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Araştırma Makalesi / Research Article

TRANSPORT OF NUTRIENTS TO MARMARA SEA BY SURFACE WATER SOURCES OF TEKİRDAĞ AND THE ECONOMIC LOSS CAUSED BY THIS

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Abstract: The region of Trakya is a place where excessive amount of fertilizer per unit area is used. Since fertilizers applied to the soil reach, either by draining or by erosion, the rivers, the ground water and finally the Sea of Marmara the ground water and most of the river waters are neither drinkable nor usable.
In this study, seasonal distributions of certain pollutants in the streams and the economic losses were analyzed. The nitrate nitrogen and total phosphorus equivalent concentrations of chemical fertilizers and the economic losses for such fertilizers were calculated for the streams sampled monthly. According to the results of the study, a total of 368.4 mg l^{-1} nitrate nitrogen and 328.4 mg l^{-1} total phosphorus were carried from the study area to Marmara Sea. The chemical fertilizer quantities equivalent to those concentrations in total were 6810.2 ton NH_4NO_3 year^{-1} and 5528.9 ton TSP year^{-1}.
Keywords: *Streams, Fertilizers, NO_3-N, Total P, Economic loss*

Tekirdağ Yüzeysel Su Kaynakları ile Marmara Denizi'ne Nutrient Taşınımı ve Bu Yolla Oluşan Ekonomik Kayıplar

Özet: Trakya Bölgesi, birim alana fazla miktarda gübre kullanılan bir bölgedir. Toprağa uygulanan gübreler, drene olarak veya erozyon yoluyla nehirlere, yeraltı sularına ve sonunda Marmara Denizine ulaşmaktadır, yeraltı suları içilemez ve pek çok nehir kullanılamaz durumdadır.
Bu araştırmada, bazı kirleticilerin incelenen derelerdeki mevsimsel dağılımları ve ekonomik kayıplar analiz edilmiştir. Aylık olarak örneklenen, dere sularında, nitrat azotu ve toplam fosfor derişimlerinin eşdeğeri olan kimyasal gübre formları ve bu gübrelerin ekonomik kayıp miktarları hesaplanmıştır.
Araştırmadan elde edilen sonuçlara göre, toplam 368.4 mg l^{-1} nitrat azotu ve 328.4 mg l^{-1} toplam fosfor, araştırma alanından Marmara Denizine taşınmıştır. Bu derişimlerin eşdeğeri olan kimyasal gübre formu miktarları ise, toplam 6810.2 ton NH_4NO_3 yıl^{-1} ve 5528.9 ton TSP yıl^{-1} olarak hesaplanmıştır.
Anahtar kelimeler: *Dereler, Kimyasal gübreler, NO_3-N, Toplam fosfor, Ekonomik kayıplar*

Introduction

Solutes enter river water from both natural and anthropogenic sources, with rainfall, rock weathering and evaporation-precipitation processes being the most important natural contributors to solute levels in rivers (Gibbs, 1970; Feth, 1971 and Kilham, 1990). Use of excessive nitrogen fertilizer in agriculture is the most important factor in pollution of the surface and ground waters. The primary source of increased nitrate in surface waters is nitrogen fertilizer applied to croplands. An increase in the nitrate concentration of water bodies is correlated with increased agricultural activity in river watersheds (Smith et al., 1987 and Galloway et al., 2003). Relationships between land uses and pollutants in rivers have hence been established in many studies (Cuffney et al., 2000; Ometo et al., 2000).

Chemical structure and application rate of the fertilizers can occure environmental risk. The fertilizer dose should be adjusted more carefully and environmental interaction should be kept at a minimum level while environmental pollution and agricultural and economic efficiency parameters are optimized.

In a research conducted on River Thames, the NO_3-N concentration was found to rise up to 15 mg l^{-1}. The researchers underlined that the soil type and fertilizer quantity were also important factors in nutrient losses while the phosphorus loss in the sandy soils were at considerable levels which in turn caused eutrophication (Whitehead et al., 1988).

The water quality investigations conducted on the Mississippi River revealed that agricultural flows caused a great level of pollution. The researchers stated that phosphorus was an important element in eutrophication and they further emphasized that the total phosphorus concentrations increased in the agricultural basins within the two days from laying of the fertilizer (Schreiber and Cullum, 1992).

