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Hydrochemistry of Rainfall and Stemflow of *Juglans regia Linn* and *Cupressus sempervirens L.* Var. *Fastigiata* in the North of Iran

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ABSTRACT The relocation of nutrients and water fluxes to the forest floor varies spatially due to partition of rainfall into throughfall and stemflow by tree canopies. In this study, nutrient concentrations of rainfall and stemflow were measured for seven rainfall events in Chaboksar area in the Hyrcanian ecozone of Iran composed of *Juglans regia Linn* and *Cup. Sempervirens L.*Var. *Fastigiata* where such information was absent. In the course of the study, a total of 24 samples were collected, and stemflow samples of these species were analysed in relation to rainfall. The results of this study suggest that the nutrient concentrations in stemflow are mainly influenced by vegetation species. The concentrations of $CaCO_3$, nitrate, calcium, magnesium, sodium, zinc, and chloride, were all higher in the stemflow of cypress tree than that of the walnut tree. The concentration of iron in both stemflow samples was zero. The pH level in the stemflow of *Juglans regia Linn* and *Cup. Sempervirens L.* Var. *Fastigiata* was slightly lower than rainfall pH level. However, in terms of heavy metals, the concentration of lead in cypress stemflow was found to be higher than that in walnut stemflow. Furthermore, a very small amount of copper was detected in the stemflow of cypress tree. Electrical conductivity of cypress stemflow was also higher than that of walnut stemflow.

Key words: *Cypress, Hyrcanian ecozone, Nutrient concentration, Stemflow, Walnut*

1 INTRODUCTION

Temperate hardwood ecosystems cover approximately 4 billion hectares of land surface worldwide (FAO-UN, 2005) of which 75% are in the northern hemisphere (FAU- UN, 2005). The Hycranian ecosystem, a narrow strip of forest found in the north of Iran is an example of such hardwood ecosystems. The Hyrcanian zone extends throughout the south coast of Caspian Sea located in the north of Iran. This zone is rich with biodiversity, which includes 8000 plant species representing a variety of life form such as grass, herb, shrub and trees. The important tree species in this area are; *Fagus orientalis, Carpinus betulus, Tilia rubra, Taxus baccata, Ulmus glabra, Quercus castanefolia, Parotia percisa, Alnus glutinosa*, and *Punica granatum* (Heshmati, 2007). The Hyrcanian zone is categorized in a humid climatic region wose average annual precipitation ranges between 530 mm in the east, to 1350 mm in the west, and sometimes reaching up to 2000 mm

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(Akhani *et al.*, 2010). This zone has a warm Mediterranean climatic condition in the east, and temperate to semi-temperate Mediterranean and sometimes temperate xeric in the central and western zones (Akhani *et al.*, 2010). Apart from commercial purposes, the principal role of these forests is to conserve soil and water resources in this region. This region is among one of the most sensitive ecosystems in Iran, given its mild climatic conditions and a very fertile soil (Akhani *et al.*, 2010). Therefore, in addition to heavy industrial activities and extensive urbanization, it is densely populated (Akhani *et al.*, 2010).

The aerodynamic properties of temperate forests play an important role in scavenging of atmospheric wet and dry deposition (Levia *et al*., 2011). They also have a crucial role in the initializing of interface for atmosphere-biosphere interaction within these ecosystems (Levia and Frost, 2006). In addition, the foliar and woody components of temperate forests significantly alter the spatial pattering of atmospheric inputs (Ford and Deans, 1978; Staelens *et al*., 2008) by intercepting incident precipitation (Levia and Frost, 2006) as well as dry deposited materials from the nature (Lovett and Lindberg, 1984), and anthropogenic sources (Avila and Rodrigo, 2004). Tree canopies concentrate and channel water and nutrients to the base of the trees (Johnson & Lehmann, 2006) through washing of the dry deposition from the canopy by rainfall, (Kazda, 1990) and leaching of materials (Tukey, 1970) to the forest floor.

