LEAF LITTER DECOMPOSITION AND NUTRIENT EVALUATION OF THREE RIPARIAN TREES

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ABSTRACT:

The study estimated the decomposition rate and nutrient dynamics of the litter of three riparian tree species; Morus nigra L. (Moraceac), and Salix tetrasperma Roxb. and Populus alba L. (Salicaceae). Dead fallen leaves of the studied species were collected from the banks of El-Khamseen canal; an ultimate Nile branch passing along Saft El-Laban town, Giza Governorate, Egypt. The amount of nutrients released back into water after the decomposition of the dead leaves' tissues was investigated in plastic tanks located in the ecology lab of Botany Department of Cairo University, at the window side under natural conditions. The litterbag technique was followed. The species detritus decomposition was studied during the autumn season (from September 25 to November 25), 2014. In order to determine the decay rates, litterbags (1.5 mm) were applied and collected at seven times intervals for three replications, each. All samples were dried, weighed and analyzed for total soluble sugars, P, N, ash and lignin concentrations. Decomposition of Morus leaf litters was faster than that of the other two species due to its high quality (lower lignin, higher P and moderate N and total soluble sugars contents), in comparison to other species. More than 50% of the initial leaf masses of the study species were decomposed during two months. The difference in decay rate was affected by the ratios: C/N, C/P, lignin /N and lignin /P. The variation in the microbial activities caused fluctuations in the litter nutrient concentrations and the nutrient content remaining. Bacterial and fungal counts differed on the surfaces of the remaining masses depending on the variation in P and N concentrations. Leaf litter decay of the species was mainly dependent on bacterial counts that ranged between limited numbers to uncountable than on fungi. Suitable thermal and aerobic conditions contributed to the explanation of the high decay of the species.There was a strong positive correlation between the species and mass remaining, species and N content remaining and between all nutrient concentrations and all nutrient content remaining. No positive correlation was found between harvest time and sugar, P and N content remaining. The leaf litter extracts affected the seed germination of Eruca sativa. Moreover, the extracts caused root growth inhibition and promoted the shoot growth of the seedlings.

Keywords: *litterbags – nutrient content – germination – regression – correlation.*

INTRODUCTION:

Riparian zones are strips of land bordering rivers, streams, lakes and wetlands (Menendez et al., 2013). They link; the dry land ecosystem to the aquatic ecosystem and are ideal sites for re-vegetation projects. With a good cover of plants, these areas help control stream bank erosion, provide habitat for wildlife as vegetation produces shade, food or as shelters, and prevent the pollution of water (Menendez et al., 2013). Riparian zones can store and retard drainage water flow. The assortment of riparian zone trees typically consists of plants that either are emergent aquatic plants, herbs, (Planty-Tabacchi et al., 1996), trees and shrubs that thrive in proximity to water. Ungrazed, well-planted riparian zones act as 'filters' which settle out sediments for absorption into the soil. The width of a riparian zone can vary from a few meters to tens of meters

depending on topography, flow fluctuations and adjacent land uses. The width should be at least equal to the top height of trees or shrubs within the zone (Canterbury Regional Council, 2011). The leaf litter is an important energy source for food webs in woodland streams (Fisher and Likens, 1973).The particular dynamics of riparian ecosystems that are subject to frequent fluctuations in water flow destabilizes the streamside and favors the establishment of new species (Planty-Tabacchi et al, 1996). Salem et al., (2013) considered Morus alba; as a riparian speciespossessing a good potency level of antibacterial activity.

Egypt has a long net of irrigation and drainage canals. More than 50% of these canals planted by poplar (Populus alba) and willow (Salix tetrasperma), and distributed from north to south according to the environmental adaptability (Ismail, 2011). Populus alba is planted in the northern wet part, which can grow well under high water table and salinity in compacted soil. Salix tetrasperma grows well all over the country wet or dry, in the north or in the south. All willow plantations are used as shade trees and for the stabilization of drainage and irrigation canals. Poplar and willow are rapidly growing trees; grow very well in most provinces of Egypt (Ismail, 2011).In most ecosystems, the major source of nutrients for trees is the process of decomposition (Baldy et al., 1995). Decomposition refers to the processes that convert dead organic matter into smaller and simpler compounds. The products of complete decomposition are carbon dioxide, water, and inorganic ions (like ammonium, nitrate, phosphate, and sulfate). Decomposition is mainly a biological process carried out by insects, worms, bacteria, and fungi both on the soil surface, in the soil and inside the water bodies (Berg and McClaugherty, 2008).

The rate of decomposition is influenced by many factors. Because decomposition is a biological process carried out primarily by bacteria and fungi, its speed will be affected by temperature and soil moisture (Battle and Mihuc, 2000). Generally, decomposition increases exponentially with temperature. Decomposition is inhibited in very dry soils because bacteria and fungi dry out. Decomposition is also slow in very wet soils because anaerobic conditions develop in saturated soils. Anaerobic decomposition is less efficient than aerobic and as a result is slower. Decomposition proceeds faster at intermediate water contents (Kuers and Simmons, 2005). The quality of the leaves as a food source for microbial decomposers is another important factor. Substrate quality has been defined in many different ways - as the nitrogen concentration (N), as the lignin content, and as the C: N ratio (Moorhead et al. 1999). Researchers have found that decomposition of leaf litter can be predicted by the C:N ratio (Taylor and Johnes, 1990), by the lignin content (Meentemeyer 1978), or by the lignin:nitrogen ratio (Melillo et al. 1982). Basically, high quality leaves will decompose faster than low quality leaves. Substrate quality can even vary within a leaf. Berg and co-workers (Berg and Staaf 1980; McClaugherty and Berg 1987) have shown that in the initial stages (0 to 3 months) of leaf breakdown of small carbon molecules, like starches and amino acids, are lost first leaving behind the more recalcitrant molecules like lignin. Decomposition during this first phase is rapid because these molecules are easy to break down. The second stage of decomposition - the breakdown of lignin - is much slower because lignin consists of very large and

complex molecules. This rapid initial breakdown followed by a longer period of slow decomposition results in a mass loss curve that resembles an exponential decay curve (Berg et al., 2010).

Differences between tree species litter decomposition have commonly been related to distinct substrate quality with litter C/N, N/P and lignin content (Cornelissent et al., 2006; Berg et al., 2010). However, tree species can also alter decomposition rates indirectly through their effects on environmental conditions. For example, tree species can induce changes in soil fertility, microclimate and faunal and microbial communities in the forest floor (Aponte et al., 2011), all of which influence the decomposition process (Austin and Vivanco, 2006). The simultaneous effects of trees on decomposition both through their litter quality and by modifying the environmental conditions might cause positive litter-environment interactions and further increase decomposition.

The relative importance of the decomposition process of leaf litter of riparian species on the alterations of water quality (as a substrate) and its nutritive value remain unclear. As litter decomposition progresses through time, litter quality varies and the factors controlling litter mass loss might change (Berg and McClaugherty, 2008). Early decomposition is often determined by the availability of limiting elements such as N and P whereas in late stages, the carbon loss has been related to elements required to decompose recalcitrant components such as lignin that accumulate in remaining litter (Berg et al., 2010). Variables controlling the early decomposition stage and nutrient release could differ from those influencing the proportion of slow decomposing litter and therefore the buildup of soil organic matter and carbon sequestration. Occasionally, the same variable could have counteraction effects on early and late stages of decomposition (Hobbie et al., 2012).

We aimed to compare the decomposition rates of leaf litters of three riparian species; namely Morus nigra, Salix tetrasperma and Populus alba and their effects on the nutrient status of water (natural drain or tap water) as a substratum during the fall season. We also aimed to address the variables that might affect the decay rates such as: total soluble sugars, N, P, C/N, N/P and lignin and estimate the correlations between them. In addition, we examined how the breakdown might be affected by the microbial activities through the counting procedure of fungi and bacteria. Further aim was to analyze the patterns of liberation and immobilization of chemical elements from the decomposing litter of these species. In order to confirm the decomposition potentialities of the study leaf litters and the external release of leaf metabolites in water, a seed germination experiment was conducted on Eruca sativa at two different harvest times; the third (20 days after the beginning of the experiment (DAB) and the last (60 DAB).

MATERIALS AND METHODS:

Study site

The studied riparian species (Morus nigra L., Salix tetrasperma Roxb. and Populus alba L.) are growing along the bank of EL-Khamseen canal; a branch of Al-Zomar larger Nile canal providing Giza Governorate, Egypt. The canal is the main source for water inflow to the agricultural areas of Saft El-Laban (a small town located at the southwestern part of Giza; about 8.2 km far from Cairo University). The canal is not only subjected to the agricultural effluents but also too many domestic pollutants due to human activities. Discharges resulting from the small

industrial units of paints and ceramic manufacturing add to the contamination. Additional sources of pollution are the traffic emissions, burning of charcoal and garbage and receiving of the dead animals.