Researches showed that agriculturing was the main source of nitrogen and phosphorus in the surface and ground waters and these two nutrients were found to contribute significantly to the eutrophication of the surface waters. Increasing of the NO_3-N concentration in the surface water was found to be parallel to the increase of fertilizer (Rossi et al., 1991; Novotny and Olem, 1994; Prochazkova et al., 1996; Oenema and Roest, 1997).

Water quality researches performed in the Northern Iowa Racoon River demonstrated that the NO_3-N concentration in the river exceeded 10 mg l^{-1} level. The river, into which agricultural lands are drained to a great extent, the high concentration levels occurred in the months April and May, in other words, the periods of high nitrogen fertilizer use (Lucey and Goolsby, 1993).

In general, the concentrations of pollutants in surface waters are significantly higher during the dry season than the wet season because of the dilution by large quantities of rainfall in the wet season. Moreover, surface water is an important source for irrigation, especially during the dry season. Irrigation can be a significant pathway for entry of water pollutants to the soil–plant system (Grimshaw et al., 1976; Dassenakis et al., 1998 and Markich and Brown, 1998).

The amount of the fertilizer per unit land in the region of Trakya is twice that of Turkey's average and half that of Europe (Bayraktar, 1997). Even at this level, fertilizer components reach the streams by means of surface flow or washing and then to Marmara Sea, thus making it more and more eutrophic. Therefore, the nitrogen and phosphorus that flow into the water resources should be taken under control. Because eutrophication decreases water quality and increases cost of water treatment.

Within the scope of the studies performed within Tekirdağ Provincial Borders, 73 drinking water wells containing ammonia nitrogen were examined, and over 30 % of the electrical conductivity values were found to be exceeding the acceptable level for drinking water (Katkat et al., 1997).

The purpose of this study is to reveal the disadvantageous impacts of the chemical fertilizers used in agriculture in Tekirdağ on the streams in the region and the Marmara Sea. For this purpose, the seasonal distributions of the nitrate nitrogen and total phosphorus concentrations of the streams discharging to Marmara Sea within the basin between Kumbağ and Marmara Ereğlisi district were determined. The influence of such factors as climate, fertilizer application season on the nitrate nitrogen and total phosphorus concentration were investigated.

Materials and Methods

Research area: The position of Tekirdağ Province is $40^0.36'$ N latitude and $26^0.43'$ E longitude. The research watershed includes 1095.8 km^2 water drainage area between Kumbağ and Marmara Ereğlisi. The land use is mainly agriculture, soil types are more sandy and sandy loams (Ekinci, 1990). Dry agriculture areas are dosminate in this region. It has an intensive agriculture of sunflower (*Helianthus annuus*) and wheat (*Triticum durum*) with only a small area devoted to vegetables. This region has a larger population and has a light-industry.

Climate: When two of the climate components, precipitation and temperature are taken into consideration, Tekirdağ Province can be considered to be in the Mediterranean. The total average precipitation in Tekirdağ is 662.3 $mm.year^{-1}$. For our study, (between January 1998 and January 1999) the total precipitation was 849.2 mm, the minimum and maximum precipitation records were 4.3 mm in August and 147.1 mm in September, respectively . The average temperature of Tekirdağ Province is 13.7 ºC. In the year of research was carried out, the annual average temperature was 14.3 ºC (according to the records of the Directorate of Meteorology).

The streams are a receiver of water pollution from agricultural and silvicultural nonpoint sources. The streams which flow to the Marmara Sea in this area were taken as the subject of study and the positions of the streams are shown in Figure 1.