Stemflow (SF) is defined as the proportion of precipitation that flows down of the bole of tree, and often pipe water directly into the forest floor (Tate, 1996). The amount of stemflow is very important, especially in semi-arid areas where water can increase plant yields (Elewijck, 1989). Plant yields are enhanced by the movement of nutrients from the canopy to the soil through stemflow or throughfall. Stemflow contains a highly enriched localized input of nutrients such as K, Ca, and Mg near tree stems (Durocher, 1990; Herwitz and Levia, 1997). Consequently, it has an important contribution to the forest flux of water via preferential soil water infiltration (Levia and Herwitz, 2000). Stemflow chemistry and hydrology is mainly affected by a variety of factors such as species assemblage (Levia and Herwitz, 2000), canopy structure (Levia and Herwitz, 2002), meteorological conditions (Lindberg *et al*., 1986), origin of air masses (Levia and Herwitz, 2000), and seasonality (Soulsby *et al*., 1997). In addition, stem diameter, branch inclination, bark texture, and epiphyte cover are key factors affecting the chemistry and hydrology the residence time of water (Levia and Herwitz, 2000).

A certain amount of precipitation is required to generate stemflow. For example, after a dry period, roughly 1-3 mm of precipitation is required to wet the canopy to produce stemflow or throughfall (Geiger, 1965). However, canopy interception can alter the chemistry of throughfall and stemflow in different ways. For instance, the type, duration, and severity of precipitation are important to dissolve the collected materials in the canopy. In addition, deposited salts on the leaf surface due to water intercepted by the leaves may leach their nutrients. There is often a net increase in the nutrient concentration in throughfall rather than in precipitation as the nutrients can be absorbed by the leaves and transferred down to the base of the trees by precipitation (Boyton 1954; Carlisle, Brown & White 1966; Wittwer & Teubner 1969). As precipitation interacts with vegetation canopy, large amount of nutrients are transferred from different parts of trees to the soil. Nutrients can be transferred to the soil through stemflow and throughfall (Eaton *et al*., 1972). The amount of stemflow contributes about 12% of gross precipitation to the total below canopy fluxes and dissolved nutrients (depending on the stand type and elements)

(Parker, 1983). Stemflow contains a major mineral input to some areas of forest floor (Parker, 1983). It can also be an important transfer medium of SO4 and Ca to ecosystem (Mayer and Ulrich, 1972). Therefore, determining of nutrient fluxes is an important process in the development of an appropriate land use system, in particular, in low-fertility soils (Schroth *et al*., 2001). As the precipitation progresses, the stemfow redistributes heterogeneously over space and time which is an important part of cultivating localized area of enhanced solute materials to the forest floor (Levia and Frost, 2006). This enriched water is ecologically a valuable pool, changing the spatial pattering of soil moisture (Chang and Matzner, 2000) and soil chemistry solutions (Falkengren-Grerup, 1989; Chang and Matzner, 2000). Moreover, stemflow can also shape the spatial distribution of understory vegetation (Crozier and Boerner, 1984).

Variations in precipitation chemistry exist in different in agro-climatic zones (Khan, 1999). Accordingly, the quantity of leached materials per unit of rain is higher during low intensity event than during heavy rain (Khan, 1999). This is due to the resistance time of water on the surface of the leaf (Khan, 1999). Moreover, the chemistry of stemflow does not only include the nutrients leached from vegetation, but also nutrients washed from the canopy surface, as well as those that are available in precipitation (Eaton *et al*,. 1972). The quantification of nutrient fluxes is often the key component in the estimation of nutrient cycle within an ecosystem. The important fluxes include precipitation, throughfall, stemflow, soil water, ground water and discharge. However, based on research questions and study area, the instrumentation of a research varies. Therefore, attention is also required on the various procedures of sample handling, chemical determinations and data management to ensure the validity of the results (Mitchell *et al*., 2001). However, stemflow has received minor attention because it constitutes less than 10% of water balance to the forest floor (Hofhansl *et al*., 2012). However, it is immensely important ecologically given the stemflow nutrients (Hofhansl *et al*., 2012).

