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EFFECT OF ALDER ON NITROGEN TRANSPORT TO SURFACE WATERS AND CATION LOSSES IN NATURAL ECOSYSTEMS IN ŞiMŞiRLi WATERSHED

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ABSTRACT

Plant species compositions in the ecosystem and soils developed under these species compositions cause nutrients to be fixed or transport away from the site. The change of plant species compositions of forest ecosystems in precipitation watersheds changes the quality of water produced from these watershed. Especially, the fact that species such as Alder with nitrogen fixation ability enter into plant species composition will be effective on nutrient cycling. In this study, the effect of Alder on nitrogen transport to surface waters and therefore the cation losses in the ecosystem in stands where it is dominant was investigated. For this purpose, 36 surface water samples from 3 sub-watersheds selected in Şimşirli stream watershed throughout 1 water year and 39 soil samples from 15 soil profiles opened in forest areas were taken. While water quality parameters such as pH, EC, total nitrogen (TN), nitrate (NO_3-N), ammonium (NH_4-N), Ca^{++}, Mg^{++}, K^+ and Na^+ were determined in surface waters, sand, silt, clay, pH, EC, soil organic matter, total nitrogen and exchangeable cations (Ca^{++}, Mg^{++}, K^+ and Na^+) were determined in soil samples. TN and NO_3^-N concentrations in surface waters have increased along with the increase in the rate of forest area in the lower watersheds. Increase of NO_3^-N concentration in surface waters increased the basic cation (Ca^{++}, Mg^{++} and K^+) concentrations. This situation shows that leaching of nitrate in the sub-watersheds increases the cation losses. Annual TN transport in the sub-watersheds varied between 6.17 - 95.09 kg N Ha^{-1} and was 44.93 kg N $Ha^{-1}Year^{-1}$ on the average. Findings obtained as a result of the study suggest that Alder might be an important species under the control of the ecosystem and provide valuable information about the possible eutrophication of Galyan-Atasu dam reservoir.

Keywords: Alder, TN and NO_3^- export, cation losses, eutrophication

ŞİMŞİRLİ HAVZASINDAKİ DOĞAL EKOSİSTEMLERDE KIZILAĞACIN YÜZEY SULARINA AZOT TAŞINIMI VE KATYON KAYIPLARINA ETKİSİ

ÖZET

Ekosistemdeki bitki tür bileşimleri ve bu tür bileşimleri altında gelişen topraklar, besinlerin tutulmasına veya ortamdan uzaklaşmasına sebep olurlar. Yağış havzalarındaki orman ekosistemlerinin bitki tür bileşimlerinin değişimi bu havzalardan üretilen suyun kalitesini değiştirir. Özellikle azot bağlama yeteneğine sahip Kızılağaç gibi türlerin bitki tür bileşimine girmesi besin döngüsü üzerinde etkili olacaktır. Bu çalışmada, hakim olduğu meşcerelerde

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Kızılağacın yüzey sularına azot taşınımı ve dolayısıyla ekosistemdeki katyon kayıplarına etkisi araştırılmıştır. Bu amaçla, Şimşirli dere havzasında seçilen 3 alt havzadan 1 su yılı boyunca 36 adet yüzey suyu örneği ile orman alanlarında açılan 15 toprak profilinden 39 adet toprak örneği alınmıştır. Yüzey sularında pH, EC, toplam azot (TN), nitrat (NO_3-N), amonyum (NH_4N), Ca^{++}, Mg^{++}, K^+ ve Na^+ gibi su kalite parametreleri, toprak örneklerinde kum, toz, kil, pH, EC, organik madde, toplam azot ve değişebilir katyonlar (Ca^{++}, Mg^{++}, K^+ ve Na^+) belirlenmiştir. Alt havzalardaki orman alanı oranının artmasıyla birlikte yüzey sularındaki TN ve NO_3^-N konsantrasyonları artmıştır. Yüzey sularındaki NO_3^-N konsantrasyonunun artması bazik katyon (Ca^{++}, Mg^{++} ve K^+) konsantrasyonlarını artırmıştır. Bu durum alt havzalardaki nitrat yıkanmasının katyon kayıplarını arttırdığını göstermektedir. Alt havzalardaki yıllık TN taşınımı 6.17 - 95.09 kg N Ha^{-1} arasında değişmekte ve ortalama 44.93 kg N $Ha^{-1}$$Yıl^{-1}$'dır. Çalışma sonucunda elde edilen bulgular, ekosistem kontrolünde Kızılağacın önemli bir tür olabileceği ve Galyan-Atasu barajı göletinin muhtemel ötrofikasyonu hakkında değerli bilgiler verebilir.