Sampling, mass loss and mass remaining experiment

Along the studied canal bank, leaf litter of senesced aboveground riparian trees were collected after leaf fall in September 2014 using five randomly distributed trees. The collected leaves were thoroughly washed with tap then distilled water. Leaf samples were then oven-dried at 65◦ Cfor 48 hours. Drain water was collected in a large container, transported to the laboratory, and stored in a refrigerator at 4◦ C on the implementation of the experiment. 10 g of oven-dried leaves were cut into 5.0 cm pieces and confined into fiberglass window screen litterbags of 10×10 cm with a narrow mesh (1.5 mm) to allow fluent transport of water, sediments and organisms. Each three bags were strung together using nylon thread to be harvested at a particular date and were attached to a bar for incubating 20 cm below the water level. Seven groups of 3-stung litterbags (one for each harvest) were placed in a plastic tank (35×30×25 cm) with 7-L drain water. Harvesting took place 5, 10, 20, 30, 40, 50 and 60 DAB (days after the beginning of the experiment). Analogous series of three tanks (one for each species) was used - for comparison - with tap water instead of the drain one. A net number of six tanks was used. All tanks were placed in the laboratory under natural conditions at the window side. Daily record of the laboratory temperature (22±2 ◦C), as well as the water temperature (20±2 ◦C) in the tanks was undertaken during the experimental period (from September 25 to November 25, 2014). Water level was marked using a marker and the part evaporated from the tanks was periodically compensated by adding distilled water to replace the lost water by evaporation. Water in the tanks was ventilated (twice of one hour a day). At each harvest, the litterbags were thoroughly washed with tap water then with sterilized distilled water to remove sediments. The remaining litter in the bags was air-dried, oven dried for constant weight at 65 ◦C for 48 hours and re-weighed to determine the final mass at a particular time.

CHEMICAL ANALYSES

Subsamples of leaf litter(from 0.05- 0.5 g) -of the initial and the remaining masses of the different harvests, in either drain or tap waters - were dried at 65oC for 48 hours, ground into fine powder using a silica pistil and mortar. Lignin content was determined (Soutar and Bryden, 1955) by placing a definite weight of ground leaves in 72% H_2SO_4 for 4 h. The volume was completed to 1L with distilled water then boiled in a sand bath.The contents were cooled and filtered through Gauche funnel, finally dried at 105◦ C and re-weighed. Ignition of other leaf samples took place in a muffle furnace at 550oC for six hours to estimate the carbon and ash content. Dried plant matter was digested in H_2SO_4 and $HClO_4$ acid (1:1 v/v) in a sand bath in order to estimate N and P concentrations by the spectrophotometer (CECIL CE 1021; Cecil Instruments Ltd, UK).The phenylnitroproside – sodium hypochlorite method adopted by Fawcott and Scott (1960) and by Chaney and Marbach (1962) was followed to estimate the total nitrogen content. The ammonium molybdate - sulphite- metol method adopted by Clark and Switzer (1977) was applied to estimate the total phosphorus concentration in plant

tissues. On the other hand, the SnCl2 – potassium dihydrogen phosphate method (Kapour and Govil, 2000) was used for phosphorus estimation in water. The total soluble sugars in the extract were determined with anthrone reagent using glucose as a standard (Kapour and Govil, 2000). The nutrient content was calculated by multiplying the mass remaining of leaf litter (g) by the nutrient concentration solely for each nutrient type (mg nutrientg-1 litter). Then nutrient contents are expressed as a percent of the initial content (at the beginning of the experiment).

CALCULATION AND DATA ANALYSIS

The data of the studied species were the means of three replicates per species at each treatment (drain and tap waters) at each harvest date. The percentage of the remaining dry mass was calculated according to the equation:

Dry mass remaining (%) = (Mt / Mo) x 100, where Mt is the litter dry mass remaining after time t and Mo is the original mass. The dry mass remaining was used to determine the decay rate according to the single exponential decay model: Mt = Mo e-kt , where k is the breakdown coefficient (Olson, 1963). To calculate k, linear regressions of ln (Mt / Mo) versus time (5, 10, 20, 30, 40, 50 and 60 days) were performed. This model is based on the assumption that the decomposition rate at time t is proportional to the mass at time t (Gamage and Asaeda, 2005). We used the regression procedures to evaluate statistical relationships between the time (days) as an independent variable, x, and the percent of dry mass remaining as a dependent variable, y, of every species. The regression and Pearson correlation coefficient were conducted to evaluate statistical relationships between the time (days) as an independent variable, x, and the percent of the nutrient content remaining as a dependent variable, y.

MICROBIAL COUNT FOR LEAF LITTER SAMPLES

Definite leaf litter samples from different fine-mesh bags (1 g) of the species under investigation were separately chosen for surface counting of some representative microbes (bacteria and fungi) at different harvests along the experimental period. For bacterial counts, one gram of the litter sample was mixed with sterile liquid agar media then poured in two plates; one was incubated at 35-37◦C for 24 h followed by counting and the other was incubated at 22-25◦C for 48 h then counted. The sum of bacterial colonies in the two plates denoted the total number of bacterial colonies. For fungal counts, the one g-sterile media mixture was poured in two plates and incubated at 27 ◦C for 3 days then the surface count of colonies was estimated. Choice included specimens having high and low P and N contents (percentage) of the two water types (tap and drain). Triplicate samples were taken, fixed in 3% glutaraldehyde solution and stored at 4 ◦C until further use (Winn et al., 2006).

EFFECT OF LEAF LITTER EXTRACTS OF DIFFERENT HARVESTS ON SEED GERMINATION OF ERUCA SATIVA L.

Seeds of Eruca sativa L. (Brassicaceae) were obtained from the Agricultural Research Center, Giza, Egypt. The effect of the products released from the leaf litter in water during the decay process was experienced on the seed germination and seedling growth of E. sativa. Extracts of two harvests times, (20 and 60 DAB) were

taken, filtered using Wattman filter papers (no. 1) then centrifuged to separate sediments and all strange attached materials. Three replicates of Petri dishes with 50 seeds were used in addition to the sterilized distilled water for control. Seed germination experiment was constructed (in October 15 with an average temperature of 25±5◦C and in November 16, 2014 with a mean temperature of 20±3◦C) under natural laboratory conditions. Experiment prevailed for 8 days in each time. By the end of the experimental period, the number of germinated seeds was counted and the root and shoot lengths were measured.

STATISTICAL ANALYSIS

Data were subjected to one-way analysis of variance (ANOVA) test at 1 and 5% levels of probability according to the SPSS statistics program. The least significant difference (LSD) was calculated to verify the significance of the differences between the means of each parameter at the different harvests.

RESULTS

Water quality

The characteristics of water in the used tanks such as depth (cm), temperature, pH, salinity, total phosphorous (mg ml-1) and total nitrogen (mg ml-1) were examined at the beginning and at the end of the experiment (Table 1). By the end of the experiment, salinity of the tap water was nearly 3-fold of that the initial, whereas was duplicated for drain water. Differences between initial and final salinity among the studied species were significant. A high significance was recorded between initial tap and drain water as well as between final tap and drain containing Morus litter. Initial tap water was phosphorus free and the content raised to a final value of 0.41 (mg ml-1) with high significance. No significance was recorded between the final P content of tap and drain waters containing litters of the studied species. Initial N content (0.18) of drain water was significantly higher (0.48 mg ml-1) than that of tap water.

Table 1. Initial and final characteristics of tap water and the water of El-Khamseen drainage canalduring the experimental period September, 25 to November, 25, 2014. Final values were estimated 60 days after the beginning of the experiment.