Also, it is an important pathway for the localized input of significantly enriched solutes to the forest ground (Hofhansl *et al*., 2012).

There have been a few studies looking at the temporal changes of stemflow water and solute inputs within each individual rain events (McClain *et al*., 2003). This is an important factor in understanding the intra-storm variation in stemflow and solute flux to the forest floor (McClain *et al*., 2003). For example, stemflow water solutes were significantly variable within a particular event, and in most cases it reflected precipitation inputs once the bark storage capacity was filled (Levia *et al*., 2010). Moreover, according to Kazda (1990) the ion concentrations in stemflow is "largest" at the onset of rainfall and it decreases as the event continues. The reduction rate of ion concentration is dependent on rainfall intensity as well as the amount of dry deposition (Kazda, 1990). However, until now, no single study is known to investigate stemflow chemistry in relation to atmospheric deposition in a particular vent to annual time scale (Levia *et al*., 2011). Furthermore, there is little information regarding the importance of stemflow acting as a nutrient transfer to the forest soil in different ecosystem succession stage (Potter, 1992), particularly in the Hyrcanian ecozone of Iran where such data is unavailable. This paper discusses the results of the hydrochemistry of precipitation and stemflow of *Juglans regia Linn* and *Cup. Sempervirens L.* Var. *Fastigiata* in the Hyrcanian zone of Iran. In the temporal analysis samples were collected from 2005-2006 (November - June) from a relatively young species of *Juglans regia Linn* and also from a tall and a very dense canopy of *Cup. Sempervirens L.* Var. *Fastigiata* tree in Chaboksar area. The specific aims of this research were to: (1) examine intra-storm stemflow washoff and leaching pattern; (2) compare the stemflow solute flux between a coniferous and a deciduous tree over the course of the research.

2 STUDY AREA AND STAND CHARACTERISTICS

The study site was located in Chaboksar region (36° 57’ N, 50° 35' E) in the north of Iran. A plot of 1234 m^2 was selected at an elevation of -26 m above the sea level. The main reason for selecting this particular area was accessibility to the site, and logistical issues like feasibility and cost of stay, and easy availability of transportation. There were two trees selected at the site, a walnut tree and a cypress tree which had diameter at the breast height (DBH) of 15 and 32.5cm respectively. Figure 1 shows the study site, and locations of instruments at the site. The mean annual precipitation and temperature of the site were approximately 1164 mm and 19.2C°, respectively based on Ramsar Meteorological Station (1995 to 2005 data).