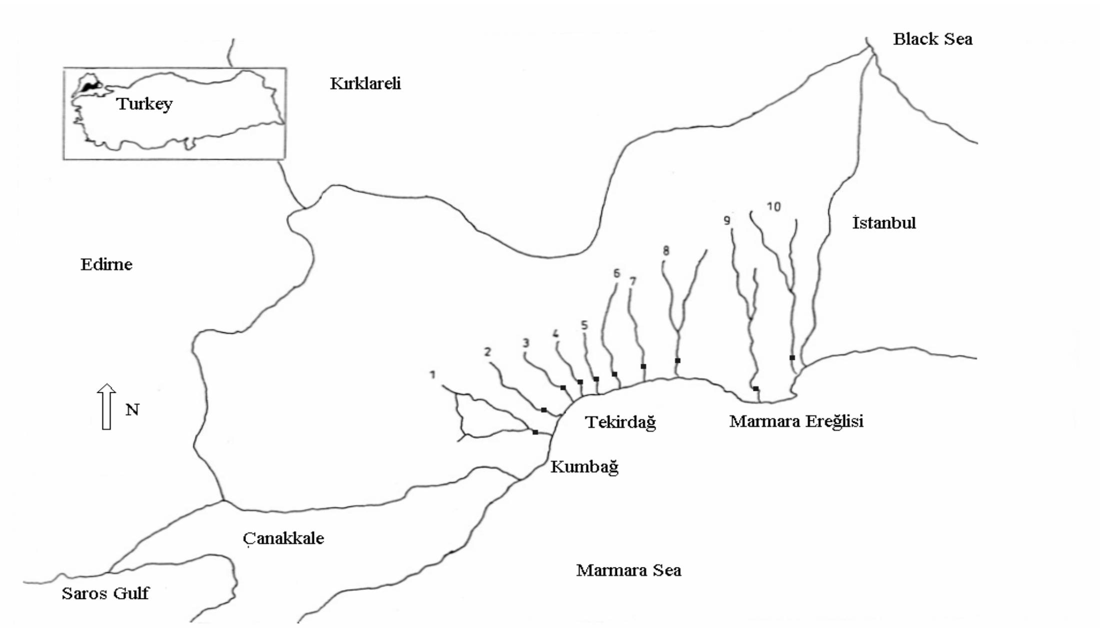

Figure 1. List of streams: 1. Kumbağ, 2. Barbaros, 3. Tekirdağ, 4. Dereağzı, 5. Kayı, 6. Gazioğlu, 7. Karaevli, 8. Şerefli, 9. Bağlar, 10. Seymen.

Water sampling points.

Taking water samples: Detailed monthly longitudinal surveys of stream water were taken from the most appropriate points and depths (25-30 cm) that reflect the properties of the streams. Water samples were collected (once in a month) by using brown 500 ml bottles. Bottles were rinsed three times with stream water prior to the collection of samples. On each sampling occasion, one water sample was taken from the margin and another from the midstream of the stream. For transportation to the laboratory, the bottles were stored in a dark cool box. They were then kept in a refrigerator at 4 °C for no longer than 1 day for NO_3-N, 0.8 ml concentrate H_2SO_4 ℓ^{-1} solution was added for preservation. After measurements of NO_3-N and total P, mean values were calculated.

Chemical analysis methods: Total phosphorus was measured according to APHA-AWWA-WEF, 1992. NO_3-N was measured by titrimetric method (Sağlam, 1994) after vapour distillation.

Determining total discharged nutrient: The amount of total nutrient discharged to the sea in a month was determined by multiplying the concentrations of the nutrients by monthly flow rate (Ekmekyapar, 2000). Flow rates (min. $0.01 \cdot 10^6$ – max. $1.9 \cdot 10^6$ m^3 s^{-1}) were measured by used matter flotation method. The section of streams were divided and estimated each slice areas.

$$[[C\ (mg\ l^{-1}) \cdot 10^3]\ X\ [Q_a\ (m^3 \cdot month^{-1})]\ ]\ /\ 10^9 = D_n\ (ton \cdot month^{-1})$$

In this formula:
C = Concentration (mg l^{-1})
Q_a= Monthly flow rate ($m^3 \cdot month^{-1}$)
D_n= The amount of total discharged nutrient ($ton \cdot month^{-1}$)

Determination of the amount and loss of fertilizer equivalent to the discharged nutrient: This region has a light-industry and the land use is mainly agriculture. For this reason, the determined nutrients were assumed only inputs to streams from agricultural areas. The amount of discharged nutrient was determined by multiplying the nitrogen contents of the amount of the discharged nutrient and chemical fertilizers. The amount of economic loss was obtained by multiplying the amount of discharged fertilizer by the unit price of the fertilizer.

$$D_n\ (ton \cdot month^{-1}) \cdot F_n\ (\%) = L_f\ (ton \cdot month^{-1})$$

In this formula:
D_n = Discharged nutrient ($ton \cdot month^{-1}$)
F_n = Nutrient content of fertilizer (%)
L_f = The amount of lost fertilizer ($ton \cdot month^{-1}$)

$$L_f\ (ton\ month^{-1}) \cdot F_p\ (USD \cdot ton^{-1}) = C_f\ (USD \cdot month^{-1})$$

In this formula:
L_f = The amount of lost fertilizer (ton·month^{-1})
F_p = The unit price of fertilizer (USD·ton^{-1})
C_f = The cost of the lost fertilizer (USD·month^{-1})

Statistical analyses: Non-parametric statistical procedures (Test of Friedman X^2r) were applied when normality of residuals and homogeneity of variances were not given (Soysal, 1995).

