and Discussion

In the scope of the study, the number of live BBH and KBH in Karaman province for the year 2022 was determined. As shown in Table 3, Table 4a,b, and Figure 1, the district with the highest presence of BBH in Karaman province is the sum of the villages affiliated with Karaman, with a total of 32,504 animals and a percentage of 40%. The central district follows with a percentage of 35%.

The district with the lowest BBH presence is Başyayla with 1,457 animals and a percentage of 1.79%. The district with the highest KBH presence is the villages belonging to the Center with 499,276 animals and a percentage of 45%. The district with the lowest KBH presence is also Başyayla with 8,540 animals and a percentage of 0.84%. When examining the livestock numbers in Karaman province, its districts, neighborhoods, and villages, it can be observed that KBH farming has a higher percentage. After calculating the livestock numbers in Karaman province, the generated diffuse pollutant loads were calculated. The calculated pollutant loads are presented in Table 5 and Table 6a,b,c.

Table 3. Livestock numbers in Karaman districts for the year 2022

District Name	BBH Total	KBH Total	Total Livestock	Total Livestock Percentage	BBH Percentage	KBH Percentage
Ayrancı	7138	280613	287751	26.14%	8.77%	27.53%
Ermenek	5372	50019	55391	5.03%	6.60%	4.91%
Başyayla	1457	8540	9997	0.91%	1.79%	0.84%
Kazımkarabekir	3541	31047	34588	3.14%	4.35%	3.05%
Sarıveliler	3005	12825	15830	1.44%	3.69%	1.26%
Karaman Villages	32504	466772	499276	45.36%	39.95%	45.79%
Karaman Center	28351	169461	197812	17.97%	34.84%	16.63%

BBH= cattle, KBH= ovine animals

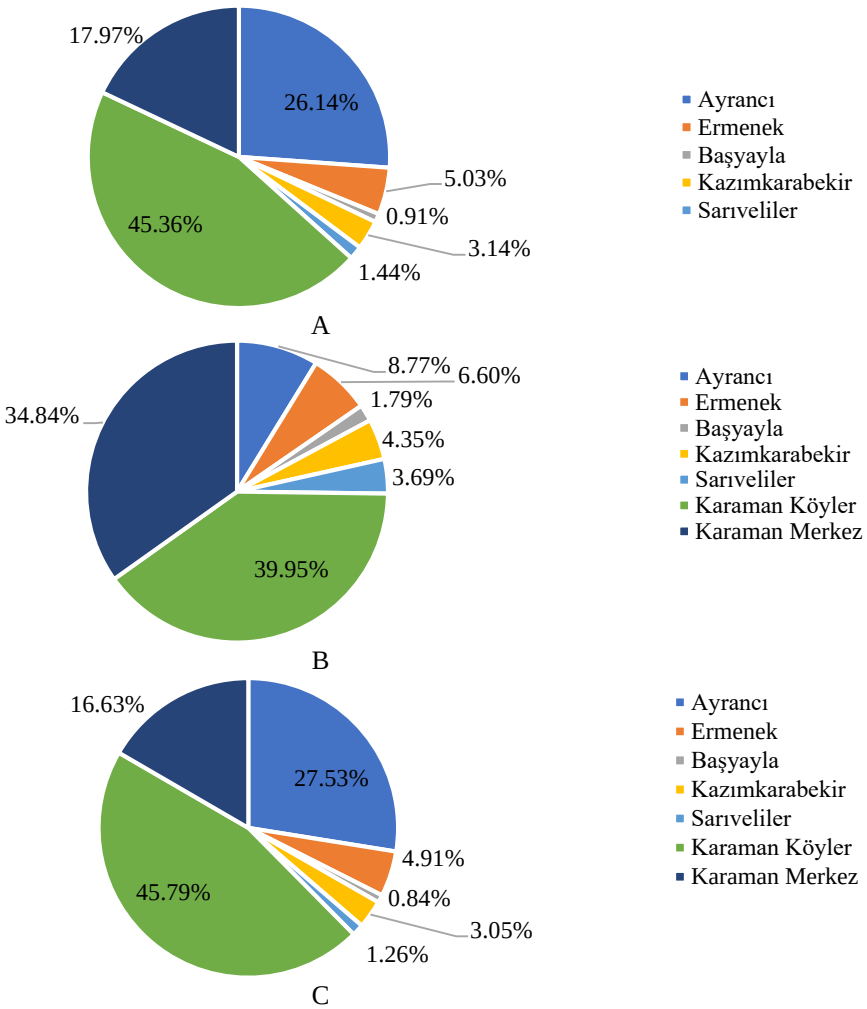


Figure 1. (a) Distribution according to total number of animals, (b) Distribution according to BBH numbers, (c) Distribution according to KBH numbers.

Table 4a. Number of livestock in the villages and neighborhoods of Karaman in 2022