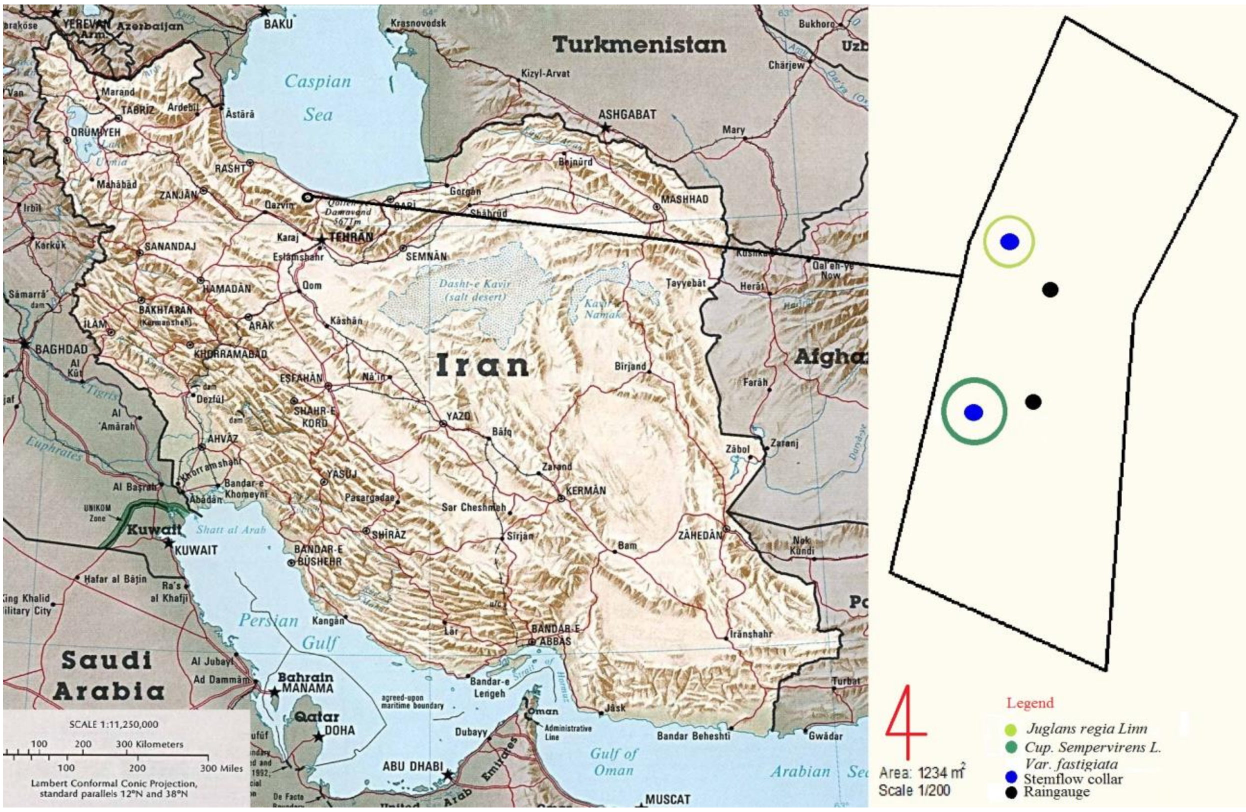

Figure 1 Map showing the location of study area, and instruments at the site.

3 RESEARCH METHODS

3.1Measurement of Stemflow

As aforementioned, stemflow is the proportion of precipitation that flows down of the tree trunk, often piping water directly into the forest floor (Tate, 1996). Stemflow is an important part of water balance as it can be used for plant growth and productivity. There is a lack of standard agreement on the number and model of gauges to accurately sample stemflow volume or chemistry. However, it is often measured by fixing flexible tubing (Figure 2) around the bole of trees (Levia and Frost, 2003). However, the basic technique to measure stemflow involves the placement of a collar around the main trunk of the plant at a certain angle so that the volume of stemflow can be transferred to a collector. Toba & Ohta (2005) stated that stemflow can be collected by a tube, which can be fixed onto the bole of the trees at a height of 1.2 m. Crockford& Richardson (2000) explained that stemflow is measured by splitting a plastic hose, and wrapping and fixing it around the bole of a tree by galvanized iron staples then sealed silicone.

In this study, two trees, a walnut and a cypress tree were randomly selected to represent a range of tree diameters as well as canopy area within the stands. In this method, a garden hose was used, of which one third of the circumference was removed, and then was fixed to the bole of the trees. The hose was then wrapped two times around the bole of the tree using silicon mastic and stainless steel screws and nails. The end of the hose was directed into 20 litre jugs. If the volume of stemflow happened to be more than 20 litres, another 10 litre jug was added. The material of stemflow bin is an opaque graduated polyethylene bins (20 and 10 litres) to prevent any chemical reactions. Sites were equipped with two stemflow collars on the selected trees which were connected to jugs, and two bulk precipitation samplers were located in the opening. After each rainfall event the total amount of water in collectors of bulk precipitation, and stemflow was determined volumetrically using measuring cylinders (this data is not presented in this paper).