Anahtar Kelimeler: Kızılağaç, TN ve NO_3^- taşınımı, katyon kayıpları, ötrofikasyon

INTRODUCTION

The land cover/land use, plant species composition and change in the catchment watersheds are effective on the quantity and quality of water. Although it is known that the water quality has increased in the catchment watershed covered with forests, difference in forest species composition play important role in the export of nutrients from watershed soils to surface waters. Increasing of the concentration of organic origin nutrients in surface waters negatively affects the water quality. Among these, nitrogen is one of the most important nutrient elements that regulates the water quality and production of aquatic ecosystems (Mazumder and Havens, 1998; Camargo and Alonso, 2006). High amount of nitrogen inputs to aquatic ecosystems may lead to algae bloom and eutrophication, which causes the deterioration of water quality (Downing and McCauley, 1992; Rabalais, 2002). In forest ecosystems, amount of nutrients that have an importance place in plant production can turn into a source of pollution for water resources in the same watershed. Nutrient pollution in water has many undesirable effects leading to an increase in phytoplankton and other aquatic plants (eutrophication) (Conley, 1999; de Wit, 2001). On the other hand, high amount of nitrogen transport which may cause the eutrophication from the soils in precipitation watersheds can lead to nitrogen losses in terrestrial ecosystems and imbalance in the nutrient cycle (Murdoch and Stoddard, 1992; Likens and others, 1996; Vitousek and others, 1997).

Plant species compositions are important factors affecting the soil fertility and nutrient cycle in the ecosystems. Plant species may cause the retention of nutrients in the ecosystem during the nutrient cycle and also nutrient losses in the watershed scale (Lovett and others, 2000). Some plant species have symbiotic nitrogen fixation in terrestrial ecosystems. It is stated that pure forms of stands of some tree species can fix 50 - 200 kg N Ha^{-}1 nitrogen per year in this way (Boring and others, 1988; Binkley and others, 1994).

As in this study, it is stated that alders could significantly increase the nitrogen content of soils in pure or mixed stands (Binkley and others, 1992; Binkley and others, 1994). Alder may cause the leaching of cations in soil in addition to soil acidification for the future of both species with which it is composed and itself (Brozek, 1990; Compton and others, 1997). Moreover, it may increase the nitrogen contents of river waters in the watersheds it is located and therefore the near lake ecosystems (Goldman, 1961; Binkley and others, 1982; Stottlemyer and Toczydlowski, 1999).

In this study carried out in Şimşirli watershed supplying Galyan-Atasu dam which was built to produce drinking water and domestic water, relationships between the nitrogen exported from forest areas in different proportions to surface waters and cation losses were investigated. It is noteworthy that the nitrogen exported to surface waters and cation losses increased as the ratio of alder in the stand increased in forest areas.

MATERIAL AND METHODS

Research area

Galyan-Atasu dam was built for the drinking, domestic and industrial water needs of Trabzon and some of its districts. Galyan and Şimşirli streams supply the dam reservoir (Usta, 2011). The reservoir area of the dam which was built to provide 91 million m^3 of water is 0.83 km^2, and its storage capacity is 37.5 million m^3 (Nişancı et al., 2007). Şimşirli stream watershed is 5805.41 ha. The granite bedrock is surfaced in sub-watersheds received in Kaçkar granitoid formation (Güven, 1993). Study was carried out in sub-watersheds with approximately same (average of 1500 m) locations and average altitudes in the side tributaries of Şimşirli stream.