Water Characteristics	Water Status	Type of Water	
		Tap Water	Drain Water
Level (cm)		22	22
Temperature (◦C)		22±5	22±5
pH	Initial	$7.65\pm0.01^{c\,(***)}$	7.51 ± 0.01^{b}
	Final with:		
	Morus nigra	$7.37\pm0.01^{b(***)}$	7.81 ± 0.01^{d}
	Salix tetrasperma	$7.67\pm0.01^{d(***)}$	7.46 ± 0.01^{a}
	Populus alba	$7.05\pm0.01^{a(***)}$	7.56 ± 0.01^{c}
EC (μmhos cm^{-1})	Initial	$653.33\pm5.77^{a(***)}$	$1{,}266.67\pm57.74^{a}$
	Final with:		
	Morus nigra	$2{,}183.33\pm28.87^{b(***)}$	$2{,}583.33\pm28.87^{d}$
	Salix tetrasperma	$2{,}200.00\pm0.00^{b}$	$2{,}266.67\pm57.74^{b}$

	Populus alba	2,166.67±57.74$^{b(*)}$	2,366.67±57.74^{c}
P (mg ml^{-1})	Initial	0.00±0.00$^{a(***)}$	0.41±0.08^{a}
	Final with:		
	Morus nigra	0.48±0.01^{b}	0.47±0.05^{ab}
	Salix tetrasperma	0.59±0.01$^{c(*)}$	0.55±0.02^{b}
	Populus alba	0.55±0.05^{c}	0.54±0.01^{b}
Total N	Initial	0.18±0.04$^{a(**)}$	0.48±0.10^{b}
((mgml^{-1})	Final with:		
	Morusnigra	0.38±0.10^{b}	0.25±0.08^{a}
	Salix tetrasperma	0.43±0.08$^{b(*)}$	0.22±0.03^{a}
	Populus alba	0.38±0.04^{b}	0.35±0.05^{a}

Subscribed letters indicate the significant difference between initial and final water characteristics in the different study species.

Stars indicate the significant difference between the water characteristics of tap and drain water before and after the experiment.

For tap water, a considerable significant increase (0.38, 0.43 and 0.38 mg ml-1) in N content was recorded for Morus, Salix and Populus, respectively at the end of the experiment. On the contrary and in the case of drain water, a remarkable decrease (0.25, 0.22 and 0.35 mg ml-1) in N concentration was respectively recorded. These variations might be attributed to microbial activities.

CHEMICAL COMPOSITION OF THE LEAVES OF DIFFERENT TREE SPECIES

The leaves of P .alba and S. tetrasperma showed significantly higher content of carbon in comparison to M. nigra (Table 2). In the contrary, the leaves of M. nigra showed significantly higher content of P and ash than those of S. tetrasperma and P.alba. There were non-significant differences between Salix and Populus with regard to lignin content. The concentrations of soluble sugars were similar in the studied species. Ratios of C: N, C: P, lignin: N and lignin: P were high in S. tetrasperma, intermediate in P. alba and low in M. nigra.

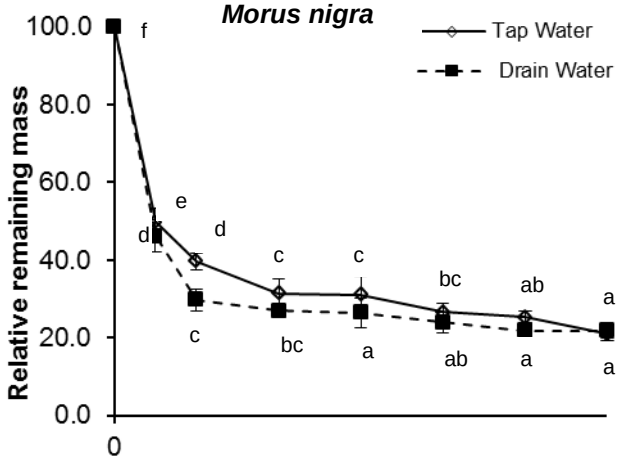
LEAF LITTER DECOMPOSITION

Leaf litter decomposition of M. nigra was faster than that of S .tetrasperma and P. alba (Fig. 1). High decay rate (mass loss) of Morus (68.6 and 73.2 % in tap and drain waters, respectively) was attained within the first 20 days of the experimental period. The decay slowed down in the following days. Decay of Morus leaf litter was slightly higher in drain than in tap water. Final mass remaining reached about 22% of the initial for both water types. On the other hand, the decomposition rate of S. tetrasperma and P. alba was nearly similar. No difference was recorded between the mass loses of S. tetrasperma in both water types and the final mass remaining was 39.6 and 41.1 % of the initial mass in tap and drain water, respectively. Decay of P. alba leaf litter showed a trend similar to that of S. tetrasperma. The mass loss did not exceed 57.8 and 63.2 % in both water, successively. Mass loss and consequently mass remaining in both water types showed significant

differences at the third and sixth harvests (20 and 50 DAB).Mass remaining of P. alba ranged between 42.2 (in tap water) and 36.8 % (in drain water). The decay constant (k) of Morus leaf litter (Table 3) gave lower values in tap than in drain water, although it was higher than that of the other two species. The decay constant values gradually decreased with time progress. It reached its lower values at the last harvest of the experiment. A high significance was monitored 10 DAB. By the end of the experiment, the difference completely disappeared. k values for the leaf litters of the other two species were the same in both water types and showed lower values than of Morus.

Table 2. Some chemical characteristics of the leaves of studied species. All values were expressed on dry mass basis (mean ± SD, n= 3). TSS, Total soluble sugars. Within each raw, means with different letter are significantly different at p<0.05.

Property	*M. nigra*	*S. tetrasperma*	*P. alba*
N (mg g^{-1})	35.83 ± 1.53^{ab}	32.5 ± 0.50^{a}	39.00 ± 4.92^{b}
P (mg g^{-1})	13.98 ± 0.74^{b}	12.36 ± 0.40^{a}	12.32 ± 0.51^{a}
C (%)	73.87 ± 1.01^{a}	81.60 ± 1.22^{b}	80.93 ± 1.01^{b}
Lignin (%)	25.13 ± 4.13^{a}	37.15 ± 3.48^{b}	33.93 ± 4.28^{b}
TSS (mg g^{-1})	99.68 ± 6.33^{a}	98.60 ± 4.98^{a}	105.88 ± 2.38^{a}
C:N	20.62	25.11	20.75
C:P	52.84	66.02	65.69
Lignin:N	7.01	11.43	8.7
Lignin:P	17.98	30.06	27.54
Ash (%)	26.13 ± 1.01^{b}	18.40 ± 1.22^{a}	19.07 ± 1.01^{a}



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Salix tetrasperma

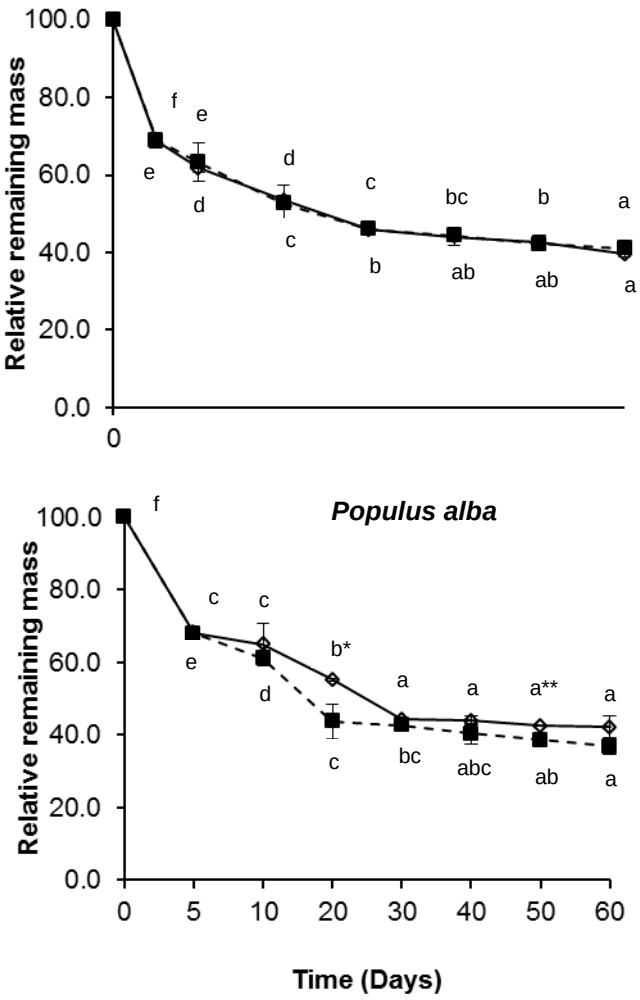

Fig. 1. Relative dry mass remaining of M. nigra, S. tetrasperma and P. alba leaf litters subjected to decomposition in both tap and drain water for different time intervals.