3.2Rainfall and stemflow samples collection

Rainfall samples were collected in an open area in a polyethylene (plastic) bucket. However, for this research, special consideration was given to the method of collection, as any mistake in sampling, or delay in transporting the collected samples to the lab might alter the results (Delphis *et al*., 2003). The sample collection frequency was at every 12 days period of rainfall, in which 150 ml of stemflow was taken from the graduated bins, and transferred into laboratory cleaned bottles (Figure 3). The remaining stemflow in the bin was carefully poured out around the base of the trees. Finally the samples were transported to the laboratory by courier.

3.3 Measures against sample contamination

To obtain accurate information on the nutrient fluxes, it is important that precise measurements of the chemistry of samples are followed. The following procedures were taken in the lab to achieve this goal: Contamination of sampling containers was avoided, chemical transformation from the time of collection to the time was analysis was prevented or at least minimized, and the laboratory where the chemical determinations were being done had good quality assurance and quality control procedure. Moreover, the bins were washed and cleaned weekly to prevent algae growth. The samples were stored in dark bottles and in cool conditions (<4 C°) prior to arrival into the lab. These steps were taken to prevent any unwanted biochemical changes during storage between sampling and analysis (Gillian, 2001).

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Figure 2 Stemflow collar on *Juglans regia Linn.*

Figure 3 Stemflow and rainfall samples ready to be sent to the lab.

3.4 Sampling design and hydrochemistry analyses

Sampling for hydrochemistry was performed every 12 days of rainfall event (n = 8) from 2nd Nov 2005 to 10th March 2006. Precipitation events below 3 mm were discarded in consideration of canopy interception storage. 7 precipitation events were collected which were then studied for solute concentrations in stemflow. The collector samples were individually analyzed to assess the heterogeneity of stemflow fluxes in the selected species. The hydrochemistry of stemflow (SF) is altered by the canopy exchange (CE) and dry depositions (DD). The following equation presents this relationship:

$$SF=BP+CE+DD \qquad (1)$$

Volume-weighted mean concentrations (VWM, Eq. (2) of each stemflow and rainfall collector were used to present solute concentration during the study period which were calculated by the below equation:

$$VMW = \frac{\sum_{i=1}^{n} (Ci*Vi)}{\sum_{i=1}^{n} Vi} \qquad (2)$$

C_i represents the concentration of a specific solute and V_i is the stemflow volume during the event (Hofhansl *et al*., 2012).

The pH level of samples was measured using a Metrohm 744 pH Meter. The conductivity of samples was measured using CMD 500 WPA conductivity meter. The concentrations of Ca, Mg, Fe, Cu, Pb, Na, and Zn were examined using Atomic Absorption – Spectrophotometer – Shimadzu AA-6650F. Chemicals like CaCO3, and NO_3 were measured by Total Hardness Test Kit and Nitrate Test Kit respectively. Finally, Cl was determined by $AgNO_3$ in nitration with $K_2Cr_2O_7$ indicator (Gillian, 2001). Data analysis was performed using Chromeleon Version 6.70 Build 1820.

4 RESULTS

Stemflow process is an important part of hydrological cycle, for it contributes to the cycling of nutrients in forest ecosystems. However, the stemflow quantity and chemistry are the products of complex interactions of different factors such as meteorological conditions, seasonality, species, biophysical characteristics as well as canopy architecture. In fact, by assessing each of these involved parameters it may be possible to understand how each of them individually influences the chemistry of stemflow (Levia& Frost, 2003). Stemflow of tree species is regularly more enriched chemically than throughfall (Herwitz 1987; Neary and Gizyn 1994; Likens and Bormann, 1995), and the results of this study also demonstrate that stemflow is more enriched than rainfall (no study on through fall in this study). The primary cause for this enrichment is the washing off of deposited materials that have been captured by the canopy of trees, which are followed by transferring the solute materials through the trunk and into the base of the trees. However, there was a significant difference in the stemflow compositions of the studied trees in almost all the nutrient elements. As expected, the stemflow of the coniferous tree was more enriched than that of the deciduous tree due to leaf out in hardwood trees in the fall. Table 1 presents the results based on day of year (DOY) throughout the study period.