Results

Fertilizers equivalent to the discharged NO_3-N and the amounts of the economic loss: NO_3-N concentrations of the streams examined in monthly periods are given in Table 1. According to the non-parametric statistical analysis results (Soysal, 1995), corresponding to various streams and months, there are differences between the streams and the months during the year ($X^2{}_r = 89.5^{**}$).

Table 1. Mean (S.D) concentrations of NO_3-N in streams.

						NO_3- N (m g l^{-1})							
STREAMS	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**MEAN**
KUMBAĞ	1.4	1.1	3	4.1	4.8	4	1.5	1.3	1.5	2.8	3.2	2.5	2.6±1.2
BARBAROS	2.5	2	4	4.7	5.4	5	3.8	3	2.7	3.2	4	2.9	3.6±1.0
TEKİRDAĞ	2.2	2	3.4	3.8	4	3.3	2.3	1.9	1.5	3.2	3.6	2.5	2.8±0.8
DEREAĞZI	3.3	3	4.1	4.5	4.9	4	2.7	2.1	1.5	3	4	3	3.3±0.9
KAYI	2.5	2	3.4	4.2	4.8	3.3	2.2	2	1.8	2.4	2.8	2.6	2.8±0.9
GAZİOĞLU	2.7	2.1	3.4	3.9	4.3	3	2.2	2	1.8	2.2	2.9	2.7	2.7±0.7
KARAEVLİ	2.5	2	3.2	3.7	4.1	3.3	2.5	2.2	2	2.8	3.2	2.6	2.8±0.6
ŞEREFLİ	2.4	2	3.4	4.1	5	3.8	3.1	3	2.5	3.3	4.2	2.9	3.3±0.8
BAĞLAR	2.3	2.1	3.8	4.2	5	3.6	3.1	2.8	2	3.4	4	2.8	3.2±0.9
SEYMEN	2.9	2.1	3.4	4.2	5	3.7	3	2.8	2.5	3.2	4	3.3	3.3±0.7
MEAN	2.5±0.4	2± 0.4	3.5±0.3	4.1±0.3	4.7±0.4	3.7±0.5	2.6±0.6	2.3±0.5	2± 0.4	3± 0.3	3.6±0.5	2.7±0.2	

The highest NO_3-N concentration was determined as 5.4 mg l^{-1} in Barbaros Stream in May. The lowest NO_3-N concentration was determined as 1.1 mg l^{-1}in Kumbağ Stream in February. Considering the mean values, the NO_3-N concentrations of the streams in the research area increased after March, reached a maximum value of 4.7±0.4 mg l^{-1}in May, decreased during summer months and then increased again after October. The lowest mean NO_3-N was 2.0±0.4 mg l^{-1} in September. When the means of various NO_3-N concentrations are examined, the lowest average 2.6±1.2 mg l^{-1} belongs to Kumbağ Stream, the highest average 3.6 ± 1.0 mg l^{-1} belongs to Barbaros Stream. In the research area, NO_3-N concentrations in all streams have the highest values in spring period since ammonium nitrate and calcium ammonium nitrate fertilizers are used more than the other fertilizers in this region.

Higher nitrate input concentrations from agricultural sources to the river during the winter period when the catchments have wetted up and there is the greatest runoff from the land**.** For the Thames Basin rivers, the relatively high influence of agricultural sources of nitrate are shown (Neal et al., 2006).

In Marmara Ereğlisi, NO_3-N concentrations in streams Şerefli, Bağlar, Seymen are higher than the other streams. This may be due to the sandy soil (Ekinci, 1990), allowing the nutrients to be washed away easily.