District	Village/Town	CC	SC	GC	District	Village/Town	CC	SC	GC
Ayrancı	Ağızboğaz	562	16199	1813	Sarıveliler	Uğurlu	38	44	442
Ayrancı	Akpınar	12	8895	1290	Sarıveliler	Merkez	70	799	133
Ayrancı	Ambar	0	8244	930	Sarıveliler	Merkez-Başmahalle	85	52	183
Ayrancı	Berendi	147	65404	1236	Sarıveliler	Merkez-Çakıllar	183	762	586
Ayrancı	Böğecik	416	15628	327	Sarıveliler	Merkez-Karakaya	26	112	286
Ayrancı	Buğdaylı	347	2576	12	Sarıveliler	Merkez-Kkarapınar	12	99	34
Ayrancı	Büyükkoraş	0	4727	1377	Sarıveliler	Merkez-Turcalar	348	112	213
Ayrancı	Çat	0	7758	373	Sarıveliler	Merkez-Ulucami	92	1476	395
Ayrancı	Divle	232	6690	839	Sarıveliler	Merkez-Yeşilyurt	41	59	3
Ayrancı	Dokuzyol	372	17403	1100	Merkez	Ada	81	1160	1472
Ayrancı	Höyükburun	245	4037	190	Merkez	Ağaçyurdu	103	292	1924
Ayrancı	Kale	82	1924	167	Merkez	Ağılönü	1850	2314	298
Ayrancı	Karaağaç	0	11084	1288	Merkez	Akçaalan	10	605	2663
Ayrancı	Kavaközü	26	11767	957	Merkez	Akçaşehir	585	31875	4358
Ayrancı	Kavuklar	2067	7468	33	Merkez	Akpınar	73	10964	1813
Ayrancı	Kayaönü	0	12110	1100	Merkez	Alaçatı	745	821	1
Ayrancı	Kıraman	1292	12918	1197	Merkez	Aşağıakın	0	4	1797
Ayrancı	Küçükkoraş	0	5409	919	Merkez	Aşağıkızılca	14	222	1597
Ayrancı	Melikli	168	6046	666	Merkez	Aybastı	282	3854	3346
Ayrancı	Pınarkaya	1	9697	3476	Merkez	Bademli	61	0	1536
Ayrancı	Saray	0	3046	534	Merkez	Barutkavran	223	1145	378
Ayrancı	Yarıkkuyu	51	6505	388	Merkez	Başkışla	277	808	731
Ayrancı	Merkez-Dede	365	1651	420	Merkez	Bayır	60	509	1280
Ayrancı	Merkez-Musa	0	3317	835	Merkez	Beydilli	6	1071	26
Ayrancı	Merkez-Ulu	24	2604	169	Merkez	Bostanözü	0	167	94
Ayrancı	Merkez-Yenimahalle	729	5631	239	Merkez	Boyalı	238	3174	1229
Ermenek	Ağaççatı	4	253	1295	Merkez	Bozkondak	946	454	1560
Ermenek	Ardıçkaya	128	4	1011	Merkez	Bölükyazı	12	1070	248
Ermenek	Aşağıçağlar	258	1094	2473	Merkez	Bucakkışla	0	84	1275
Ermenek	Balkusan	30	2648	19	Merkez	Burhan	71	1405	1083
Ermenek	Boyalık	14	4	183	Merkez	Burunoba	46	5416	386
Ermenek	Çamlıca	4	16	1561	Merkez	Büyükerenkavak	118	858	152
Ermenek	Çatalbadem	89	1247	2880	Merkez	Cerit	134	1379	3525
Ermenek	Çavuş	10	0	285	Merkez	Çakırbağ	1083	8500	1206
Ermenek	Elmayurdu	267	0	121	Merkez	Çatak	299	1364	4222
Ermenek	Evsin	1	0	574	Merkez	Çavuşpınarı	819	3394	1131
Ermenek	Gökçekent	367	232	256	Merkez	Çiğdemli	263	1499	171
Ermenek	Gökçeseki	0	105	671	Merkez	Çimenkuyu	29	124	29
Ermenek	Görmeli	23	775	3303	Merkez	Çoğlu	551	11857	2535
Ermenek	İkizçınar	146	93	352	Merkez	Çukur	6	99	1948
Ermenek	Katranlı	592	1202	1144	Merkez	Çukurbağ	29	1091	1785
Ermenek	Kayaönü	31	0	1135	Merkez	Dağkonak	103	270	1141
Ermenek	Olukpınar	2	0	254	Merkez	Damlapınar	67	965	1211
Ermenek	Pamuklu	41	0	254	Merkez	Değirmenbaşı	24	516	50
Ermenek	Pınarönü	80	14	344	Merkez	Demiryurt	587	3419	200
Ermenek	Sarıvadi	169	46	1428	Merkez	Dereköy	479	5036	1680
Ermenek	Tepebaşı	92	66	226	Merkez	Dinek	129	3578	300
Ermenek	Yalındal	55	77	880	Merkez	Eğilmez	336	9046	1240
Ermenek	Yaylapazarı	13	108	559	Merkez	Ekinözü	666	21334	1161
Ermenek	Yerbağ	70	12	320	Merkez	Elmadağı	58	76	3615
Ermenek	Yukarıçağlar	173	274	807	Merkez	Eminler	204	5643	666
Ermenek	Güneyyurt-Aralık	272	146	530	Merkez	Göcer	0	359	1803
Ermenek	Güneyyurt-Cami	133	236	675	Merkez	Gökçe	34	687	346
Ermenek	Güneyyurt-Habib	39	10	36	Merkez	Göztepe	387	1892	125
Ermenek	Güneyyurt-Kışlacık	136	236	419	Merkez	Güçler	24	3277	252
Ermenek	Güneyyurt-Oda	83	36	25	Merkez	Güldere	20	15285	986
Ermenek	G.Yurt-Ortamahalle	69	82	5	Merkez	Gülkaya	285	7670	1182
Ermenek	Güneyyurt-Pınargözü	91	201	44	Merkez	Hamidiye	38	2640	254
Ermenek	G.Yurt-Yenimahalle	575	266	16	Merkez	İhsaniye	75	3056	3550

CC: Cattle Count; SC: Sheep Count; GC: Goat Count;

Table 4b. Number of livestock in the villages and neighborhoods of Karaman in 2022