Table 3. Percentage mass loss and decay constant (k) of Morus nigra, Salix tetrasperma and Populus alba leaf litters,

Species	Mass Parameter	Treatment	Time (days)							
			0	5	10	20	30	40	50	60
Morusnigra	Loss (%)	T	0$^{(a)}$	50.15±3.59$^{(b)}$	60.31±2.11**$^{(c)}$	68.57±3.53$^{(d)}$	68.93±4.58$^{(d)}$	73.45±2.12$^{(de)}$	74.67±1.52$^{(ef)}$	79.07±1.59$^{(f)}$
		D	0$^{(a)}$	53.86±4.05$^{(b)}$	70.30±2.77$^{(c)}$	73.15±1.43$^{(cd)}$	73.61±3.72$^{(cde)}$	76.06±2.72$^{(ef)}$	78.15±1.59$^{(f)}$	78.29±1.80$^{(f)}$
	K constant	T	-	0.14±0.01$^{(e)}$	0.09±0.01**$^{(d)}$	0.06±0.01$^{(c)}$	0.04±0.01$^{(b)}$	0.03±0.00$^{(ab)}$	0.03±0.00$^{(ab)}$	0.03±0.00$^{(a)}$
		D	-	0.16±0.02$^{(e)}$	0.12±0.01$^{(d)}$	0.07±0.00$^{(c)}$	0.04±0.00$^{(b)}$	0.04±0.00$^{(ab)}$	0.03±0.00$^{(ab)}$	0.03±0.00$^{(a)}$
Salix tetrasperma	Loss (%)	T	0$^{(a)}$	31.22±1.37$^{(b)}$	38.28±1.77$^{(c)}$	46.53±0.91$^{(d)}$	54.20±0.74$^{(e)}$	55.92±0.52$^{(ef)}$	57.41±2.20$^{(f)}$	60.38±1.74$^{(g)}$
		D	0$^{(a)}$	31.05±0.50$^{(b)}$	36.80±4.98$^{(c)}$	47.40±4.90$^{(d)}$	54.01±0.38$^{(e)}$	55.68±0.71$^{(ef)}$	57.71±0.06$^{(ef)}$	58.89±2.16$^{(f)}$
	K constant	T	-	0.07±0.00$^{(f)}$	0.05±0.00$^{(e)}$	0.03±0.00$^{(d)}$	0.03±0.00$^{(c)}$	0.02±0.00$^{(b)}$	0.02±0.00$^{(ab)}$	0.02±0.00$^{(a)}$
		D	-	0.07±0.00$^{(f)}$	0.05±0.00$^{(e)}$	0.03±0.00$^{(d)}$	0.03±0.00$^{(c)}$	0.02±0.00$^{(b)}$	0.02±0.00$^{(a)}$	0.01±0.00$^{(a)}$

subjected to the decomposition in both tap and drain water for different time intervals.

Populus alba	**Loss (%)**	**T**	**0$^{(a)}$**	**31.84±0.52$^{(b)}$**	**35.05±5.75$^{(b)}$**	**44.74±0.31*$^{(c)}$**	**55.69±0.72$^{(d)}$**	**55.97±1.39$^{(d)}$**	**57.51±0.09**$^{(d)}$**	**57.75±3.16$^{(d)}$**
		D	**0$^{(a)}$**	**31.98±1.12$^{(b)}$**	**38.88±1.06$^{(c)}$**	**56.25±4.79$^{(d)}$**	**57.38±0.84$^{(de)}$**	**59.62±2.84$^{(def)}$**	**61.35±1.24$^{(ef)}$**	**63.22±2.25$^{(f)}$**
	***K* constant**	**T**	**-**	**0.08±0.00$^{(g)}$**	**0.05±0.00$^{(f)}$**	**0.03±0.00*$^{(e)}$**	**0.03±0.00$^{(d)}$**	**0.02±0.00$^{(c)}$**	**0.02±0.00$^{(b)}$**	**0.01±0.00*$^{(a)}$**
		D	**-**	**0.08±0.00$^{(f)}$**	**0.05±0.00$^{(e)}$**	**0.04±0.01$^{(d)}$**	**0.03±0.00$^{(c)}$**	**0.02±0.00$^{(b)}$**	**0.02±0.00$^{(ab)}$**	**0.02±0.00$^{(a)}$**

T, Tap water; D, Drain water; k: exponential breakdown coefficient (day-1); SD: standard deviation. Subscribed letters indicate the significant difference between harvests in the same species. Asterisks indicate significant difference between tap and drain water.

Litter nutrient concentrations

concentrations of total soluble sugars, p, n and ash were estimated for the leaf litters of the studied species inserted in either tap or drain water (fig. 2). In the case of morus, the litter total soluble sugars (mg g-1) significantly differed in both water types at the last harvest (60 dab) while was highly significant at the first harvest (5 dab). On the other hand, after 20 dab there were statistically significant differences between the p concentrations in the tap and drain water (fig. 2). N litter concentrations showed significant differences between the two water types at the first, fourth and fifth harvests and the difference was highly significant only at the seventh harvest (60 dab). During the first five days of the decay experiment, 17.6 and 14.3 % of morus ash contents were lost in tap and drain waters, successively. A significant difference between the ash contents of morumass remaining litter in tap and drain water was detected, 30 dab. However, the maximum values were recorded for tap and drain waters at the last two harvests (41.73 and 42.13 %, respectively). During the first 10 days, sugars and p concentrations decreased in morus leaves decomposed in tap water as well as in drain water. This was followed by a significant increase during the following days. On the contrary, n concentrations showed gradual increase during the first 20 days of the experiment. This was followed by gradual decline until day 50 of the experiment.

as regards the litter decomposition of salix, it was found that the soluble sugars in the litter decomposed in both water types significantly differed during the third and the sixth harvests. The p concentration in the litter showed high significance in the sixth harvest while being significantly different at the second, fifth and seventh harvests. The p concentration of salix litter in either water types was significantly different at the fourth and fifth harvests. All litter nutrient concentrations showed significant fluctuations with time (fig. 2). 46.6 & 36.9 % of salix ash content was lost in tap and drain water during the first five days of the experiment. Ash content of salix litters (fig. 3) significantly differed in both water types only at the third and the sixth harvests. During the first month, sugar concentrations in salix leaf litter, significantly and gradually increased in both water types. On the contrary, p and n concentrations showed remarkable decreases in the remaining mass litters during the first 10 days while being fluctuated with maximal values of 14.66mg g-1 (incubated in drain water, 50 dab) and 55.17 mg g-1 (incubated in tap water, 20 dab), respectively for the two components.

the concentrations of soluble sugars and p differed significantly ($p<0.05$) between the litters of populus incubated in tap and drain water at the second harvest (10 dab) and merely after 50 days for n. Concentrations of all nutrients were significantly oscillated with time. The percentage loss in populus ash content in tap and drain waters ranged between 38.5 and 17.7 during the first five days of the experiment. During the first 20 days of the experiment, ash content in populus leaves was variably different in litters incubated in the two water types. The highest values of nutrient concentrations (sugars, p and n) were monitored for populus leaf litter at 50 days for p and 60 days for sugars and n.