As the results show, there are some periods in which no rainfall event occurred within the 12 days of period sample collection frequency. Therefore, the canopy of trees had a longer time to capture the materials on their woody structure. For example, the amount of $CaCo_3$, and other materials in the first two events DOY 328, and DOY 340 were more enriched in the stemflow of trees. This was found particularly in cypress tree, as it captured more materials compared to walnut canopy. Moreover, if we compare this trend to the next event DOY 355, the amount of absorbed materials in cypress stemflow increases, whereas the absorbed materials were decreasing in the walnut tree due to senescence. Therefore, senescence time in deciduous tree and also the gap between the events present a crucial role in the enrichment of stemflow. This is true for all the chemical elements studied in this research. Moreover, there were no cypress stemflow for DOY 35, and DOY 47 as cypress required more amount of rainfall (8- 10 mm) in order to produce stemflow rather than of walnut (2-4 mm) canopy which is an evidence of importance of canopy density and architecture in producing stemflow.

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Table 1 Results of chemical analyses throughout the study period.

Days of year	Chemical elements	Rainfall	Stemflow of *Juglans regia linn*	Stemflow of *Cup. Sempervirens L. Var fasrigiata*
	CaCo3 (ppm)	7	53.4	89
	Nitrate (ppm)	0	1	10
	Ca (ppm)	4.5	6.4	23.4
	Cu (ppm)	0	0	0
	Fe (ppm)	0	0	0
	Mg (ppm)	0	1.77	3.48
	Na (ppm)	4.5	5.5	6.7
	Pb (ppm)	0	0	0.04
	Zn (ppm)	0	0.28	0.2
	PH (ppm)	6.7	6.5	6.1
	Cl (ppm)	30	27	45
328	EC (micros cm^{-1})	28	122.5	346
	CaCo3 (ppm)	8	35	196
	Nitrate (ppm)	8	10	30
	Ca (ppm)	0.25	5.4	39.5
	Cu (ppm)	0	0.011	0.017
	Fe (ppm)	0	0	0
	Mg (ppm)	0.57	2.67	3.6
	Na (ppm)	6.4	5.53	7.4
	Pb (ppm)	0	0	0
	Zn (ppm)	0	0.016	0.09
	PH (ppm)	7.1	6.9	5.9
	Cl (ppm)	42	64	105
340	EC (micros cm^{-1})	53	235	612
	CaCo3 (ppm)	17	34	125
	Nitrate (ppm)	7	10	10
	Ca (ppm)	2.3	12	27
	Cu (ppm)	0	0	0
	Fe (ppm)	0	0	0
	Mg (ppm)	0.5	3.6	3.3
	Na (ppm)	4.2	7.5	5.8
	Pb (ppm)	0.67	0	0.67
	Zn (ppm)	0	0.03	0.2
	PH (ppm)	6.84	6.86	6.56
	Cl (ppm)	30	64	78
355	EC (micros cm^{-1})	18	231	331
	CaCo3 (ppm)	0	35	71
	Nitrate (ppm)	0	0	10
	Ca (ppm)	0	5.3	11.3
	Cu (ppm)	0	0	0
	Fe (ppm)	0	0	0
	Mg (ppm)	0.5	3.2	3.6
	Na (ppm)	4.3	4.3	6.9
	Pb (ppm)	0	0	0
	Zn (ppm)	0.06	0.16	0.06
	PH (ppm)	7.1	6.7	6.5
	Cl (ppm)	21	50	50
8	EC (micros cm^{-1})	10	150	203

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Table 1 (Continue)