District	Village/Town	CC	SC	GC	District	Village/Town	CC	SC	GC
Ermenek	Kazancı-Bucak	42	189	282	Merkez	İslihisar	270	1884	231
Ermenek	Kazancı-Gökceler	184	0	634	Merkez	Kalaba	6	654	1624
Ermenek	Kazancı-Merkez	243	330	684	Merkez	Kameni	2533	4957	441
Ermenek	Kazancı-Tepecik	53	50	160	Merkez	Karacaören	333	6251	1437
Ermenek	Kazancı-Türbeseki	107	4	0	Merkez	Kaşoba	8	893	102
Ermenek	Kazancı-Uluköy	155	38	0	Merkez	Kılbasan	4315	11754	1892
Ermenek	Kazancı-Yukarı	0	18	132	Merkez	Kızık	173	5988	462
Ermenek	Merkez-Akçamescit	7	164	933	Merkez	Kızıllarağini	0	2991	1600
Ermenek	Merkez-Başpınar	5	0	0	Merkez	Kızılyaka	983	1285	0
Ermenek	Merkez-Çınarlısu	0	0	4	Merkez	Kisecik	54	7495	556
Ermenek	Merkez-Değirmenlik	85	334	118	Merkez	Kozlubucak	68	769	249
Ermenek	Merkez-Deliallar	5	0	0	Merkez	Kurtderesi	1013	2375	371
Ermenek	Merkez-Güllük	11	146	307	Merkez	Kurucabel	0	0	338
Ermenek	Merkez-Gülpazarı	0	4	475	Merkez	Küçükerenkavak	132	785	455
Ermenek	Merkez-Karalar	128	6	0	Merkez	Lale	1143	4782	1044
Ermenek	Merkez-Keçipazarı	7	152	318	Merkez	Madenşehri	246	2631	1109
Ermenek	Merkez-Keşillik	39	1196	1647	Merkez	Medreselik	31	1889	109
Ermenek	Merkez-Meydan	74	713	2065	Merkez	Mesudiye	142	1844	134
Ermenek	Merkez-Ortamahalle	3	600	2151	Merkez	Morcalı	759	2465	1336
Ermenek	Merkez-Sandıklı	11	18	643	Merkez	Muratdede	309	2551	3282
Ermenek	Merkez-Seyran	44	84	41	Merkez	Narlıdere	82	995	1803
Ermenek	Merkez-Susaklı	81	295	309	Merkez	Ortaoba	620	10821	347
Ermenek	Merkez-Taşbaşı	31	860	347	Merkez	Osmaniye	86	4857	198
Başyayla	Bozyaka	40	16	324	Merkez	Özdemir	87	299	4073
Başyayla	Büyükkarapınar	164	24	4	Merkez	Paşabağı	271	2821	482
Başyayla	Kışla	720	513	2358	Merkez	Pınarbaşı	57	2334	587
Başyayla	Üzümlü	143	227	1485	Merkez	Salur	158	1880	52
Başyayla	Merkez-Başköy	72	791	576	Merkez	Sarıkaya	6	457	94
Başyayla	Merkez-Göztepe	22	1251	69	Merkez	Sazlıyaka	80	48	101
Başyayla	Merkez-Kirazlıyayla	205	857	39	Merkez	Seyithasan	0	950	220
Başyayla	Merkez-Şirindere	76	2	4	Merkez	Sudurağı	2147	17191	395
Başyayla	Merkez-Yenimahalle	15	0	0	Merkez	Süleymanhacı	697	11570	1586
Kazımkarabekir	Akarköy	525	2036	405	Merkez	Tarlaören	38	236	389
Kazımkarabekir	Karalgazi	0	1371	291	Merkez	Taşkale	95	15467	9198
Kazımkarabekir	Kızılkuyu	1	3137	504	Merkez	Üçbaş	138	0	242
Kazımkarabekir	Mecidiye	42	656	26	Merkez	Üçkuyu	0	1438	533
Kazımkarabekir	Özyurt	71	3721	371	Merkez	Yeşildere	1264	14945	3151
Kazımkarabekir	Sinci	1	2486	171	Merkez	Yılangömü	0	692	980
Kazımkarabekir	Merkez-Boyacı	624	2936	1263	Merkez	Yollarbaşı	271	9093	5732
Kazımkarabekir	Merkez-Eminettin	284	957	240	Merkez	Yukarıakın	0	0	1369
Kazımkarabekir	Merkez-Emsalhayat	69	2675	737	Merkez	Yukarıkızılca	48	1152	4471
Kazımkarabekir	Merkez-Oba	0	694	98	Merkez	Yuvatepe	875	877	219
Kazımkarabekir	Merkez-Pazar	25	838	312	Merkez	Zengen	436	2609	914
Kazımkarabekir	Merkez-Selçuklu	800	492	310	Merkez	Merkez	14437	106907	33595
Kazımkarabekir	Merkez-Subaşı	72	2229	977	Merkez	Merkez-Atatürk	545	883	74
Kazımkarabekir	Merkez-Timsal	1027	600	514	Merkez	Mer.-Bahçelievler	163	2830	114
Sarıveliler	Adiller	268	123	398	Merkez	Merkez-Beyazkent	0	49	110
Sarıveliler	Civandere	116	1239	138	Merkez	Mer.-Cumhuriyet	58	55	0
Sarıveliler	Civler	481	306	614	Merkez	Merkez-Çeltek	543	1468	138
Sarıveliler	Çevrekavak	105	3	62	Merkez	Merkez-Fatih	814	508	154
Sarıveliler	Çukurbağ	108	1	0	Merkez	Merkez-Hacıcelal	0	55	1
Sarıveliler	Daran	59	7	529	Merkez	Merkez-Hisar	298	1084	124
Sarıveliler	Dumlugöze	353	18	1127	Merkez	Merkez-Prireis	2165	3383	363
Sarıveliler	Esentepe	61	47	469	Merkez	Merkez-Siyahser	8	96	22
Sarıveliler	Göktepe	87	75	52	Merkez	Merkez-Sümer	823	1535	13
Sarıveliler	Günder	2	276	10	Merkez	Merkez-Şeyhşamil	0	337	184
Sarıveliler	Işıklı	43	1	98	Merkez	Merkez-Urgan	7484	11739	1632
Sarıveliler	Koçaşlı	102	9	1433	Merkez	Merkez-Yenişehir	1013	1640	336
Sarıveliler	Ortaköy	325	0	0	Merkez	Merkez-Yeşilada	0	18	14

CC: Cattle Count; SC: Sheep Count; GC: Goat Count;

Table 5. Distributed pollutant loads originating from BBH and KBH waste in Karaman province and its districts

District Name	BBH Load TN QTN (ton/year)	KBH Load TN QTN (ton/year)	BBH Load TP QTP (ton/year)	KBH Load TP QTP (ton/year)	Total TN QTN (ton/year)	Total TP QTP (ton/year)
Ayrancı	58.62	290.43	6.52	13.75	349.06	20.27
Ermenek	44.12	51.77	4.90	2.45	95.89	7.36
Başyayla	11.97	8.84	1.33	0.42	20.81	1.75
Kazımkarabekir	29.08	32.13	3.23	1.52	61.22	4.75
Sarıveliler	24.68	13.27	2.74	0.63	37.95	3.37
Karaman Villages	266.96	483.11	29.68	22.87	750.06	52.55
Karaman Center	232.85	175.39	25.88	8.30	408.24	34.19

BBH= cattle, KBH= ovine animals

Table 6a. Distributed pollutant loads originating from BBH and KBH wastes of Karaman neighborhoods and villages