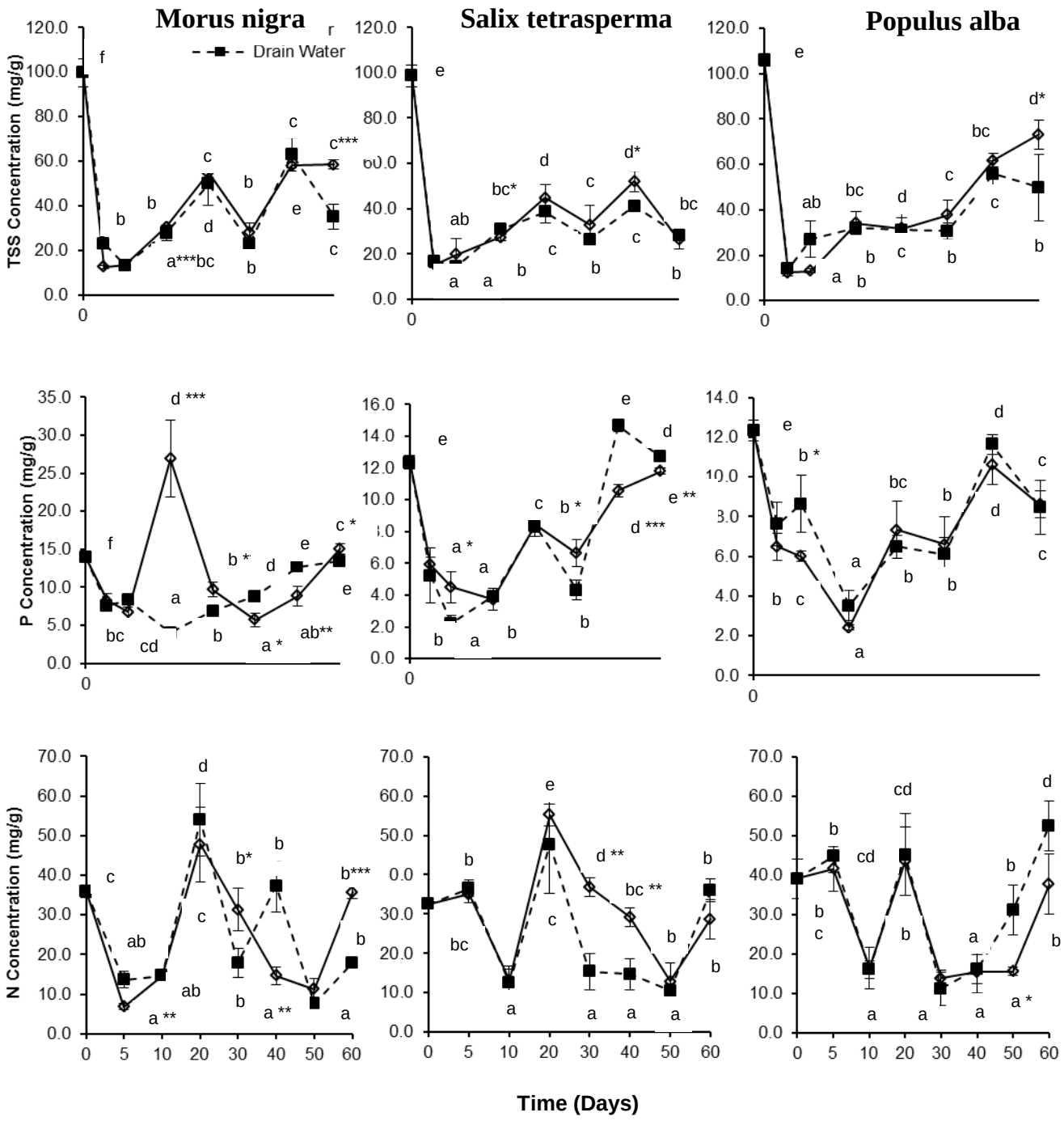

Fig. 2. Nutrient concentration (mg g-1) of Morus nigra, Salix tetrasperma and Populus alba remaining leaf litters subjected to the tap and drain water during the experimental period of 60 days from (September 25 to November 25, 2014). TSS= total soluble sugars.

Morus nigra

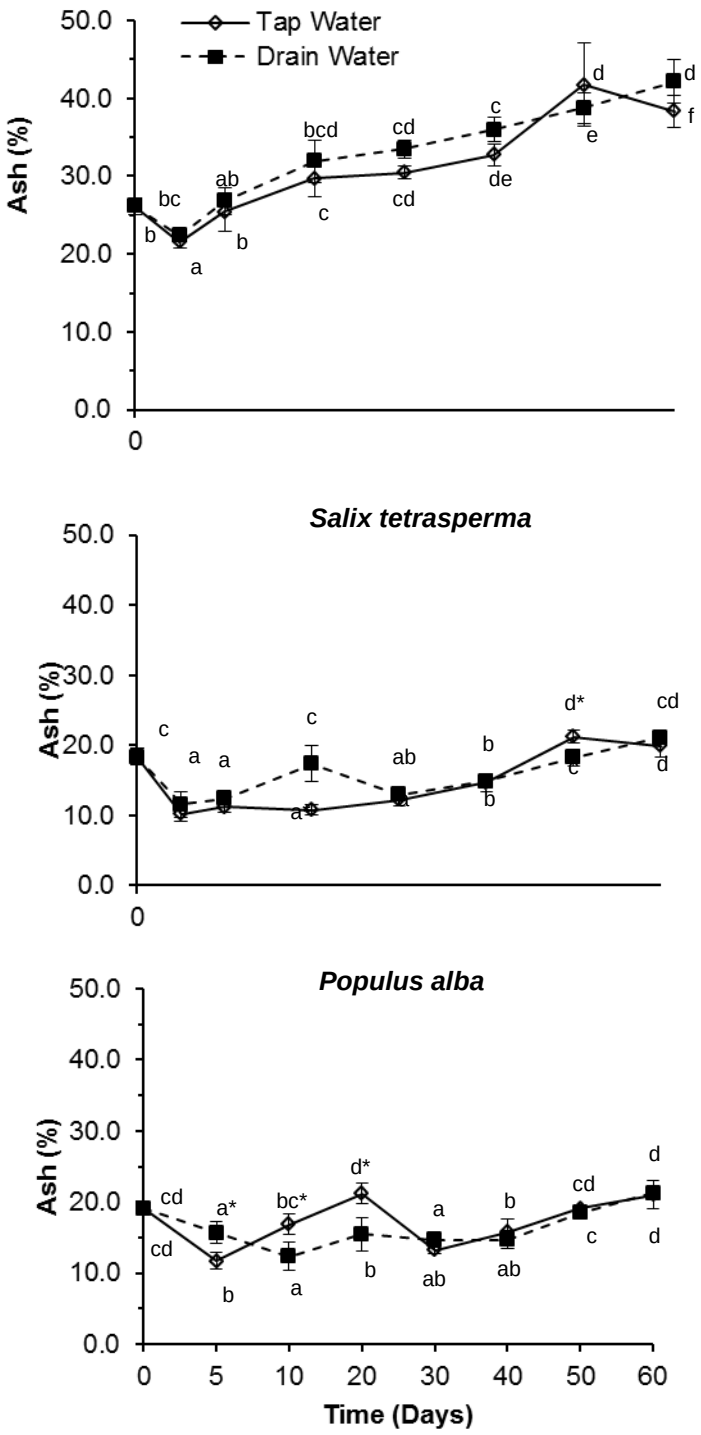

Fig. 3. Ash content (% of the dry mass) in the different leaves after time period in tap and drain water

LITTER NUTRIENT CONTENT REMAINING

Generally, for all studied species, nutrient remaining contents (total soluble sugars, P and N) of the species leaf litters incubated in both water types were significantly fluctuated with time (Fig. 4). In the case of Morus nigra, high significant difference between these contents was recorded for sugars (at the first harvest), P (at third and fourth harvests), and for N, (at the fourth and fifth harvests). By the end of the decomposition period, sugars, P, N contents remaining of litters incubated in tap water were higher than those incubated in drain water.

All nutrients remaining in Salix litter were fluctuated with time. Only high significance difference was recorded between litters of both water types at the sixth harvest for P and at the fourth and fifth harvests for N. At the end of the decay period, nearly sugar contents of Salix litter in tap and drain water consequently, (10.59 and 11.58 %) were similar to those of the first harvest (10.57 and 11.85).

By the end of the decomposition period, P content remaining in litters subjected to the drain water (42.21 %) significantly exceeded those of the first harvest (29.45%) while the N content remaining was significantly decreased to half its value. Highly significant N value (90.79 %) was recorded for litters incubated in tap water 20 DAB while that of P (48.97 %) was for drain water 50 DAB.

Concerning Populus, besides the fluctuation in sugar content remaining with time, only a significant difference was monitored for litter incubated in tap as compared to drain conditions, especially at the second and seventh harvests, at the second harvest for P and at the sixth one for N. By the end of the decomposition experiment, total soluble sugars remaining amounted from 1.9 to 3.7 fold of their contents after five DAB. Final content remaining of P diminished to about 60.1- 82.2 % of its value at the first harvest. N declined to give a final content remaining of 56.1- 63.1 % its value, five DAB.