	CaCo3 (ppm)	5	8	125
	Nitrate (ppm)	0.5	0.7	25
	Ca (ppm)	0	0	23
	Cu (ppm)	0	0	0
	Fe (ppm)	0	0	0
	Mg (ppm)	0.9	0.8	4
	Na (ppm)	4.7	3.9	7
	Pb (ppm)	0	0	0
	Zn (ppm)	0	0.06	0
	PH (ppm)	6.8	6.8	6.45
	Cl (ppm)	42	65	130
21	EC (micros cm^{-1})	25	26	270
	CaCo3 (ppm)	17	34	0
	Nitrate (ppm)	0	1	0
	Ca (ppm)	2.4	6.1	0
	Cu (ppm)	0	0	0
	Fe (ppm)	0	0	0
	Mg (ppm)	0.7	3.03	0
	Na (ppm)	3.3	3.3	0
	Pb (ppm)	0	0	0
	Zn (ppm)	0	0.15	0
	PH (ppm)	6.9	6.6	0
	Cl (ppm)	28	35	0
35	EC (micros cm^{-1})	28	130	0
	CaCo3 (ppm)	18	35	0
	Nitrate (ppm)	0.5	0.9	0
	Ca (ppm)	3.3	4.2	0
	Cu (ppm)	0	0	0
	Fe (ppm)	0	0	0
	Mg (ppm)	0.9	2.2	0
	Na (ppm)	4.7	4.5	0
	Pb (ppm)	0	0	0
	Zn (ppm)	0.1	0.3	0
	PH (ppm)	6.7	6.9	0
	Cl (ppm)	29	35	0
47	EC (micros cm^{-1})	26	100	0
	CaCo3 (ppm)	17	125	35
	Nitrate (ppm)	0	1	10
	Ca (ppm)	3.5	3.8	7.8
	Cu (ppm)	0	0	0
	Fe (ppm)	0	0	0
	Mg (ppm)	0.98	4.1	2.9
	Na (ppm)	4.5	6.3	5.1
	Pb (ppm)	0	0	0
	Zn (ppm)	0	0	0
	PH (ppm)	6.7	6.1	6.7
	Cl (ppm)	25	100	28
69	EC (micros cm^{-1})	32	378	142

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5 CONCLUSION

The $CaCO_3$ concentration enhancement in the stemflow of *Cup. Sempervirens L.* Var. *Fastigiata* was 13 times larger in cypress tree and 4 times larger in walnut tree when compared to rainfall. In addition, the nitrate concentration increased slightly in the stemflow of *Juglans regia Linn* while it tripled in the stemflow of *Cup. Sempervirens L.* Var. *Fastigiata.* The Ca concentration increased by approximately 3 times and 13 times in walnut and cypress stemflow respectively. The amount of Fe in all the samples was zero. The Mg concentration increased by 7.5 times in walnut and 9.6 in cypress. The Na value increased slightly in both of the species. The chloride concentration increased by 1.5 times in walnut and 2.2 times in cypress stemflow. The electrical conductivity was increased by 5.9 times in walnut and 13 times in cypress. Finally, the pH level of rainfall was 6.88 on average, which was very close to neutral range (6.2-6.5). However, the pH level of cypress stemflow was more acidic than that of walnut. This might be due to the resin availability in the stemflow of cypress and the presence of juglandin in the walnut tree. Unfortunately, we did not study the influence of these materials in this study.