Village/Town	A	B	C	D	E	F	Village/Town	A	B	C	D	E	F
Ağızboğaz	4.62	18.64	0.51	0.88	23.26	1.40	Uğurlu	0.31	0.50	0.03	0.02	0.82	0.06
Akpınar	0.10	10.54	0.01	0.50	10.64	0.51	Merkez	0.57	0.96	0.06	0.05	1.54	0.11
Ambar	0.00	9.50	0.00	0.45	9.50	0.45	Başmahalle	0.70	0.24	0.08	0.01	0.94	0.09
Berendi	1.21	68.97	0.13	3.27	70.18	3.40	Mer.-Çakıllar	1.50	1.40	0.17	0.07	2.90	0.23
Böğecik	3.42	16.51	0.38	0.78	19.93	1.16	Karakaya	0.21	0.41	0.02	0.02	0.63	0.04
Buğdaylı	2.85	2.68	0.32	0.13	5.53	0.44	Kkarapınar	0.10	0.14	0.01	0.01	0.24	0.02
Büyükkoraş	0.00	6.32	0.00	0.30	6.32	0.30	Turcalar	2.86	0.34	0.32	0.02	3.19	0.33
Çat	0.00	8.42	0.00	0.40	8.42	0.40	Ulucami	0.76	1.94	0.08	0.09	2.69	0.18
Divle	1.91	7.79	0.21	0.37	9.70	0.58	Yeşilyurt	0.34	0.06	0.04	0.00	0.40	0.04
Dokuzyol	3.06	19.15	0.34	0.91	22.21	1.25	Ada	0.67	2.72	0.07	0.13	3.39	0.20
Höyükburun	2.01	4.37	0.22	0.21	6.39	0.43	Ağaçyurdu	0.85	2.29	0.09	0.11	3.14	0.20
Kale	0.67	2.16	0.07	0.10	2.84	0.18	Ağılönü	15.19	2.70	1.69	0.13	17.90	1.82
Karaağaç	0.00	12.81	0.00	0.61	12.81	0.61	Akçaalan	0.08	3.38	0.01	0.16	3.46	0.17
Kavaközü	0.21	13.17	0.02	0.62	13.38	0.65	Akçaşehir	4.80	37.50	0.53	1.78	42.31	2.31
Kavuklar	16.98	7.76	1.89	0.37	24.74	2.25	Akpınar	0.60	13.22	0.07	0.63	13.82	0.69
Kayaönü	0.00	13.67	0.00	0.65	13.67	0.65	Alaçatı	6.12	0.85	0.68	0.04	6.97	0.72
Kıraman	10.61	14.61	1.18	0.69	25.22	1.87	Aşağıakın	0.00	1.86	0.00	0.09	1.86	0.09
Küçükkoraş	0.00	6.55	0.00	0.31	6.55	0.31	Aşağıkızılca	0.11	1.88	0.01	0.09	2.00	0.10
Melikli	1.38	6.95	0.15	0.33	8.33	0.48	Aybastı	2.32	7.45	0.26	0.35	9.77	0.61
Pınarkaya	0.01	13.63	0.00	0.65	13.64	0.65	Bademli	0.50	1.59	0.06	0.08	2.09	0.13
Saray	0.00	3.71	0.00	0.18	3.71	0.18	Barutkavran	1.83	1.58	0.20	0.07	3.41	0.28
Yarıkkuyu	0.42	7.13	0.05	0.34	7.55	0.38	Başkışla	2.28	1.59	0.25	0.08	3.87	0.33
Merkez-Dede	3.00	2.14	0.33	0.10	5.14	0.43	Bayır	0.49	1.85	0.05	0.09	2.34	0.14
Merkez-Musa	0.00	4.30	0.00	0.20	4.30	0.20	Beydilli	0.05	1.14	0.01	0.05	1.18	0.06
Merkez-Ulu	0.20	2.87	0.02	0.14	3.07	0.16	Bostanözü	0.00	0.27	0.00	0.01	0.27	0.01
Yenimahalle	5.99	6.08	0.67	0.29	12.06	0.95	Boyalı	1.95	4.56	0.22	0.22	6.51	0.43
Ağaççatı	0.03	1.60	0.00	0.08	1.64	0.08	Bozkondak	7.77	2.08	0.86	0.10	9.85	0.96
Ardıçkaya	1.05	1.05	0.12	0.05	2.10	0.17	Bölükyazı	0.10	1.36	0.01	0.06	1.46	0.08
Aşağıçağlar	2.12	3.69	0.24	0.17	5.81	0.41	Bucakkışla	0.00	1.41	0.00	0.07	1.41	0.07
Balkusan	0.25	2.76	0.03	0.13	3.01	0.16	Burhan	0.58	2.58	0.06	0.12	3.16	0.19
Boyalık	0.11	0.19	0.01	0.01	0.31	0.02	Burunoba	0.38	6.01	0.04	0.28	6.38	0.33
Çamlıca	0.03	1.63	0.00	0.08	1.67	0.08	B.Erenkavak	0.97	1.05	0.11	0.05	2.01	0.16
Çatalbadem	0.73	4.27	0.08	0.20	5.00	0.28	Cerit	1.10	5.08	0.12	0.24	6.18	0.36
Çavuş	0.08	0.29	0.01	0.01	0.38	0.02	Çakırbağ	8.89	10.05	0.99	0.48	18.94	1.46
Elmayurdu	2.19	0.13	0.24	0.01	2.32	0.25	Çatak	2.46	5.78	0.27	0.27	8.24	0.55
Evsin	0.01	0.59	0.00	0.03	0.60	0.03	Çavuşpınarı	6.73	4.68	0.75	0.22	11.41	0.97
Gökçekent	3.01	0.51	0.34	0.02	3.52	0.36	Çiğdemli	2.16	1.73	0.24	0.08	3.89	0.32
Gökçeseki	0.00	0.80	0.00	0.04	0.80	0.04	Çimenkuyu	0.24	0.16	0.03	0.01	0.40	0.03
Görmeli	0.19	4.22	0.02	0.20	4.41	0.22	Çoğlu	4.53	14.90	0.50	0.71	19.42	1.21
İkizçınar	1.20	0.46	0.13	0.02	1.66	0.16	Çukur	0.05	2.12	0.01	0.10	2.17	0.11
Katranlı	4.86	2.43	0.54	0.11	7.29	0.66	Çukurbağ	0.24	2.98	0.03	0.14	3.21	0.17
Kayaönü	0.25	1.17	0.03	0.06	1.43	0.08	Dağkonak	0.85	1.46	0.09	0.07	2.31	0.16
Olukpınar	0.02	0.26	0.00	0.01	0.28	0.01	Damlapınar	0.55	2.25	0.06	0.11	2.80	0.17
Pamuklu	0.34	0.26	0.04	0.01	0.60	0.05	Değirmenbaşı	0.20	0.59	0.02	0.03	0.78	0.05
Pınarönü	0.66	0.37	0.07	0.02	1.03	0.09	Demiryurt	4.82	3.75	0.54	0.18	8.57	0.71

A: BBH Load TN QTN (ton/year); B: KBH Load TN QTN (ton/year); C: BBH Load TP QTP (ton/year); D: KBH Load TP QTP (ton/year); E: Total TN QTN (ton/year); F: Total TP QTP (ton/year)

Table 6b. Distributed pollutant loads originating from BBH and KBH wastes of Karaman neighborhoods and villages