Nitrate pollution had large spatial variation from 0.31 to 43.5 mg N kg^{-1} and reached serious pollution status, the highest nitrate concentration being four times higher than the legal limit of 10 mg N kg^{-1} for drinking water in their study (Xiong et al., 2006**).** Besides, the general target for surface waters in Germany – the water quality class II with an upper limit of 2.5 mg l^{-1} NO_3–N (Tiemeyer et al., 2006) – is far out of reach even for the brook Zarnow, while on several occasions, the nitrate–nitrogen concentrations fell within the worst quality class possible (>20 mg l^{-1} NO_3–N).

The NO_3-N equivalent of ammonium nitrate fertilizer are given in Table 2 and the cost of the lost fertilizers are displayed in Table 3. An inspection of the statistical analysis results corresponding to various streams and months show that the results vary with streams and months during the year ($X^2{}_r = 89.5^{**}$).

According to the data obtained, the highest ammonium nitrate fertilizer was lost from Kumbağ Stream in April at a level of 224 ton·month^{-1}and 22384 USD·month^{-1}, the lowest amonium nitrate fertilizer was lost from Tekirdağ Stream in July at a level of 0.6 ton·month^{-1} and 76 USD·month^{-1}. The mean values of the NO_3-N equivalent ammonium nitrate fertilizer discharged from the streams in the research area is comparatively higher in spring season. The lost ammonium nitrate fertilizer had the highest values of 177.3±38 ton·month^{-1} and 21280 USD·month^{-1} in May, it has decreased during summer months and it has increased again after October. The lowest loss of mean ammonium nitrate fertilizer has been 7.7±4.8 ton·month^{-1} and 934 USD·month^{-1} in September.

Table 2. The amounts of ammonium nitrate fertilizer that is equivalent to NO_3-N which discharged from the streams in the research area.

NH_4 NO_3 (ton month^{-1}) L_f													
STREAMS	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TOTAL**
KUMBAĞ	36.3	38.8	128	224	220	160	23	9.9	13.1	27.3	56.5	56.9	994.0
BARBAROS	15	16.3	67.2	132	190	126	1.6	2.1	3	5.2	20.6	16.7	595.7
TEKIRDAĞ	6.5	13.6	46.5	95.4	122	53.6	0.6	0.7	1	4.2	6.8	6.8	357.7
DEREAĞZI	32.7	37	74.9	83	97.4	8.7	4	2.1	2.1	8.1	18.3	22.7	391.0
KAYI	41.8	49.4	104	143	205	48.7	13.2	2.9	5.1	29.2	37.2	39.7	719.2
GAZİOĞLU	49.2	46.3	98.4	138	184	52.9	20	2.9	7.8	16.6	46.9	47.2	590.2
KARAEVLİ	53.1	46.5	97.4	136	175	63.3	26.5	2.9	11.7	25.6	56.5	53.5	748.0
ŞEREFLİ	40.2	35.6	93.2	133	183	61.8	37.8	22.7	14.7	35.2	49.6	44.1	750.9
BAĞLAR	45.2	46.3	104	143	191	63.7	33	21.4	11.7	31	65	53.5	808.8
SEYMEN	61.8	46.3	98.4	143	206	70.8	41	17	7.3	24.2	70.9	68	854.7
MEAN	38±16	38±12	91±22	137±37	177±38	70±42	20±14	8.6±8.4	7.7±4.8	20±11	42±21	40±19	6810.2

Table 3. The amounts of economic loss of amonium nitrate fertilizer.

NH_4NO_3 (USD Month^{-1}) C_f													
STREAMS	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TOTAL**
KUMBAĞ	3636	3880	12760	22384	21368	19168	2784	1192	1576	3280	6780	6828	105636
BARBAROS	1508	1636	6720	13212	22792	15064	200	260	368	632	2476	2012	66880
TEKİRDAĞ	656	1364	4656	9548	14676	6440	76	92	120	508	820	820	39776
DEREAĞZI	3276	3700	7496	8308	11688	1052	480	260	260	972	2196	2724	42412
KAYI	4180	4940	10360	14296	24600	5852	1592	356	616	3512	4472	4768	79544
GAZİOĞLU	4928	4632	9844	13792	22048	6348	2400	356	944	1996	5636	5664	78588
KARAEVLİ	5316	4656	9740	13624	21008	7600	3188	1192	1408	3080	6780	6424	84016
ŞEREFLİ	4024	3560	11192	13316	21984	7416	4536	2724	1764	4224	5960	5292	85992
BAĞLAR	4528	4632	10436	14296	22900	7648	3960	2568	1408	3728	7800	6424	90328
SEYMEN	6180	4632	9844	14296	24740	8500	4920	2040	880880	2908	8516	8160	95616
MEAN	3823	3763	9305	13707	21280	8508	2413	1104	934	2484	5144	4912	768788

Quantity of fertilizers equivalent to the discharged total phosphorus and the amounts of the economic loss: Total phosphorus concentrations of the streams examined in monthly periods are displayed in Table 4. According to the non-parametric statistical analysis results corresponding to various streams and months, there are differences between the streams and the months during the year ($X^2{}_r = 102.9^{**}$).