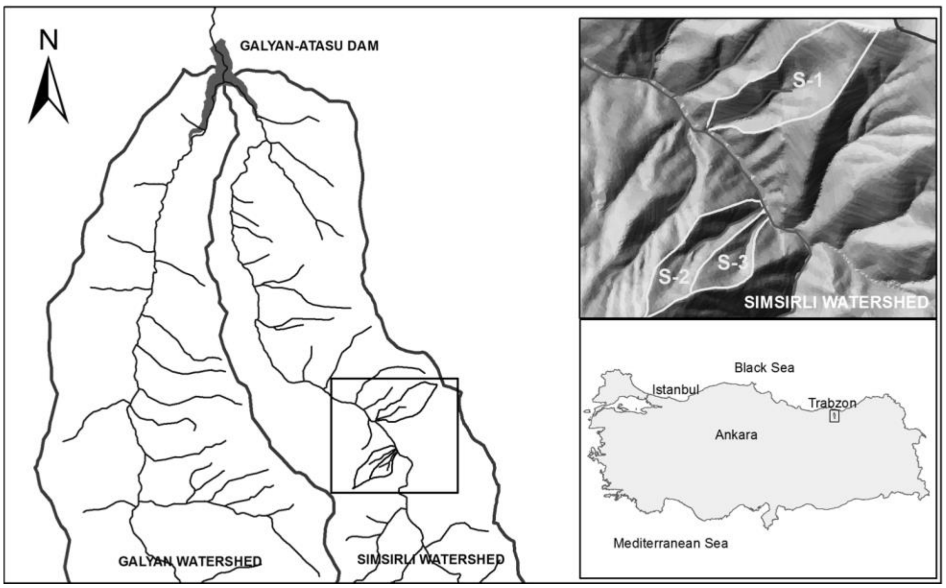

Figure 1. Location of the research area

The total area of Galyan and Şimşirli watersheds is 18536.0 ha. In watersheds, the pure alder stand area is 452.5 ha, the area of mixed stands dominated by alder is 1772.9 ha, and the area of stands with which it is mixed is 2987.5 ha (GDF, 2011). When the fact that alder is pure and mixed in 5212.9 ha of 6898.5 ha forest area in watersheds is considered, it can be said that alder has effect on approximately 75% of the forest areas in watersheds.

Table 1. Characteristics of sub-watersheds

Sub watersheds	Watershed characteristics
S-1	A area including broad-leaved forest (% 65.8), grassland (% 33.1 in seasonal use) and agricultural area with the lowest (% 1.1 in seasonal use) human influences; species of broad-leaved forest are *Alnus glutinosa* subsp. Barbata (C.A. Meyer) Yalt., *Fagus orientalis* Lipsky and *Carpinus orientalis* Mill. subsp. orientalis; S-1 is 62.51 ha.
S-2	The highest broad-leaved forest (% 85.5) and little grassland (% 14.5 in seasonal use); species of broad-leaved forest are *Alnus glutinosa* subsp. Barbata (C.A. Meyer) Yalt. and *Fagus orientalis* Lipsky. S-2 is 32.18 ha.
S-3	The highest broad-leaved forest (% 98.3) with little coniferous (*Picea orientalis* L.) area (% 1.7). Species of broad-leaved forest are *Alnus glutinosa* subsp. Barbata (C.A. Meyer) Yalt. and *Fagus orientalis* Lipsky; S-3 is 17.84 ha.

Sub-watersheds where the study was carried out were coded as S-1, S-2 and S-3, and forest area ratios vary as 65.8% (Alder, Beech, Hornbeam), 85.5% (Alder, Beech) and 98.3% (Alder, Beech), respectively (Table 1). Forest and pasture areas exist in the sub-watersheds selected, and the dominant tree species in the forest area is Alder (GDF, 2011).

Soil and water analyses

A total of 39 soil samples were taken from 15 soil profiles opened in forest areas in sub-watersheds. In soil samples, sand, silt, clay ratios were calculated by Bouyoucos's hydrometer method (Gülçur, 1974), soil pH and EC ($mscm^{-1}$) were calculated by glass electrode method in pure water (USDA, 1996), soil organic matter was calculated through oxidizable organic carbon (Arp, 1999) according to Walkley Black wet combustion method; total nitrogen (TN) was determined in Leco FP-428 nitrogen measurement device by dry combustion method, available phosphorus (P_2O_5) was determined by Bray-Kurtz method and replaceable cations (Ca^{++}, Mg^{++}, K^+ and Na^+) were determined by 1 Normal Neutral Ammonium acetate method (USDA, 1996).

Water samplings were performed once a month between the dates of September 2010 - August 2011 by taking a total of 36 water samples. Some water quality parameters (temperature, pH and EC) were measured in the field. Water samples taken by using polyethylene containers (of 0.5 L) were stored in the refrigerator at +4 ^oC by using reactive which was in compliance with the EPA (1983) standards. pH and EC (ms/cm^{-1}) were measured by Orion 5 Star device. Total Nitrogen (TN), Nitrate (NO_3N) and Ammonium (NH_4N) were determined by photometric method in the UV-VIS Shimadzu 1800 branded device by using Spectroquant branded kits. Ca^{++}, Mg^{++}, K^+ and Na^+ cations were measured in the Shimadzu AA-6601 branded Atomic Absorption Spectrophotometer device (APHA, 1989).