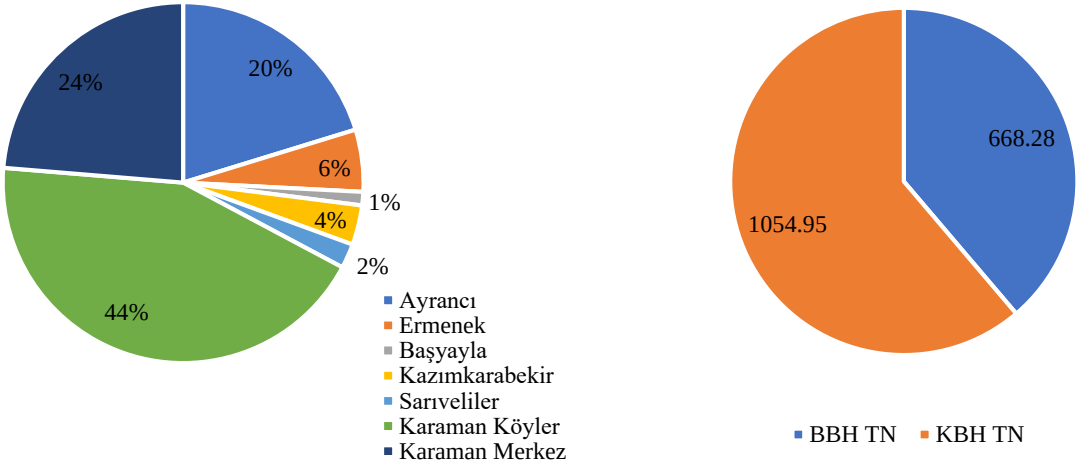
Village/Town	A	B	C	D	E	F	Village/Town	A	B	C	D	E	F
Sarıvadi	1.39	1.53	0.15	0.07	2.91	0.23	Dereköy	3.93	6.95	0.44	0.33	10.89	0.77
Tepebaşı	0.76	0.30	0.08	0.01	1.06	0.10	Dinek	1.06	4.01	0.12	0.19	5.07	0.31
Yalındal	0.45	0.99	0.05	0.05	1.44	0.10	Eğilmez	2.76	10.65	0.31	0.50	13.41	0.81
Yaylapazarı	0.11	0.69	0.01	0.03	0.80	0.04	Ekinözü	5.47	23.28	0.61	1.10	28.75	1.71
Yerbağ	0.57	0.34	0.06	0.02	0.92	0.08	Elmadağı	0.48	3.82	0.05	0.18	4.30	0.23
Yukarıçağlar	1.42	1.12	0.16	0.05	2.54	0.21	Eminler	1.68	6.53	0.19	0.31	8.21	0.50
Aralık	2.23	0.70	0.25	0.03	2.93	0.28	Göcer	0.00	2.24	0.00	0.11	2.24	0.11
Güneyyurt-Cami	1.09	0.94	0.12	0.04	2.04	0.17	Gökçe	0.28	1.07	0.03	0.05	1.35	0.08
Habib	0.32	0.05	0.04	0.00	0.37	0.04	Göztepe	3.18	2.09	0.35	0.10	5.27	0.45
Kışlacık	1.12	0.68	0.12	0.03	1.79	0.16	Güçler	0.20	3.65	0.02	0.17	3.85	0.19
Güneyyurt-Oda	0.68	0.06	0.08	0.00	0.74	0.08	Güldere	0.16	16.84	0.02	0.80	17.00	0.82
Ortamahalle	0.57	0.09	0.06	0.00	0.66	0.07	Gülkaya	2.34	9.16	0.26	0.43	11.50	0.69
Pınargözü	0.75	0.25	0.08	0.01	1.00	0.10	Hamidiye	0.31	3.00	0.03	0.14	3.31	0.18
Yenimahalle	4.72	0.29	0.52	0.01	5.01	0.54	İhsaniye	0.62	6.84	0.07	0.32	7.45	0.39
Kazancı-Bucak	0.34	0.49	0.04	0.02	0.83	0.06	İslihisar	2.22	2.19	0.25	0.10	4.41	0.35
Gökceler	1.51	0.66	0.17	0.03	2.17	0.20	Kalaba	0.05	2.36	0.01	0.11	2.41	0.12
Kazancı-Merkez	2.00	1.05	0.22	0.05	3.05	0.27	Kameni	20.80	5.59	2.31	0.26	26.39	2.58
Kazancı-Tepecik	0.44	0.22	0.05	0.01	0.65	0.06	Karacaören	2.73	7.96	0.30	0.38	10.69	0.68
Türbeseki	0.88	0.00	0.10	0.00	0.88	0.10	Kaşoba	0.07	1.03	0.01	0.05	1.10	0.06
Kazancı-Uluköy	1.27	0.04	0.14	0.00	1.31	0.14	Kılbasan	35.44	14.12	3.94	0.67	49.56	4.61
Kazancı-Yukarı	0.00	0.16	0.00	0.01	0.16	0.01	Kızık	1.42	6.68	0.16	0.32	8.10	0.47
Akçamescit	0.06	1.14	0.01	0.05	1.19	0.06	Kızıllarağini	0.00	4.75	0.00	0.22	4.75	0.22
Merkez-Başpınar	0.04	0.00	0.00	0.00	0.04	0.00	Kızılyaka	8.07	1.33	0.90	0.06	9.40	0.96
Çınarlısu	0.00	0.00	0.00	0.00	0.00	0.00	Kisecik	0.44	8.33	0.05	0.39	8.78	0.44
Değirmenlik	0.70	0.47	0.08	0.02	1.17	0.10	Kozlubucak	0.56	1.05	0.06	0.05	1.61	0.11
Deliallar	0.04	0.00	0.00	0.00	0.04	0.00	Kurtderesi	8.32	2.84	0.92	0.13	11.16	1.06
Merkez-Güllük	0.09	0.47	0.01	0.02	0.56	0.03	Kurucabel	0.00	0.35	0.00	0.02	0.35	0.02
Gülpazarı	0.00	0.50	0.00	0.02	0.50	0.02	K.Erenkavak	1.08	1.28	0.12	0.06	2.37	0.18
Merkez-Karalar	1.05	0.01	0.12	0.00	1.06	0.12	Lale	9.39	6.03	1.04	0.29	15.42	1.33