Table 4. Mean (S.D) concentrations of total phosphorus in streams.

	Total P mg l^{-1}												
STREAMS	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**MEAN**
KUMBAĞ	1.9	1.7	2.1	3	3.4	2.8	2	1.9	3.1	3.4	3.5	2.8	2.6±0.6
BARBAROS	1.9	1.8	2.2	3.2	3.3	2	1.9	1.8	3.1	3.4	3.6	2.9	2.6±0.7
TEKİRDAĞ	1.8	1.5	1.9	2.7	3.3	2.1	2	1.9	3	3.8	3.9	2.2	2.5±0.8
DEREAĞZI	1.1	1.2	1.9	2.5	3.2	1.9	1.8	1.6	2.5	3.9	4	2.2	2.3±0.9
KAYI	1.9	1.7	2	3.4	4.8	2.1	1.8	1.7	2.2	3.5	3.6	2.8	2.6±0.9
GAZİOĞLU	2.1	1.8	2.1	3.2	4.2	2.2	1.8	1.7	2.1	3.7	3.9	2.8	2.7±0.9
KARAEVLİ	2.2	1.9	2.3	3.7	5	2.3	2	1.9	2.6	3.7	3.9	2.4	2.8±0.9
ŞEREFLİ	2.8	2.1	3.2	4.8	6.1	3.4	3	2.8	3.3	5.2	6	3	3.8±1.3
BAĞLAR	1.9	1.8	2.2	3.2	3.5	2.5	2.1	1.6	3.2	4.1	4.7	3.4	2.9±0.9
SEYMEN	1.8	1.7	2.2	3.3	3.5	2.8	2.2	1.9	2.6	3.6	3.8	2.7	2.7±0.7
MEAN	1.9± 0.4	1.7±0.2	2.2±0.3	3.2±0.6	4.0± 0.9	2.4±0.4	2.1±0.3	1.9±0.3	2.8±0.4	3.8±0.5	4.1±0.7	2.7±0.3	

The highest total phosphorus concentration was 6.1 mg l^{-1} in Şerefli Stream in May. The lowest total phosphorus concentration was 1.1 mg l^{-1} in Dereağzı Stream in January. Considering the mean values, the total phosphorus concentrations of the streams in the research area increased after March, reached the maximum value of 4.0± 0.9 mg l^{-1} in May, decreased during summer months and then increased again after October. The lowest mean total phosphorus was 1.7±0.2 mg l^{-1} in February.

The main period fort he transport of diffuse, agricultural sources of P is during the winter and particularly the autumn rains which are key drivers of the transport processes involved (Mainstone and Parr, 2002; Cooper et al., 2002) The high total phosphorus concentration for all streams in the spring period can be attributed to the density of precipitations, and to the increased fertilizer applications. The density of precipitations following the fertilizer applications causes erosion and total transport of phosphorus. As a result, the phosphorus concentration from agricultural areas is highest during the spring flows (Bowes et al., 2005 and Cooper et al., 2002).

An examination of the mean values of various total phosphorus concentrations show that the lowest mean 2.3±0.9 mg l^{-1} belongs to Dereağzı Stream, the highest mean 3.8± 1.3 mg l^{-1} belongs to Şerefli Stream.

Westlake (1981), suggested that nutrients will not be limiting in rivers water with phosphate concentrations >30 µg P l^{-1} and nitrate concentrations >30 µg N l^{-1}; conversely it is likely that periphytic algal biomass will be limited by nutrient availability across a wide spectrum of nutrient concentrations.

Total maximum limits adopted by the Turkish Water Pollution Regulations for phosphorus concentrations are shown in Table 5. All of the streams, with total phosphorus concentrations greater than the upper limit of 0.65 mg l^{-1}, appear to have "fourth class". The mean concentrations of NO_3-N and total phosphorus of streams in research area are shown in figure 2.