The flow of surface waters was measured in the field by FP111 Flow Meter device for 12 months as once a month. Nutrient concentrations (mg/l) in surface waters were converted into quantities per unit area (kg/ha) with the help of flows by considering the watershed areas.

Statistical analysis

In the study, variance analysis was performed by considering water quality parameters and soil properties of sub-watersheds (S-1, S-2 and S-3) as dependent variables, and sub-watersheds as factors. For the variables which were found to be statistically different, sub-watersheds were compared by "Duncan test". Relationships between forest area ratio and concentrations of water quality parameters in sub-watersheds and the amounts exported to surface waters were tested by correlation analysis. Regression analysis was used in determining the annual amount of nitrogen exported to surface waters. All statistical analyses were performed in SPSS 16.0 program (SPSS, 2011).

RESULTS

According to variance analysis results, water quality parameters of the sub-watersheds were statistically similar outside TN and NO_3N. TN and NO_3N amounts were observed to be highest in S-3 watershed and to be lowest in S-1 watershed (Table 2).

Table 2. Parameters measured in stream waters

Sub W.	Discharge m^3dk^{-1}	pH	EC ms cm^{-1}	TN mgL^{-1}	NH_4^-N μgL^{-1}	NO_3^-N mgL^{-1}	Ca^{++} mgL^{-1}	Mg^{++} mgL^{-1}	K^+ mgL^{-1}	Na^+ mgL^{-1}
S-1	1.13±0.83a*	7.42±0.21a	90.6±15.23a	2.64±1.45a	40±23a	1.14±0.30a	2.73±1.30a	1.20±0.23a	0.76±0.19a	1.38±0.32a
S-2	0.71±0.59a	7.31±0.27a	99.2±16.79a	4.52±2.22b	22±16a	2.20±0.89ab	2.71±1.40a	1.25±0.24a	0.66±0.17a	1.40±0.31a
S-3	0.46±0.95a	7.23±0.23a	94.0±13.62a	6.01±1.83b	36±12a	3.16±1.56b	3.32±1.79a	1.15±0.26a	0.74±0.20a	1.41±0.33a

Sub W.: Sub Watersheds, ± : Standart Deviation, * : the different letters indicate statistical differences of total averages between different sites at $p<0.05$ (Duncan test)

The average annual nitrate concentrations of water samples vary between 1.14 - 3.16 mg N L^{-1}, and TN concentrations vary between 2.64 - 6.01 mg N L^{-1} (Figure 2). Ammonium concentrations in very low amounts vary between 22 - 40 µg N L^{-1} on average. TN loss from watersheds was found to be between 6.17 - 95.09 kg N Ha^{-1} $Year^{-1}$ and to be 44.93 kg N $Ha^{-1}Year^{-1}$ on average (Figure 3).