Keçipazarı	0.06	0.49	0.01	0.02	0.54	0.03	Madenşehri	2.02	3.87	0.22	0.18	5.89	0.41
Merkez-Keşillik	0.32	2.94	0.04	0.14	3.26	0.17	Medreselik	0.25	2.07	0.03	0.10	2.32	0.13
Merkez-Meydan	0.61	2.88	0.07	0.14	3.48	0.20	Mesudiye	1.17	2.05	0.13	0.10	3.21	0.23
Ortamahalle	0.02	2.85	0.00	0.13	2.87	0.14	Morcalı	6.23	3.93	0.69	0.19	10.17	0.88
Merkez-Sandıklı	0.09	0.68	0.01	0.03	0.77	0.04	Muratdede	2.54	6.04	0.28	0.29	8.57	0.57
Merkez-Seyran	0.36	0.13	0.04	0.01	0.49	0.05	Narlıdere	0.67	2.90	0.07	0.14	3.57	0.21
Merkez-Susaklı	0.67	0.63	0.07	0.03	1.29	0.10	Ortaoba	5.09	11.56	0.57	0.55	16.65	1.11
Merkez-Taşbaşı	0.25	1.25	0.03	0.06	1.50	0.09	Osmaniye	0.71	5.23	0.08	0.25	5.94	0.33
Bozyaka	0.33	0.35	0.04	0.02	0.68	0.05	Özdemir	0.71	4.53	0.08	0.21	5.24	0.29
Büyükkarapınar	1.35	0.03	0.15	0.00	1.38	0.15	Paşabağı	2.23	3.42	0.25	0.16	5.64	0.41
Kışla	5.91	2.97	0.66	0.14	8.88	0.80	Pınarbaşı	0.47	3.02	0.05	0.14	3.49	0.20
Üzümlü	1.17	1.77	0.13	0.08	2.95	0.21	Salur	1.30	2.00	0.14	0.09	3.30	0.24
Merkez-Başköy	0.59	1.41	0.07	0.07	2.01	0.13	Sarıkaya	0.05	0.57	0.01	0.03	0.62	0.03
Merkez-Göztepe	0.18	1.37	0.02	0.06	1.55	0.08	Sazlıyaka	0.66	0.15	0.07	0.01	0.81	0.08
Kirazlıyayla	1.68	0.93	0.19	0.04	2.61	0.23	Seyithasan	0.00	1.21	0.00	0.06	1.21	0.06
Şirindere	0.62	0.01	0.07	0.00	0.63	0.07	Sudurağı	17.63	18.20	1.96	0.86	35.83	2.82
Yenimahalle	0.12	0.00	0.01	0.00	0.12	0.01	Süleymanhacı	5.72	13.62	0.64	0.64	19.34	1.28
Akarköy	4.31	2.53	0.48	0.12	6.84	0.60	Tarlaören	0.31	0.65	0.03	0.03	0.96	0.07
Karalgazi	0.00	1.72	0.00	0.08	1.72	0.08	Taşkale	0.78	25.53	0.09	1.21	26.31	1.30
Kızılkuyu	0.01	3.77	0.00	0.18	3.78	0.18	Üçbaş	1.13	0.25	0.13	0.01	1.38	0.14
Mecidiye	0.34	0.71	0.04	0.03	1.05	0.07	Üçkuyu	0.00	2.04	0.00	0.10	2.04	0.10
Özyurt	0.58	4.24	0.06	0.20	4.82	0.27	Yeşildere	10.38	18.73	1.15	0.89	29.11	2.04
Sinci	0.01	2.75	0.00	0.13	2.76	0.13	Yılangömü	0.00	1.73	0.00	0.08	1.73	0.08
Merkez-Boyacı	5.12	4.35	0.57	0.21	9.47	0.78	Yollarbaşı	2.23	15.34	0.25	0.73	17.57	0.97
Eminettin	2.33	1.24	0.26	0.06	3.57	0.32	Yukarıakın	0.00	1.42	0.00	0.07	1.42	0.07
Emsalhayat	0.57	3.53	0.06	0.17	4.10	0.23	Yukarıkızılca	0.39	5.82	0.04	0.28	6.21	0.32
Merkez-Oba	0.00	0.82	0.00	0.04	0.82	0.04	Yuvatepe	7.19	1.13	0.80	0.05	8.32	0.85
Merkez-Pazar	0.21	1.19	0.02	0.06	1.40	0.08	Zengen	3.58	3.65	0.40	0.17	7.23	0.57
Selçuklu	6.57	0.83	0.73	0.04	7.40	0.77	Merkez	118.57	145.42	13.18	6.88	263.99	20.07