Table 5. Regulations of Turkish Water Pollution Control.

Class of Water Quality	NO_3-N (mg l^{-1})	Total Phosphorus (mg l^{-1})
1. Class	5	0.02
2. Class	10	0.16
3. Class	20	0.65
4. Class	> 20	> 0.65

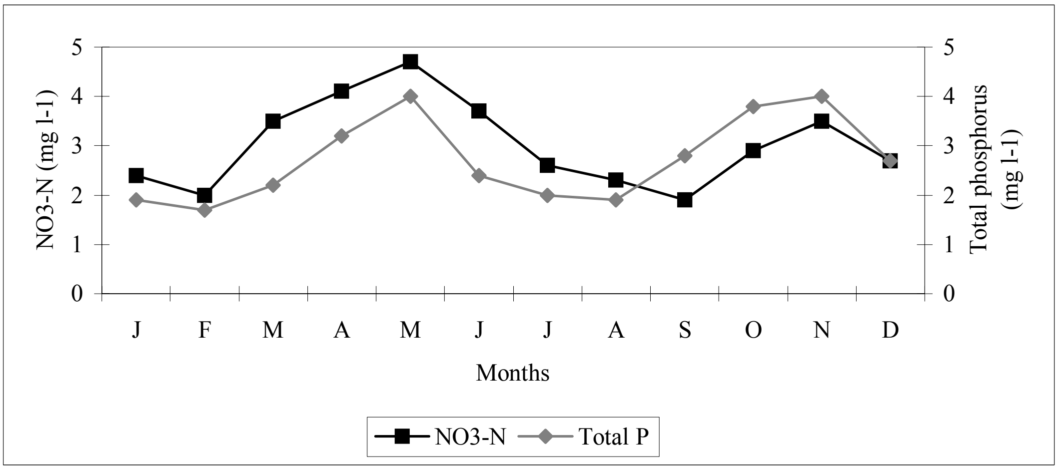

Figure 2. The mean concentrations of NO_3-N and total phosphorus of streams in research area.

The amount of triplesuperphosphate fertilizer equivalents of total phosphorus are given in Table 6, and the cost of the lost fertilizers are displayed in Table 7 for the streams inspected. According to the non-parametric statistical analysis results corresponding to various streams and months, there are differences between the streams and the months during the year ($X^2{}_r = 98.7^{**}$).

Table 6. The amounts of triplesuperphosphate fertilizer that is equivalent to total phosphorus which discharged from the streams in the research area.

					TSP (ton month^{-1}) L_f								
STREAMS	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TOTAL**
KUMBAĞ	4.9	57.8	86	157	149	106	29	14	26	31.6	59	61.1	823.4
BARBAROS	10.9	13.6	34	86	113	48	0.5	1.1	3.3	5.4	17	15.8	348.6
TEKİRDAĞ	4.9	9.8	25	64	96	32	0.5	0.5	1.6	4.9	6.5	5.4	251.1
DEREAĞZI	10.4	13.6	34	44	61	3.8	2.2	1.6	3.3	10.4	16	16	216.3
KAYI	8.5	40.4	58	110	196	29	10	2.2	6	40.3	45	41.4	586.8
GAZİOĞLU	36.5	38.7	58	11	175	38	15	2.2	8.7	27.3	61	47.4	518.8
KARAEVLİ	45.3	41.4	68	130	204	42	20	8.2	15	32.7	65	47.9	719.5
ŞEREFLİ	44.7	35.9	85	149	214	52	35	20	19	52.9	68	43.6	819.1
BAĞLAR	36.5	37.1	57	102	128	42	21	12	19	35.4	73	62.7	625.7
SEYMEN	38.2	35.9	60	107	139	50	28	11	7	26	63	54.5	620.1
MEAN	35±23	32.4±15	56±20	96± 46	147±50	44± 25	16± 12	7.3± 6	11± 8	27±15	47±24	39± 20	5528.9

Table 7. The amounts of economic loss of triplesuperphosphate (TSP) fertilizer.