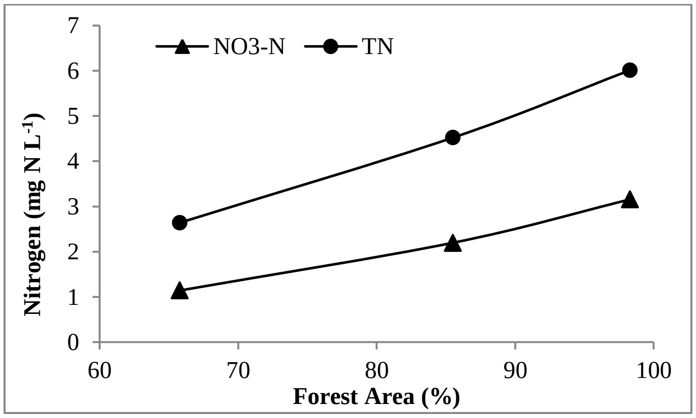

Figure 2. Relationship between leaved forest area and nitrogen forms

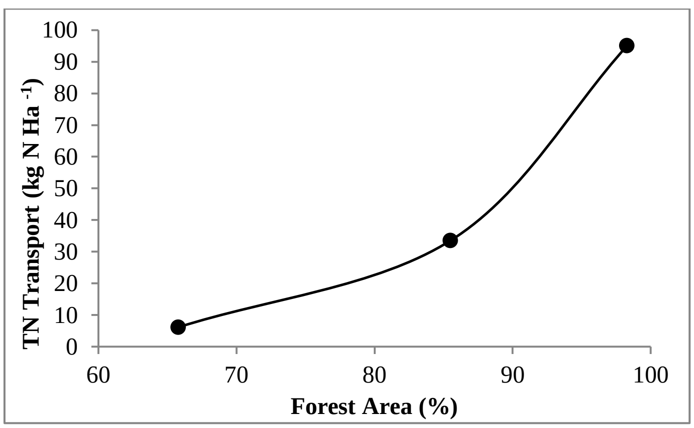

Figure 3. Effect of leaved forest area ratio on TN loss

As a result of the correlation analysis, positive relationships were found between TN ($p<0.001$, $r=0.610$) and NO_3-N ($p<0.001$, $r=0.627$) concentrations measured in the forest area and surface waters in watersheds (Table 3). In addition, positive relationships were determined between NO_3N concentrations measured in surface waters and basic cations. These relationships are; Ca^{++} ($p<0.001$, $r=0.532$), Mg^{++} ($p<0.05$, $r=0.416$) and K^+ ($p<0.05$, $r=0.443$) (Table 3).

Table 3. Relationship between leaved forest areas and some water quality parameters

	TN (%)	NH_4N (ppm)	NO_3N (ppm)	Ca^{++} (ppm)	Mg^{++} (ppm)	K^+ (ppm)	Na^+ (ppm)
Forest Area (%)	0.610**	-0.099	0.627**	0.148	-0.070	-0.055	0.043
TN (%)		-0.419*	0.400*	0.230	-0.291	0.102	-0.410**
NH_4N (ppm)			0.218	0.301	-0.003	0.628**	-0.414*
NO_3N (ppm)				0.532**	0.416**	0.443**	0.145
Ca^{++} (ppm)					0.495**	0.720**	-0.016
Mg^{++} (ppm)						0.308**	0.449**
K^+ (ppm)							-0.120

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Annual TN transport in sub-watersheds was determined, and forest area ratio and the amount of nitrogen exported were subjected to correlation analysis. As a result of the regression analysis performed to determine the annual nitrogen transport occurring in forest areas, annual TN transport was ideally obtained by the following formula.

Annual TN Transport (kg Ha^{-1}) = -132.649 + 2.016 x Forest (%) (r^2 = 0.657)

Annual cation losses in forest areas are given in Figure 3. With the increase in forest ratio, increase was determined in Ca^{++}, Mg^{++}, K^+ and Na^+ in sub-watersheds (Figure 4). The highest cation loss occurred in Ca^{++}. Accordingly, taking into account S-3 watershed where the highest forest area ratio and cation losses occurred, annual losses were determined as 33.82 kg Ha^{-1} in Ca^{++}, as 3.32 kg Ha^{-1} in Mg^{++}, as 1.43 kg Ha^{-1} in K^+ and as 5.04 kg Ha^{-1} in Na^+.

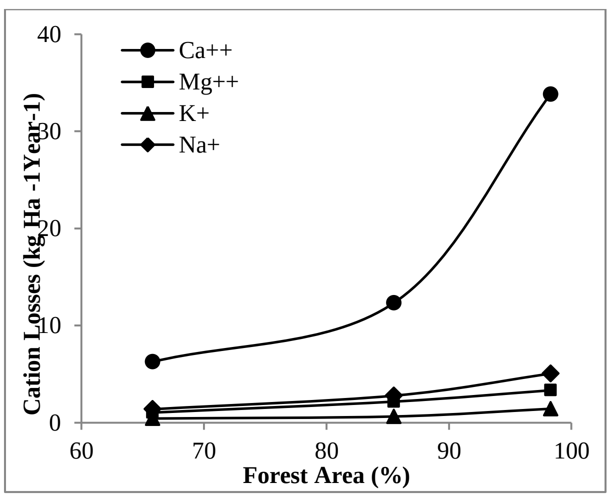

Figure 4. Relationship between forest area ratios and cation losses

The average values of some physical and chemical properties of soil samples taken from the forest areas are given in Table 4. According to the results of variance analysis, statistical difference was found between sub-watersheds in terms of pH, Ca^{++} and Mg^{++}. According to Duncan test, S-2 and S-3 sub-watersheds are similar in terms of pH and Ca^{++}, and average pH and Ca^{++} values of these watersheds are lower compared to S-1 watershed. S-1 and S-3 sub-watersheds are statistically different in terms of Mg^{++}, and S-2 sub-watershed was found to be similar with S-1 and S-3 sub-watersheds.