A: BBH Load TN QTN (ton/year); B: KBH Load TN QTN (ton/year); C: BBH Load TP QTP (ton/year); D: KBH Load TP QTP (ton/year); E: Total TN QTN (ton/year); F: Total TP QTP (ton/year)

Table 6c. Distributed pollutant loads originating from BBH and KBH wastes of Karaman neighborhoods and villages

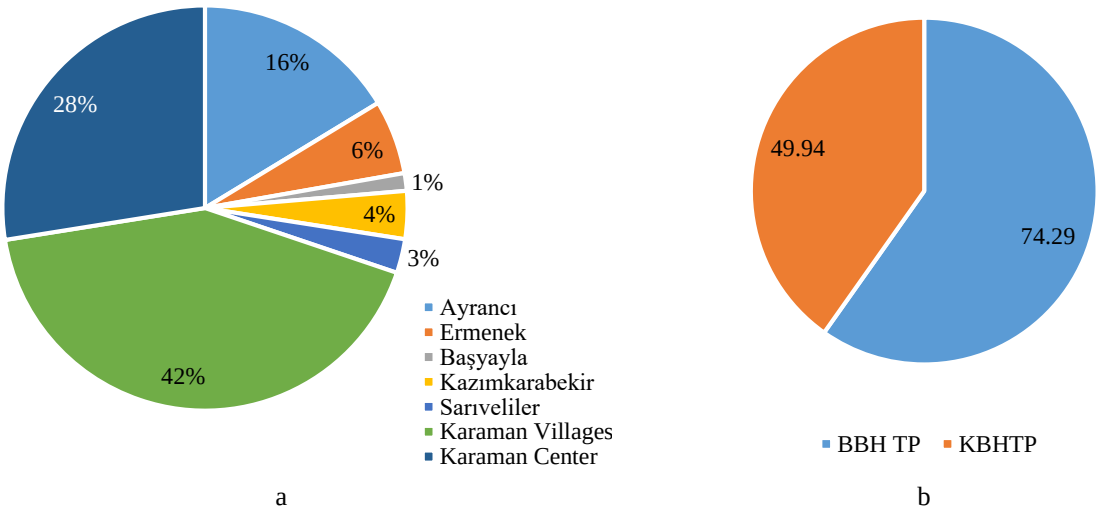
Village/Town	A	B	C	D	E	F	Village/Town	A	B	C	D	E	F
Merkez-Subaşı	0.59	3.32	0.07	0.16	3.91	0.22	Mer-Atatürk	4.48	0.99	0.50	0.05	5.47	0.54
Merkez-Timsal	8.43	1.15	0.94	0.05	9.59	0.99	M.Bahçelievler	1.34	3.05	0.15	0.14	4.39	0.29
Adiller	2.20	0.54	0.24	0.03	2.74	0.27	M.-Beyazkent	0.00	0.16	0.00	0.01	0.16	0.01
Civandere	0.95	1.43	0.11	0.07	2.38	0.17	M.-Cumhuriyet	0.48	0.06	0.05	0.00	0.53	0.06
Civler	3.95	0.95	0.44	0.05	4.90	0.48	M.-Çeltek	4.46	1.66	0.50	0.08	6.12	0.57
Çevrekavak	0.86	0.07	0.10	0.00	0.93	0.10	M.-Fatih	6.69	0.69	0.74	0.03	7.37	0.78
Çukurbağ	0.89	0.00	0.10	0.00	0.89	0.10	M.-Hacıcelal	0.00	0.06	0.00	0.00	0.06	0.00
Daran	0.48	0.55	0.05	0.03	1.04	0.08	Merkez-Hisar	2.45	1.25	0.27	0.06	3.70	0.33
Dumlugöze	2.90	1.19	0.32	0.06	4.08	0.38	Merkez-Prireis	17.78	3.88	1.98	0.18	21.66	2.16
Esentepe	0.50	0.53	0.06	0.03	1.04	0.08	M.-Siyahser	0.07	0.12	0.01	0.01	0.19	0.01
Göktepe	0.71	0.13	0.08	0.01	0.85	0.09	M.-Sümer	6.76	1.60	0.75	0.08	8.36	0.83
Günder	0.02	0.30	0.00	0.01	0.31	0.02	M.-Şeyhşamil	0.00	0.54	0.00	0.03	0.54	0.03
Işıklı	0.35	0.10	0.04	0.00	0.46	0.04	Merkez-Urgan	61.47	13.84	6.83	0.66	75.31	7.49
Koçaşlı	0.84	1.49	0.09	0.07	2.33	0.16	M.-Yenişehir	8.32	2.05	0.92	0.10	10.36	1.02
Ortaköy	2.67	0.00	0.30	0.00	2.67	0.30	M.-Yeşilada	0.00	0.03	0.00	0.00	0.03	0.00

A: BBH Load TN QTN (ton/year); B: KBH Load TN QTN (ton/year); C: BBH Load TP QTP (ton/year); D: KBH Load TP QTP (ton/year); E: Total TN QTN (ton/year); F: Total TP QTP (ton/year)



a b

Figure 2. Distribution of TN load originating from livestock in Karaman province in general (a) According to provinces and districts and (b) Distribution according to animal species



a b

Figure 3. The distribution of TP load originating from livestock in Karaman province in general (a) According to provinces and districts and (b) Distribution according to animal species

The distribution of TN (total nitrogen) load from livestock sources in Karaman province is shown in Figure 2(a) by districts. Additionally, the distribution of TN load by animal species is depicted in Figure 2(b). Moreover, Figure 3(a) displays the TP (total phosphorus) load distribution in the province, calculated for each district. Figure 3(b) illustrates the distribution of TP load by animal species.

According to the provided information, the villages affiliated with Karaman have the highest TN load from diffuse pollutants, with a total of 750.06 tons/year, accounting for 44% of the total. On the other hand, Başyayla district has the lowest TN load of 20.81 tons/year, representing 1% of the total.

The density distribution map of TN load attributed to livestock and the distribution map of TP load calculated for neighborhoods and villages within Karaman province are shown in Figure 4 and Figure 5, respectively. When looking at the pollution load density maps, it can be said that nearly 80% of Karaman province is exposed to widespread pollutants. This is mainly due to the fact that a large portion of livestock activities are carried out on an individual basis. Most of the livestock owners in this area conduct their operations within their own means, indicating that livestock activities are conducted outside of regulated facilities.

When examining the annual TP load formation attributed to BBH and KBH based on animal species in the province, it was calculated that 74.29 tons and 49.94 tons were generated, respectively. Furthermore, the villages affiliated with Karaman have the highest TP load with 52.55 tons per year (42% of the total), while Başyayla district has the lowest TP load with 1.75 tons per year (1% of the total). After calculating the spreading pollutant load originating from animal waste in the province, the amounts of dry manure that can be generated from animal waste were calculated. The calculated amounts of dry manure are presented in Table 7, and the distribution of dry manure is shown in Figure 6. The total amount of dry manure generated from annual animal waste was calculated as 172,290 tons.

As seen in Figure 6 (b), the total amount of dry manure generated in Karaman province is 76% attributed to BBH (bovine-based husbandry). The area with the highest livestock-derived waste in Karaman province is the villages affiliated with Karaman, with 71,279.58 tons per year (41% of the total). The annual potential pollutant loads from livestock activities are estimated to be 1,723.23 tons of TN (total nitrogen) and 124.23 tons of TP (total phosphorus). It is necessary to take appropriate measures to prevent these high pollution loads from contaminating underground and surface water sources. Additionally, Karaman province generates 172,290 tons of dry manure. Proper storage and utilization of commercially valuable animal waste will contribute to the local and national economy.

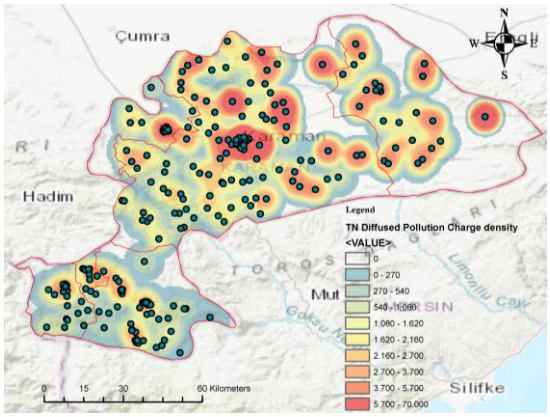


Figure 4. Density distribution map of TN load originating from livestock in Karaman province