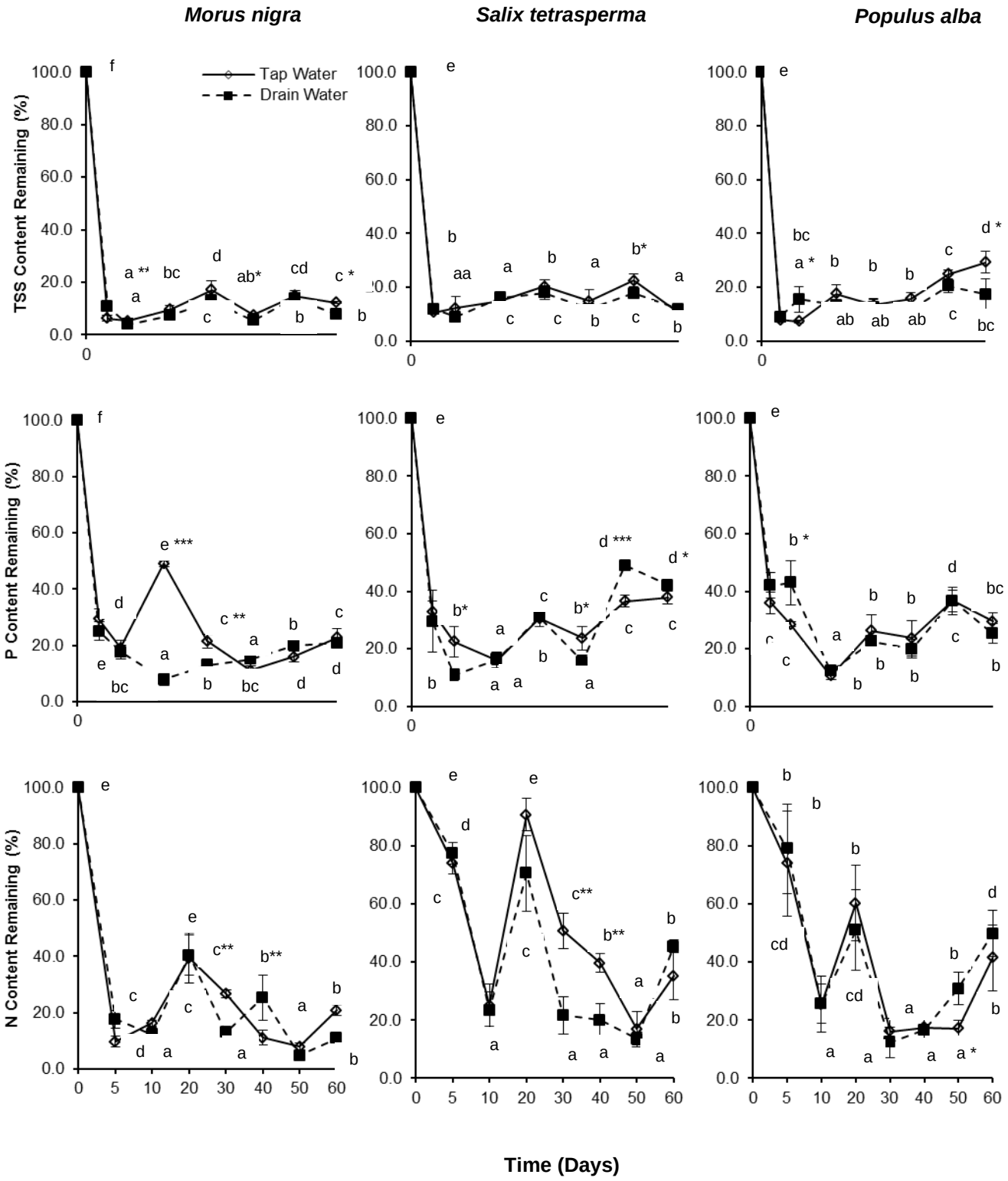

Fig. 4. Nutrient content remaining (percentage) of Morus nigra, Salix tetrasperma and Populus alba leaf litter in tap and drain water during the experimental period of 60 days from (September 25 to November 25, 2014). TSS= total soluble sugars.

CORRELATION BETWEEN DIFFERENT PARAMETERS:

Study of the relationship between the species, water type, time of harvesting, nutrient concentration and content remaining was undertaken by Pearson's Correlation Coefficient (Table 4). It revealed strong negative correlations between time of harvesting and nutrient content remaining. The correlation coefficient between time and mass remaining, sugar, phosphorus and nitrogen content remaining attained values of -0.78, -0.50; -0.51 and -0.62 respectively. In contrast to harvesting time, a strong positive correlation between species, mass and nitrogen content remaining was observed. A strong positive correlation was generally found between the different studied nutrient concentrations and nutrient remaining as indicated from the high positive values of correlation coefficient.

Table 4. Pearson correlation coefficient between different estimated parameters TSS, Total Soluble Sugar; SCR, Sugar Content Remaining; PCR, Phosphorus Content Remaining; NCR, Nitrogen Content Remaining.

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

	Species	Water type	Time (Days)	%Mass remaining	Ash (%)	TSSC (mg/g)	SCR (%)	P (mg/g)	PCR (%)	N (mg/g)	NCR (%)
% Mass remaining	0.30**	-0.05	-0.78**	1	-0.47**	0.52**	0.81**	0.06	0.82**	0.22**	0.81**
Ash (%)	-0.69**	0.03	0.33**	-0.47**	1	0.21*	-0.04	0.39**	-0.12	-0.06	-0.29**
TSSC (mg/g)	0.023	-0.05	-0.14	0.51**	0.21*	1	0.8**	0.45**	0.76**	0.16*	0.50**
SCR (%)	0.070	-0.03	-0.50**	0.81**	-0.04	0.89**	1	0.36**	0.92**	0.21**	0.72**
P (mg/g)	-0.267**	-0.07	0.10	0.06	0.39**	0.45**	0.36**	1	0.55**	0.19	0.12
PCR (%)	0.10	-0.04	-0.51**	0.82**	-0.12	0.76**	0.92**	0.55**	1	0.20**	0.70**
N (mg/g)	0.15	0.02	-0.15	0.22**	-0.06	0.16*	0.21*	0.10	0.12	1	0.70**
NCR (%)	0.22**	-0.02	-0.62**	0.81**	-0.29**	0.50**	0.72**	0.12	0.70**	0.70**	1

MICROBIAL COUNT FOR LEAF LITTER SAMPLES

Surface microbial counts of one-gram specimens of Morus nigra leaf litters clarified the elevation of bacterial number to a value of 1 x 104 CFU/g. However, the number of fungal units amounted 273 colony forming unit per g leaf litter (CFU/g). This was the case at the third harvest in drain water. The specimens, however, were characterized by its high N and low P contents (Table 5). Higher bacterial (1 x 105) and lower fungal counts (24 CFU/g) were maintained at Morus leaf litter surface of the sixth harvest incubated in drain water when P content exceeded that of N. Lower counts of microbes were recorded for specimens of other harvests. Microbial counts differed in Salix leaves with various P and N contents. For example, specimens of the last harvest (60 DAB) from the litter incubated in drain water attained a large bacterial count (1 x 104CFU /g) and a limited fungal one (40CFU /g) where the P and N contents in the litter were high. An extensively high bacterial number cannot be count (TNTC) (Table 5) as well as a relatively high fungal count (225 CFU /g) was estimated for Populus leaf litters at the first harvest (5 DAB). High P and N contents were evaluated for these specimens. Other lower counts were monitored for Populus litters at other harvests such as those incubated in drain water for 30 and 60

days (Table 5). The results indicated that phylloplane count of both bacteria and fungi on different litter specimens greatly depend on species as well as on the nutrient status.

Table (5). Microbial surface count of the study species at different harvests.

Leaf litter sample	Status of nutrient contents (% of initial)		Total bacterial count (CFU/g sample)	Total fungal count (CFU/g sample)
	P	N		
Morusnigra(5 d T)	Med.	Low	1×10^3	<1
Morusnigra(20 d T)	High	High	1×10^2	25
Morusnigra (20 d D)	Low	High	1×10^4	273
Morusnigra(30 d D)	Med.	Med.	2×10^2	40
Morusnigra(50 d D)	Med.	Low	1×10^5	24
Salix tetraspermma(10 d D)	Low	Med.	2×10^3	25
Salix tetraspermma(20 d D)	Low	High	2×10^3	75
Salix tetraspermma(60 d D)	High	High	1×10^4	04
Populus alba (5 d D)*	High	High	TNTC	225
Populus alba (30 d D)	Med.	Low	1×10^2	36
Populus alba (60 d D)	Med.	High	1×10^5	08

CFU, Colony Forming Unit; TNTC, Too Numerous to Count; d, day; T, Tap water; D, drain water. For Morus(low content ranges from 4-10, med. from 11-29, high from 30-50%). For Salix (low = 9-20, med. = 21-30, high = 31-91%). For Populus (low = 7-20, med. = 21-30, high = 31-79%).

EFFECT OF LEAF LITTER EXTRACTS ON SEED GERMINATION OF ERUCA SATIVA L.

There was a slight, non-significant inhibition in Eruca seed germination (GP) when soaked in Morus leaf litter extract (Fig. 5) at both harvests (20- and 60-days). A little non- significant promotion in germination (73.3%) was recorded for seeds soaked in tap water Salix extract at the 20- d harvest. In the case of Populus extract of the 20-d harvest, a non-significant increase in the seed germination (72.0 and 74.67 %) was attained in either tap or drain waters, successively. It is amazing to record a high significant promotion of Eruca seed germination (82.67%) in Populus litter extract at the 60- d harvest in drain water (Table 6).

A common trend was the significant inhibition in the root lengths of seedlings grown in the leaf litter extracts of all studied species decayed in tap and drain water at the 20- and 60- d harvests in comparison to the control. On the contrary, the shoot lengths showed significant promotion on using the 20-d extracts; especially those of Morus in tap water (3.46 cm), Salix tap (3.35 cm) and drain (3.18 cm) water of 20-day harvest and Populus tap water (3.27 cm).High promotion was significant for the shoot

length (3.71 cm) when soaked in drain litter extract of Populus leaves at the same harvest (20-d). At the 60-d harvest, the shoot lengths showed significant increase when germinated in the extracts of both water types of the studied species.