	TSP (USD month^{-1}) C_f												
STREAMS	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TOTAL**
KUMBAĞ	7128	8784	13012	23788	28088	19888	5536	2664	4920	5944	11072	11480	142304
BARBAROS	1656	2072	5220	13012	21320	9020	100	204	612	1024	3280	2972	60492
TEKİRDAĞ	744	1488	3812	9780	18040	6048	100	100	304	920	1228	1024	43588
DEREAĞZI	1572	2072	5136	6712	11376	716	408	304	612	1944	3072	2972	36896
KAYI	12928	6132	8868	16740	36904	5536	1944	408	1124	7584	8404	7788	117060
GAZİOĞLU	5552	5884	8784	16492	32804	7072	2868	408	1640	5124	11376	8916	106920
KARAEVLİ	6876	6296	10276	19808	38340	7892	3792	1536	2768	6148	12300	9020	125052
ŞEREFLİ	6796	5468	12844	22628	40184	9840	6560	3792	3484	9944	12712	8200	152292
BAĞLAR	5552	5636	8620	15500	23988	7892	3996	2252	3484	6660	13736	11788	109104
SEYMEN	5800	5468	9116	16244	26036	9428	5328	2048	1332	4920	11892	10248	107860
MEAN	5460	4930	8569	16070	27708	8333	3063	1372	2028	5021	8907	7441	1001568

According to the data obtained, the highest triplesuperphosphate fertilizer was lost from Şerefli Stream in May at a level of 214 ton·month^{-1} and 40184 USD·month^{-1}; the lowest triplesuperphosphate fertilizer was lost from Barbaros and Tekirdağ Streams in July at a level of 0.5 ton·month^{-1} and 100 USD·month^{-1}. Considering the mean values, the total phosphorus equivalent triplesuperphosphate fertilizer discharged from the streams in the research area, is comparatively higher in spring season. The lost triplesuperphosphate fertilizer had the highest values of 147±50 ton·month^{-1} and 27708 USD·month^{-1} in May, decreased during summer months and increased again after October. The lowest loss of mean triplesuperphosphate fertilizer was 7.3±6 ton·month^{-1} and 1372 USD month^{-1} in August.

Discussion and Conclusion

The Water Framework Directive of the European Community (WFD; Council of European Communities, 2000) provides one of the most significant environmental targets for improving surface water quality across Europe. While considering a host of pollutants, a key focus is placed on the role of nutrients in eutrophication.

Although the process of eutrophication is reasonably well understood in lakes, there is currently no conceptual understanding of how eutrophication develops in rivers. In eutrophic and hyper-eutrophic systems, nutrients, particularly phosphorus, are drivers of the system. Rivers that are subjected to frequent, high pulse flows of long duration during the growing season are likely to show the undesirable effects of eutrophication at lower nutrient concentrations than rivers which are not subject to additional high velocity stresses. (Bowes et al., 2005).

It is generally recognised that an increase in nutrient loading is a prequisite of increased etrophication in streams. Surplus N is deposited in the agricultural soil or transferred to water bodies through runoff and leaching, and induces considerable changes in the ecosystem of the aquatic and coastal environment such as enhanced eutrophication and frequent harmful algal blooms (Zhang et al., 1999).

According to the results of this study, most of the N and P in the surface water was probably derived from anthropogenic inputs. The nutrients in streams water could mainly come from the agricultural land runoff. Intensive sunflower and wheat production uses high inputs of fertilizer, often exceeding crop uptake, which may be transported to watercourses through surface runoff and leaching.

In this study, the nutrient analyses of the streams discharging into the Marmara Sea were performed within the basin between Kumbağ and Marmara Ereğlisi of the Tekirdağ province. The results of the analyses were evaluated to determine the amounts of total chemical fertilizers carried away to the sea and the corresponding economic loss. According to the results obtained in the study, 368.4 mg l^{-1} nitrate nitrogen and 328.4 mg l^{-1} total phosphorus per year was carried to Marmara Sea from the study zone.

The quantities of the chemical fertilizer forms corresponding to such concentrations are 6 810.2 ton of NH_4NO_3 year^{-1} and 5 528.9 ton of TSP year^{-1}. These results show that the financial figures corresponding to nitrate fertilizer lost in the study zone is USD 768 788, while triple super phosphate fertilizer worth is USD 1 001 568.

As a matter of fact, this pollution takes its toll from Marmara Sea in addition to others, rendering it more eutrophic. Since the agricultural activities in the region cannot be ceased, the farmers or people involved in agricultural activities should have an environmental consciousness and protect natural resources. The economic developments should be sustainable.

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