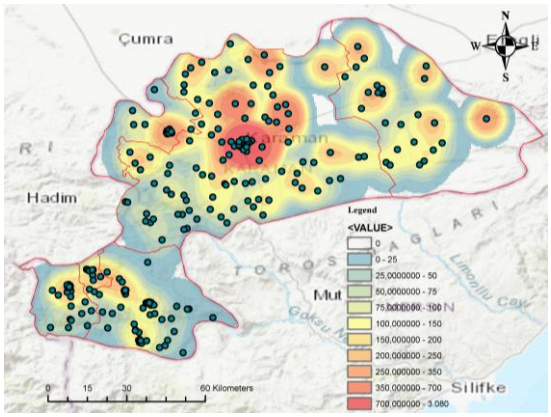
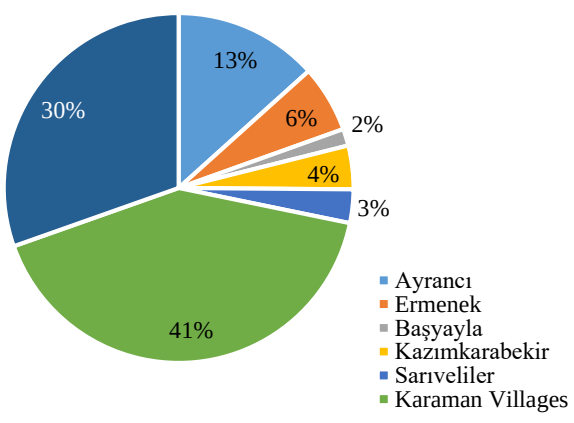
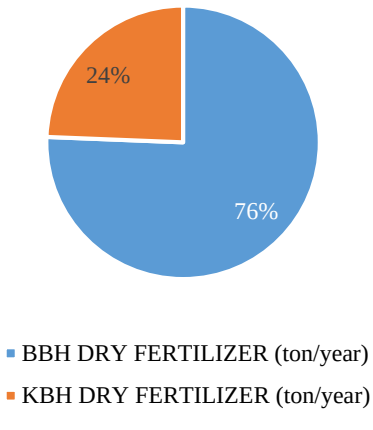


Figure 5. Density distribution map of TP load originating from livestock in Karaman province



a



b

Figure 6. The formation of dry manure originating from livestock in Karaman province in general (a) Distribution according to provinces and districts and (b) Distribution according to animal species

Table 7. The amount of fertilizer to be obtained from BBH and KBH wastes of Karaman province and its districts

District Name	BBH Dry Manure (tons/year)	KBH Dry Manure (tons/year)	Total Dry Manure (tons/year)
Ayrancı	11,431.06	11,558.52	22,989.58
Ermenek	8,602.922	2,060.295	10,663.22
Başyayla	2,333.294	351.7647	2,685.059
Kazımkarabekir	5,670.69	1,278.834	6,949.524
Sarıveliler	4,812.32	528.265	5,340.585
Karaman Villages	52,053.12	19,226.46	71,279.58
Karaman Center	45,402.35	6,980.141	52,382.5

BBH= cattle, KBH= ovine animals

Results

Determining the transport processes and quantities of pollutants is important to assess the environmental impacts on underground and surface water sources. Ultimately, it enables the identification of pollutant transport processes, which is crucial for controlling environmental pollution and improving water management practices (Akdoğan et al., 2015). The increasing demand for water resources and the decreasing availability of these resources due to environmental pollutants make the control of diffuse pollutants significant. In this context, the dominant role of agricultural activities in the formation of diffuse pollution necessitates the prevention of pollution originating from these sources (Özalp, 2009; Hacısalihoğlu, 2022; Haksevenler and Ayaz, 2021).

In this study, the diffuse pollutant loads and the amount of collected dry manure were calculated based on the number of livestock in Karaman province in 2022. The livestock population in Karaman province consisted of a total of 1,100,645 live animals (8% beef cattle and 92% dairy cattle). The estimated livestock-related diffuse pollutant loads for TN and TP were 1,723.23 tons/year and 124.23 tons/year, respectively. It was also calculated that approximately 172,290 tons/year of dry manure could be obtained from livestock activities.

Considering that 15% of TN and 5% of TP can reach water sources, it is inevitable that they will cause serious water pollution problems. These livestock wastes not only affect water sources but also contribute to carbon emissions and global warming. When looking at the density map of diffuse pollution in Karaman province, it can be said that nearly 80% of the area is exposed to diffuse pollutants. This is mainly due to the fact that a significant portion of livestock farming is carried out on an individual basis. Many livestock farmers operate within their own means, indicating that livestock farming activities are conducted outside of systematic facilities.

Livestock waste increases the nitrate content in groundwater and surface water sources. High-nitrate content groundwater and surface water, which are used for various purposes, can cause vomiting, cramps, diarrhea, and in severe cases, fatality in animals, as well as immune system disorders and the formation of genetic diseases in humans (Polat and Olgun, 2009). In addition to soil and water pollution, livestock waste also contributes to air pollution. Various gases that contribute to global climate change are released into the atmosphere from these wastes, including carbon dioxide (CO2), carbon monoxide (CO), ammonia (NH3), hydrogen sulfide (H2S), and water vapor (H2O). Furthermore, significant gases that contribute to the greenhouse effect, such as methane (CH4) and nitrous oxide (N2O), are released through certain decomposition and nitrification processes during the storage and transportation of livestock manure (IPCC, 1996). Therefore, it is necessary to store livestock manure in leak-proof and enclosed environments that comply with standards to prevent environmental pollution (Salihoğlu et al., 2019; Tırınk, 2021). In order to prevent environmental pollution from livestock waste, appropriate measures should be taken to store it in environmentally safe conditions before applying it to the land. In this regard, processes such as biogas production, composting, ventilation, and drying can be implemented to mitigate or prevent the environmental issues caused by these wastes, promoting sustainable development (Salihoğlu et al., 2019; Tırınk, 2021). In biogas plants originating from animal waste, electricity, heat and fertilizer are produced as by-products from the waste. Electricity is produced using gas generators in biogas facilities (Seyhan and Badem, 2021). Composting is the process of converting organic matter into a soil-like substance called humus by biodegrading it by bacteria and other microorganisms. The most important factors in the composting process are the C/N ratio, the amount of moisture and the amount of volatile solids (Çataltas, 2013). Disposing of bovine animal waste by reducing the moisture content in the feces by using ventilation, mechanical drying, and heating methods using sunlight, rather than removing it with water, can contribute to reducing environmental problems.

The method presented for calculating pollution loads is expected to provide a roadmap for researchers working in the field. On the other hand, this study, which indicates the source of pollution and the reasons for water contamination, is believed to serve as a guide for decision-makers and implementers.

Conflict Statement

The authors declare that there is no conflict of interest in this study.

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