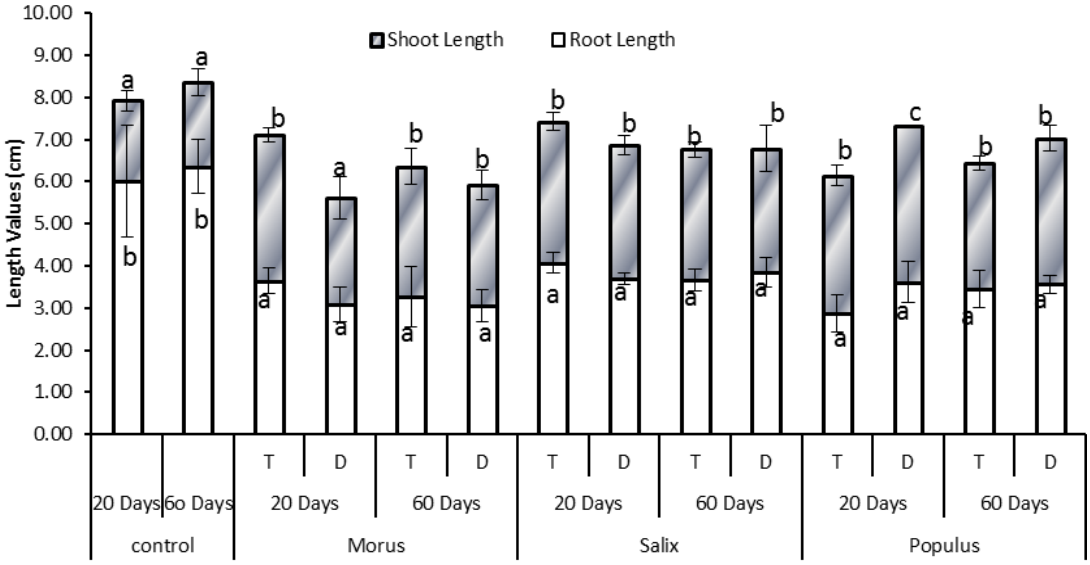

Figure 5. Shoot and root lengths of 8-d old Eruca sativa seedlings grown in the leaf litter extracts of Morus nigra, Salix tetrasperma and Populus alba, 20- and 60- DAB of the decomposition experiment. The letters indicate the significant difference between growth parameters of both water types and the control at each harvest (20 or 60 days) separately.

Table 6. Seed germination of Eruca sativa grown in 20- and 60-day litters extracts of the studied species.

Type of leaf litter extract	Treatment	Germination %	
		After 20 days	After 60 days
Control	S.D.W.	70.00±8.72[(a)]	75.33±3.06[(a)]
1-*Morus nigra*	T W	67.33±9.87[(a)]	70.67±5.03[(a)]
	D W	64.67±3.06*[(a)]	72.00±0.00[(a)]
2-*Salixte trasperma*	T W	73.33±6.43[(a)]	74.00±5.29[(a)]
	D W	65.33±16.17[(a)]	66.00±5.29[(a)]
3-*Populus alba*	T W	72.00±8.00[(a)]	74.67±4.16[(a)]
	D W	74.67±13.32[(a)]	82.67±2.31[(b)]

GP, Germination Percentage after 8 days; SDW, Sterilized Distilled Water; TW, Tap Water; DW, Drain Water. Subscribed letters indicate no significant difference between the seed germination parameters of the control, tap and drain water treatments of the same harvest. Stars indicate the significant difference between the 20 and 60- day harvests of the same extract.

DISCUSSION

Field observations of the study site; El-Khamseen drainage canal banks revealed its richness in riparian trees including; Morus nigra, Salix tetrasperma and Populus alba. The quantity, quality and diversity of litter accumulated in the stream is highly dependent on the type of riparian vegetation (Laitung and Chauvert, 2005) that have many benefits. They can alter decomposition rates of other species indirectly through their effects on environmental conditions via the ability to induce changes in soil fertility, microclimate and faunal and microbial communities in the forest floor (Aponte et al., 2011). The deciduous riparian species under investigation preferred to fall their leaves in autumn. A lot of leaves fall into the drain water of the study canal and remain in a floating manner for a period of time then sink into the bottom during the times of water recession or the leaves travel to a long distance with water inflow during the suction for the irrigation of neighboring cultivated fields. The drain water in the study canal was alkaline, moderately saline, poor in phosphorus and in nitrogen. The fallen leaves of chosen riparian trees are subjected to decay by the action of fauna and micro flora naturally present in water or accumulated from air. Magee (1993) stated that microbes colonize litter surfaces at densities of 410,000 – 410,000,000 individuals cm-2. The same author confirmed that these microbes are mainly fungi and bacteria which digest cellulose. Hobbie et al. (2012) concluded that microbes are the key of organisms that erode structural framework of the litter and their abundance and activity reflect environmental conditions. He supplemented that bacteria are more numerous on submerged than on standing dead litter, although water temperature and oxygen availability

affect bacterial response and that in many wetlands, microbes regulate decay and account for 90% of litter weight loss. Results concerning the microbial counts evinced that the leaf litter decay of the studied species was mainly dependent on bacteria than on fungi (Table 5). The bacterial growth varied with the variation of species as well as the long of decaying time. In turn, the nutrient content remaining (especially P and N) fluctuated between low and high values. Bayo et al. (2005) found that N and / or P concentration in water have been demonstrated as key factors for determining microbial activity, and therefore the decomposition rates of plant litter are different in different types of aquatic ecosystems. As regards Morus, bacterial counts amounted 1x104CFU at the third harvest (20-DAB in drain water). In contrast to N, the P nutrient remaining was low. On the other hand and at the sixth harvest, (50-DAB in drain water), bacterial numbers raised to 1x105 CFU where high P and low N was determined. In the case of Salix, at the second harvest (10-DAB), the bacterial count amounted 2x103 CFU when the P content remaining was low and N was median. However, the bacterial growth was enhanced to 1x104 CFU at the last harvest (60-DAB) reflecting. The nutrient status of P and high N contents. The number of bacterial units was uncountable, on Populus phylloplane, five-DAB in drain water. Despite, high remaining of P and N were attained. On the contrary, when the bacterial growth diminished to1x105 CFU, median P and high N were estimated. Generally, there was a fluctuation in the counts of microbes that reflects their decay potency on the leaf litters and in turn, it affected the nutrient status in the remaining masses. Besides the effect of microbes in changing the nutrient components, this change might be attributed to the uptake of nutrients by microorganisms from the surrounding water or from atmosphere (Dinka et al., 2004) which, in turn, affects the colonization and proliferation of microorganisms on the decomposing litter. Battle and Mihuc (2000) concluded that the bacterial density in the winter on Eichhornia crassipes and Sagittaria platiphylla averaged 1.4x106cm-2 after two days and decreased to 2.0x105 cm-2 after 28 days. The results emphasize the importance of the microbial community in the litter decomposition in the drainage canals, especially in autumn, during the leaf fall. Significance was only monitored between the conditions of decaying in tap and drain water during the first 10 days of the experiment especially in the case of Morus decay and after 50 days for Populus decomposition. We might conclude that there is a mutual beneficial relationship between the water micro-flora and the plant litters of either hydrophytes or riparian litters.

The present study showed a rapid decay of Morus leaf litters in comparison to the other two species, especially after the first five days of the experiment. The percentage loss of Morus litters in drain water (70.3) was significantly higher than that of tap water. (60.31) while the leaf litters of some Mediterranean tree species had been lost between 52 and 74% their masses during 14 months (Gillon et al., 1993). It is concluded that the decay of Morus leaves which was faster than those of the other two species could be attributed to the following outlines: Morus leaf possesses lower lignin, higher P and moderate N and total soluble sugars in comparison to the leaves of the other species. By the end of the experiment, the percentage loss amounted 79.07 and 78.29 %, respectively for tap and drain waters. The exponential breakdown rate (k) of Morus gave only high values (0.14 and 0.16) in tap and drain waters, respectively at the second harvest (10-DAB) with high significance. It was evident that the initial tap water - as a substratum – was much poorer (EC= 653.33µmhos cm-1, null P and 0.18 mg g-1 N) than the initial drain water (EC = 1,266.67µmhos cm-1, 0.41 mg g-1P and 0.48 mg g-1 N). This means that the quality of tap water was lower than the drain one. Therefore, it should be stated that high quality litter of Morus showed increased decomposition rate in the low – quality substrate of tap water. This result agrees with Aerts and Caluwe (1997) who stated that in

contrary to what is generally found, the leaf litter decomposition rate of the species growing at the nutrient-poorest site was higher than that of the species growing at the nutrient- richest site. It was found that more than fifty percent of the leaf litters of the studied species - in all treatments - were decomposed during two months. Studies have indicated that the decomposition rate was affected by initial litter chemistry (Yam Lan et al., 2012). Thedecay rates (percentage losses) of the leaf litters of the present study were in the order: Morus (in tap water) >Morus (in drain) >Populus (in drain water) >Salix (in tap water) >Salis (in drain water) > Populus (in tap water). Therefore, the higher the lignin content (as a supporting tissue) the higher the resistance for decay and vice versa. The slower decomposition of Salix and Populus was probably a result of microbial inhibition by the waxy – cutin and low nutritional value of water (Battle and Mihuc, 2000). It is noted that the ratios of C/N, C/P, lignin/N and lignin/P followed the same order of lignin content: Salix >Populus>Morus, suggesting that the differences in decomposition rate can partly be explained by the differences in the ratios of C: N, C:P, lignin: N and lignin: P among the three litter types. Many authors have indicated that the C: N ratio of litter is a primary determinant of variation in decomposition rate of aquatic plants (Enriquez et al., 1993; Xie et al., 2004; Eid et al., 2012).