Table 4. Average values of some physical and chemical soil properties of the forest areas

Sub Watersheds	Sand %	Silt %	Clay %	pH	EC (ms cm^{-1})	OM %	TN %	Exchangeable Bases (mgL^{-1}) Ca^{++}	Mg^{+}	K^{+}	Na^{+}
					Forest Area						
S-1	78±6a	10±2a	12±4a	5.48±0.5b	93.7±26.7a	9.10±4.3a	0.48±0.1a	712.4±449.3b	150.6±51.5b	66.7±19.1a	57.1±13.4a
S-2	84±4a	11±4a	5±4a	3.97±0.5a	144.4±68.6a	10.34±3.7a	0.60±0.2a	110.1±91.8a	71.3±12.3ab	100.9±37.8a	76.1±57.0a
S-3	86±3a	8±1a	6±2a	4.13±0.6a	100.0±53.7a	12.90±1.4a	0.76±0.4a	54.4±73.1a	36.0±21.9a	62.2±18.1a	50.0±0.8a

Regarding the physical soil properties of forest areas in sub watersheds, no statistically significant difference was found between sand, silt and clay contents ($p>0.05$). The highest average sand content was determined in S-3 sub-watershed where Alder was the dominant species. In general, average sand contents of the leaved forest areas in sub watersheds vary between % 78-86.

DISCUSSION

Nitrogen concentrations in stream waters

According to the results of variance analysis, significant differences were found between sub-watersheds in terms of TN and NO_3N amount. Other water quality parameters were found to be statistically similar. TN and NO_3N amounts were determined to be highest in S-3 watershed and to be lowest in S-1 watershed. Forest area ration in S-3 sub-watershed (98.3%) is higher compared to other sub-watersheds. Forest area ratio is the lowest in S-1 sub-watershed (65.8%). The annual average NO_3N concentrations are between 1.14 - 3.16 mg N L^{-1}, and TN concentrations are between 2.64 - 6.01 mg N L^{-1}. NH_4N concentrations in very low amounts were found to be annual average 22 - 40 µg N L^{-1}. As a result of the correlation analysis, statistically significant positive relationships were determined between TN ($p<0.001$, $r=0.610$) and NO_3N ($p<0.001$, $r=0.627$) measured in the forest area ratio and stream waters in the watersheds. With the increase in the forest area ratio in sub-watersheds, there occurred increase in TN, NO_3N and NH_4N concentrations. In sub-watersheds, high amounts of nitrogen forms in pure and mixed Alder stands in forest areas can flow into stream waters (Compton et al., 2003). In some studies carried out in watersheds with pure, leaved, mixed and coniferous species of Alder and mixed stands, nitrogen in the soil and nitrogen leaching in the soil solution were reported to be much higher (Van Miegroet and Cole, 1984; Bormann et al., 1994; Compton et al., 2003). In fact, according to variance analysis performed on the soil properties of the forest areas in sub-watersheds, statistically significant differences were found between watersheds in terms of pH, Ca^{++} and Mg^{++}, and average values are lower in S-2 and S-3 watersheds. The average pH of the forest soils in S-2 and S-3 sub-watersheds are 3.97 (S-2) and 4.13 (S-3). In the forest areas in both sub-watersheds, Alder is the dominant species and there is Beech mixing with this species. Low levels of soil pH as well as Ca^{++} and Mg^{++} values mean the leaching of soils at higher degrees by basic cations.

In sub-watersheds, annual TN transport was found to be between 6.17 - 95.09 kg N Ha^{-1} $Year^{-1}$, and to be 44.93 kg N $Ha^{-1}Year^{-1}$ on average. The lowest nitrogen transport occurred in S-1 sub-watershed with the lowest forest ratio (65.8%), and the highest nitrogen transport occurred in S-3 sub-watershed with the highest forest ratio (98.3%). This situation can be expressed as the increase of nitrogen transport depending on the increase of the forest ratio dominated by Alder. In their similar study, Compton et al. (2003) reported the highest nitrogen transport as annual 30.8 kg N $Ha^{-1}Year^{-1}$ in the watershed with forest ratio of 74%. In this study, nitrogen transport was determined to be annual 33.53 kg N $Ha^{-1}Year^{-1}$ in S-2 watershed with forest ratio of 85.5%, and results that were consistent with the study carried out by Compton et al. (2003) were obtained.