6 DISCUSSION

The outcomes of this study suggest that the temporal scale of analysis of canopy derived fluxes can be an important factor in the transport of stemflow materials to the forest floor in which different species react differently. The heterogeneity of the canopy and seasonality play an important role in the solute materials of stemflow which depends on the type of species. For example, bark roughness, canopy roughness, needle roughness, leaf surface, and branch angle have important roles in capturing the materials and consequently enriching the stemflow. In addition, senescence time in deciduous trees and the gap between rainfall events have a crucial role in enrichment of stemflow. These factors were clearly identified. However, there are some other important factors which can alter the compositions of stemflow, such as meteorological factors like rainfall intensity and precipitation type (which were not considered in this study). Moreover, stemflow flowpath was also another important factor which was different in different species. The flowpath varies as a tree grows. For example, a young walnut tree has a smooth bark which does not have many stemflow path on it, but an old walnut tree has gutter and stemflow flowpath which can capture more nutrients than a young tree. However, canopy density plays an important role in cypress tree, and allows it to capture as much materials as it can through its dense canopy. If all these parameters are considered, it is possible to model an intra-storm chemical variability more accurately which would be very useful in agroforestry, and also plantation plans.

Finally, a comprehensive and a long term study is needed to link each of the factors influencing the chemistry of stemflow in order to accurately assess stemflow nutrients in Chaboksar. As mentioned earlier, such data was unavailable regarding the importance of stemflow which acts as a nutrient transfer to the rooting zone of trees in the Hyrcanian ecozone. Therefore, the main purpose of this research was to highlight the importance of stemflow of different species. This was done by carrying out a research on comparison of nutrient concentrations of the two selected trees due to an increase in planting of *Juglans regia Linn* and *Cup. Sempervirens L.* Var. *Fastigiata* in the region. It is expected that the outcomes of this study would be considered as a basic step to further the knowledge of stemflow nutrients which has an ecological role in temperate regions and help forest managers to have a better understanding of the nutrient

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concentrations of stemflow of different species. Moreover, the results will be useful in forecasting effects of land use on nutrient yields of different ecosystems to understand how they affect the composition of stemflow. This project was carried out as one of the first studies in this area of research in Iran on cypress and walnut trees. These trees have been used for plantation and agro-forestry purposes over the last few decades without any consideration on how they may affect the nutrients of the soil. Therefore, over-plantation of these trees may have a potential of creating a problem on the soil vegetation nutrients of Chaboksar area in the close future.

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ویژگی‌های هیدروشیمی باران و ساق‌آب گونه‌های گردو (*Juglans regia Linn*) و سرو (*Cupressus sempervirens L.* Var. *Fastigiata*) در شمال ایران

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چکیده انتقال جریان مواد مغذی و آب به کف جنگل به طور مکانی با تفکیک بارندگی به میان‌داد و ساق‌آب توسط تاج پوشش درختی تغییر می‌کند. در این مطالعه، غلظت مواد مغذی در باران و ساق‌آب در گونه‌های گردو (*Juglans regia Linn*) و سرو (*Cup. Sempervirens L.* Var. Fastigiata) برای تعداد ۷ واقعه باران در منطقه چابکسر در اکوزون هیرکانی ایران جایی‌که در این موارد اطلاعاتی وجود نداشت اندازه‌گیری گردید. در طی این تحقیق، ۲۴ نمونه جمع آوری شده و مواد موجود در نمونه‌های ساق‌آب در مقایسه با باران مورد بررسی قرار گرفت. نتایج این پژوهش نشان داد که غلظت مواد مغذی در ساق‌آب وابسته به گونه گیاهی است. بر طبق نتایج مقدار کربنات کلسیم، روی و کلراید در ساق‌آب درخت سرو بیشتر از درخت گردو بود در صورتیکه مقدار آهن در نمونه ساق‌آب هر دو گونه مورد بررسی صفر بود. مقدار pH در ساق‌آب‌های گردو و سرو کمی پایین‌تر از مقدار pH در باران بود. از لحاظ فلزات سنگین مقدار سرب در ساق‌آب سرو بالاتر از ساق‌آب گردو بود. علاوه بر این مقداری مس در ساق‌آب سرو نیز مشاهده شد و رسانایی الکتریکی نیز در ساق‌آب سرو بیشتر از ساق‌آب گردو بود.

کلمات کلیدی: ساق‌آب، سرو، غلظت مواد مغذی، گردو، منطقه هیرکانی

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