Other important key factors determining the decay process is the biodiversity of water micro- flora which is related to the climatic conditions as well as the nutritive conditions undergone during the experimental period (Battle and Mihuc, 2000). The relatively favorable thermal and aerobic conditions in the water containers of the experiment during the present study period (autumn season; December - November 2014 of mild mean temperature of 22±2◦ C) represent additional factors contributing to the explanation of the high decay rate, especially for Morus litter and controlling the microbial activity. According to Schlesinger (1997), the decomposition rate doubles with every 10◦C increase in temperature. However, Kirwan et al. (2014) found that the leaf decay moderately increases at warmer temperatures by the range of 3-6% per one ◦C. The concomitant fungi and bacteria (Table 5) apparently accelerated - to a great extent - the leaf litter decay. These results cope with Battle and Mihuc (2000) who concluded that macrophytes decay faster in fall than in winter due to the effect of increased temperature. Drain water in the tanks used in the experimental design was stagnant for many hours a day. Moderate oxygenation resulted from the ventilation process created more or less good aerating conditions suitable for microbial growth. In addition, the high carbon content and the high C: P ratio, consequently of the initial M. nigra, S. tetrasperma and P. alba leaves added to the water organic inputs during the first few days of the experiment. Elevated levels of initial N, P, and soluble sugars of the study species created better conditions for their leaf litter decay. Magee (1993) attributed the breakdown of sucrose in water into glucose and fructose to fungi and that only a portion of these sugars are assimilated by microbes and the remainders are available to protists, zooplanktons and microinvertibrates. Battle and Mihuc (2000) concluded that microbes are the primary decomposers of macrophytes in the backwater areas whereas macroinvertibrates are the primary decomposers in the riverine sites. They also attributed this phenomenon to the decomposer – habitat interactions where oxygenated riverine sites are more hospitable to invertebrates and the backwater areas are more favorable to microbes because of high organic inputs and reduced flow. Owing to this inhabitable micro- flora and fauna, is the oscillation in the ash content of the studied species.

The fluctuation in the nutrient concentrations and nutrient content remaining in leaf litters of the study species, especially N and P reflected the different metabolic activities of the combined microbes. Miranda et al (2014)

concluded that all hydrophytes show remarkable ability to remove nitrates (as a soluble source of N) in water. El-Khamseen drainage canal of the present investigation is highly contaminated with the daily sources of pollution such as: the agricultural effluents, domestic and manufacturing discharges, traffic emissions, burning residues and dead animals. All these pollutants are sources for N and other nutrients. As mentioned by Garcia et al. (1994), the nitrates derived from N can be found in food and beverages and are mainly derived from the use of N-fertilizers, animal excrements, discharges of domestic and industrial waste waters, the use of food additives (canned meat and fish) of natural decomposition by microorganisms of organic nitrogen matter like animal and plant proteins.

Strong positive correlation was monitored between the species and mass remaining, species and N content remaining and between all nutrient concentrations and all nutrient content remaining. No positive correlation was found between harvest time and all nutrient (sugar, P and N) content remaining. However, Scowcroft (1997) concluded that decay rates of some forest species were significantly correlated with the initial lignin-ash ratios.

The slight promotion in seed germination of Eruca occurred in seedlings growing in the extract of the Salix litter incubated for 20-days in tap water and extract and in Populus extract of the same harvest, evenly in tap or drain water types. Highly significant promotion was attained for the seeds soaked in Populus drain extract of 60-days. Significant inhibition of the root length was detected in all 20-day extracts of both water types. However and at the same harvest the shoot growth showed significant promotion in extracts of: Morus (tap), Salix (tap and drain) and in Populus (drain) waters. Rosa et al. (2013) concluded that only the root growth was inhibited on growing Raphanus seeds in Salix extracts. Hassan et al. (2012) proved that aqueous extracts of Salix species have phytotoxic effects on seed germination and seedling growth of Sorghum bicolor. Besides the effect of Morus on the seed germination, it also had a good potency level of antibacterial activity (Salem et al., 2013).

By the end of the decomposition experiment, we can conclude that the decay of the leaf litter differs among the different riparian species. As a result, liberated nutrients are released in the drainage canal water that are carried by the water inflow and finally settle in the neighboring agricultural fields to provide them with the components they are in need. Meanwhile, the extracts of the fallen leaves, which are rich in allelochemicals, may possibly affect the seed germination and the growth of roots and shoots of the associating crop plants and field weeds. These effects will be investigated in a subsequent publication.

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تحلل وتقييم المغذيات لمخلفات أوراق ثلاثة أنواع من الأشجار الشاطئية

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قدرت الدراسة معدل تحلل والديناميكية الغذائية لمخلفات أوراق ثلاثة أنواع من الأشجار الشاطئية وهي: نبات التوت الأسود- الصفصاف والحور الأبيض. تم تجميع الأوراق الميتة المتساقطة لأنواع الدراسة في فصل الخريف بطول ضفاف ترعة الخمسين والتي تمثل فرعا نهائيا لنهر النيل والذي يمر ببلدة صفط اللبن بمحافظة الجيزة مصر. وتم دراسة كمية المغذيات الخارجة بالماء بعد تحلل أنسجة الأوراق الميتة في أوعية بلاستيكية وضعت جهة النوافذ بمعمل البيئة-جامعة القاهرة وتحت الظروف الطبيعية. ولتقدير معدلات التحلل استخدمت طريقة أكياس القمامة باستعمال شبكة من البلاستيك ذات الثقوب الضيقة (١.٥ مم) في صنع أكياس لعدد سبع مرات من الحصاد ولكل حصدة حزمة مرتبطة من ثلاث مكررات. تم تجفيف العينات ووزنها وتحليلها لتقدير كل من: المحتوى الكلي للسكريات الذائبة-الفوسفور-النيتروجين-الرماد-اللجنين. وكان تحلل التوت أسرع من النوعين الآخرين وذلك لانخفاض محتوى اللجنين وارتفاع محتواه من الفوسفور واحتوائه على قيمة متوسطة من النيتروجين والسكر الكلي المذاب وخلال شهري التجربة تم تحلل ما يزيد على ٥٠% من الوزن الأساسي لأوراق الأنواع المدروسة. وقد تأثر اختلاف معدل التحلل بالنسب: كربون/نيتروجين-كربون/فوسفور-لجنين/نيتروجين-لجنين/فوسفور. وقد أدى تباين الأنشطة الميكروبية الى احداث تقلبات في كل من التركيز والمحتوى المتبقي للمغذيات كما أدى اختلاف أعداد الخلايا المكونة للمستعمرات البكتيرية والفطرية على أسطح الكتل الورقية المتبقية الى اختلاف نسب المغذيات (الفوسفور-النيتروجين) بها. واعتمد تحلل النفايات الورقية للأنواع – بصفة أساسية على أعداد الخلايا البكتيرية والتي تراوحت بين المحدودة الى الصعب عدها أكثر من اعتمادها على الفطريات. وقد ساهمت الظروف الحرارية والهوائية المناسبة في تفسير التحلل العالي للأنواع. كما أظهرت الدراسة ارتباطا إيجابيا قويا بين: النوع والكتلة المتبقية وبين النوع وبقايا النيتروجين وبين تركيزات كافة المغذيات وبقاياها وكان الارتباط سلبيا بين وقت الحصاد وبقايا كافة المغذيات. وكان تأثير مستخلصات بقايا الأوراق المتحللة محدودا على انبات بذور الجرجير، وفي الوقت ذاته أوضحت الدراسة تأثيرا مثبطا لنمو الجذور وآخر معززا لنمو سوق البادرات.