Cation losses in forest areas

Statistical relationships were investigated and significant positive relationships were found between NO_3N concentrations and basic cations (Ca^{++}, Mg^{++}, K^{+}) measured in stream waters. In addition, annual cation losses (kg Ha^{-1}) increased depending on the increase in forest areas, and increases were determined in Ca^{++}, Mg^{++}, K^{+} and Na^{+} exported to stream waters in sub-watersheds. The highest cation loss occurred in Ca^{++}. Accordingly, taking into account S-3 watershed where the highest forest area ratio and cation losses occurred, annual losses were determined as 33.82 kg Ha^{-1} in Ca^{++}, as 3.32 kg Ha^{-1} in Mg^{++}, as 1.43 kg Ha^{-1} in K^{+} and as 5.04 kg Ha^{-1} in Na^{+}. Taking into account S-1 watershed with the lowest forest, annual losses were determined as 6.25 kg Ha^{-1} in Ca^{++}, as 1.03 kg Ha^{-1} in Mg^{++}, as 0.42 kg Ha^{-1} in K^{+} and as 1.38 kg Ha^{-1} in Na^{+}. It can increase the amount of cation in nitrate stream waters resulting from alder (Stednick and Kern, 1992). Increase in the degree of weathering in watersheds with alder may increase the cation uptake, nutrient cycling and losses of trees (Binkley et al., 1992; Homann et al., 1992).

Cation amounts of soils of the forest areas in sub-watersheds were found to be consistent with the amounts of cation exported to stream waters. In fact, forest area (98.3%) soils of S-3 watershed has the lowest cation (Ca^{++}, Mg^{++}, K^{+} and Na^{+}) amounts. Also, the significant relationships between nitrate and cations in watersheds with pure and mixed leaved forest areas show that cation losses may increase in the watershed scale with the nitrate leaching of Alder (Compton et al., 2003). Besides, the fact that soils developed from the granite bedrock are generally light texture (sandy loam and loamy sand) permeable soils and have high air capacity (Kantarcı, 2000) were effective in the increase of both nitrate and cation losses. Indeed, the highest average sand content was also found in S-3 watershed although there was no statistically significant difference.

As a result of the variance analysis, a significant difference was found between soil pHs of forest areas in sub-watersheds. Average soil pH is the highest in S-1 watershed and the lowest in S-2 watershed. Soil pHs of forest areas of S-2 and S-3 watersheds are similar. S-2 and S-3 sub-watersheds are expected to be similar. Indeed, Alder and beech species are mixed in the forest areas in both sub-watersheds. The fact that soil pH is low in these watersheds is an indication of cation losses. In addition to cation losses, low levels of average soil pH (3.97, 4.13) means gradually decrease in acid neutralization capacity of forest area soils. The fact that soil pH decreases below 4.2 will provide the release of toxic elements such as Fe, Al by the degradation of clay minerals in the soil (Kantarcı, 2000). This situation will create problems in terms of both forest ecosystems and water quality.

The dominant tree species in the forest areas in sub-watersheds is Alder. The social pressure to other species in the region leads Alder to maintain its existence in riparian ecosystems also in slope ecosystems. According to species composition of forests in sub-watersheds, Alder is accompanied by beech and hornbeam species in 3 sub-watersheds. The fact that Alder gradually increases its activity especially in dam watersheds for drinking water as in this study draws attention to this species.

The fact that granite bedrock gives filter soils leads to an increase in nutrients leached/exported from sub-watershed soils. In fact it was observed in this study that significant positive relationships were determined between NO_3N and some cations in the forest areas in sub-watersheds and stream waters. Also in this study, it was observed that NO_3N exported from sub-watersheds increased the cation losses (especially Ca^{++}, Mg^{++} and K^{+}). The leaching of NO_3N in high amounts from sub-watershed soils may increase the eutrophication of stream waters therefore water in dam reservoirs. On the other hand, the fact that NO_3N increases the cation losses in the forest soils in sub-watersheds may give rise to the emergence of problems in terms of ecosystem health and may indirectly affect the quality of water in the dam reservoir in the negative way.

Findings obtained as a result of the study suggest that Alder might be an important species in terms of ecosystem health and provide valuable information about the possible eutrophication of Galyan-Atasu dam reservoir.

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