NUTRIENT DYNAMICS DURING DECOMPOSITION OF FOUR DIFFERENT PINE LITTERS

Anna De Marco[a], Paola Vittozzi[a], Flora Angela Rutigliano[b], Amalia Virzo De Santo[a]

[a]Dipartimento di Biologia Strutturale e Funzionale, Università Federico II, Via Foria 223, 80139 Napoli-Italy
[b]Dipartimento di Scienze Ambientali, Seconda Università di Napoli, Via Vivaldi 43, 81100 Caserta-Italy

Litter decomposition is a key process for nutrient cycling. It is controlled by climate and litter quality as well as by the nature and abundance of decomposer organisms (Swift et al., 1979, "Decomposition in terrestrial ecosystems", Blackwell Scientific). Decomposition process is affected by macro- and micro-nutrients concentrations and by amount of complex substances such as chitins, celluloses, hemicelluloses and lignins, that are particularly recalcitrant to enzymatic degradation (Fioretto et al., 2001, *J. Mediterranean Ecol.*, 2). Early stages of decomposition are positively influenced by high concentrations of macronutrients, such as N, while in late stages lignin is the main regulation factor; particularly, high concentrations of lignin may inhibit the degradation process (Rutigliano et al., 1996, *Soil Biol. Bioch.*, 28).

In this study the dynamics of N, K, Mg, Mn, Fe and Cu were investigated during litter decomposition of four different pine species (*Pinus pinea* L., *P. nigra* Arn., *P. laricio* Poiret, and *P. sylvestris* L.) at Mount Vesuvius. Climate in the area is characterised by warm and dry summers and wet winters. Annual mean temperature is 13.2°C and annual mean precipitation is 960 mm (average 1926-1950, Osservatorio Vesuviano, 612 m a.s.l.).

Table 1. Initial chemical composition of needle litters.

Litter type	**Lignin** (mg/g)	**N** (mg/g)	**K** (mg/g)	**Mg** (mg/g)	**Mn** (mg/g)	**Fe** (mg/g)	**Cu** (µg/g)
P. pinea L.	369	5.1	4.8	2.7	0.06	0.2	1.9
P. nigra Arn.	223	23.9	2.3	1.5	0.03	2.9	1.4
P. sylvestris L.	266	4.0	0.5	0.4	1.2	0.3	2.5
P. laricio P.	276	4.7	2.4	1.3	0.6	0.3	1.8

Initial chemical composition of the brown needle litters differed between species (Table 1). Litter of *P. pinea* was the richest in lignin, K and Mg and the poorest in Fe as compared with the other pine litters (Table 1). *P. nigra* needles had the highest concentrations of N and Fe and were poorest in lignin, Mn and Cu (Table 1). The litter poorest in N, K and Mg was that of *P. sylvestris;* however it was the richest in Mn (Table 1).

The needle litters were collected in four different pine forests:

- needles of *P. nigra* were sampled at a Black pine stand (40 years old) in Atrio del Cavallo (800 m a.s.l. on North-Easten slope of Mount Vesuvius; Naples, South-Italy);
- needles of *P. pinea* were sampled at a Stone pine stand (40 years old) in Terzigno (250 m a.s.l. on the South-Easten slope of Mount Vesuvius; Naples, South-Italy);
- needles of *P. laricio* were sampled at a Corsican pine stand (50-80 years old) in Golia (1300 m a.s.l. on Sila Mountains, Calabria, South-Italy);
- needles of *P. sylvestris* were sampled at a Scots pine stand (130 years old) in Jädraås (185 m a.s.l., East Central Sweden).

Brown needles of *P. pinea*, *P. laricio* and *P. sylvestris* were sampled at abscission by shaking tree branches. After air-drying needles were incubated in bottom less containers (100x100 cm, 5 cm height) in the Stone pine forest. Needle samples were collected from the containers every 2-3 months for about 3 years (for more details see Virzo De Santo et al., 2002, *Acta Oecol.*, 23).

Decomposition of *P. nigra* was studied by a direct field method (see Vittozzi et al., abstract of this Congress). The whole organic profile was collected in 8 replicates by a box (20x20 cm). Four

needle layers were recognised based on morphological criteria and the linear weight was used to asses decomposition (Gourbière, 1986, *Soil Biol Bioch*, 18).
Some soil characteristics for the two experimental sites are showed in table 2.

Table 2. Some soil characteristics for the experimental sites (0-5 cm depth).

Site	pH	Organic matter (%)	C/N
Terzigno	6.0	6.1 ±0.4	24.6 ±1.8
Atrio del Cavallo	4.2	3.1 ±0.8	8.9 ±0.3

For chemical analyses each type of pine litter was dried at 75°C and pulverised by Fritsch pulverisette (type 00.502) with an agate pocket and ball mill. Nitrogen content was determined by combustion with an Elemental Analyser (NA 1500, Carlo Erba). K, Mg, Mn, Fe and Cu concentrations were determined by a SpectrAA-20 Atomic Absorption spectrometer (Varian) after digestion of the samples in a mixture of nitric (65%) and hydrofluoric (50%) acid (v:v=2:1) in a Digestore Milestone MLS1200. Nutrient dynamics are showed as absolute amounts of element, i.e. as percent of initial values. For *P. nigra*, the deeper litter layer was not considered in the elemental analyses because of difficulty to separate decomposing material from soil. The correlation between absolute amounts of element and mass loss was evaluated by the Pearson correlation coefficient.

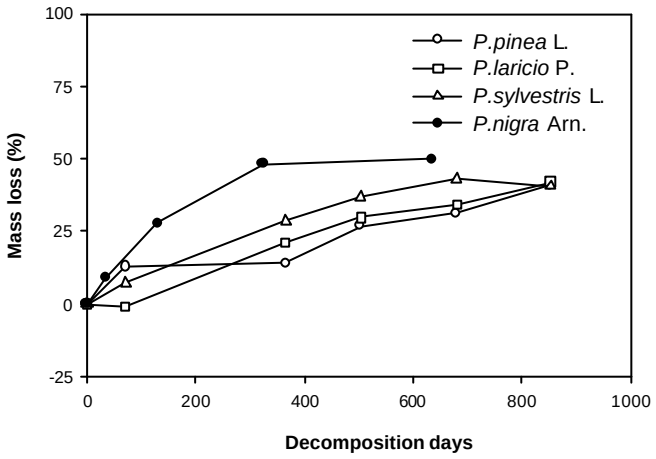

Figure 1: Mass loss of needle litters of P. pinea L., *P. laricio* P., *P. sylvestris* L. and *P. nigra* Arn.

The pattern of decomposition (Fig. 1) was well described by an asymptotic model in *P. nigra*, the litter richest in nitrogen; in contrast *P. pinea*, *P. laricio*, *P. sylvestris*, that were poorer in nitrogen, showed an exponential model of decomposition (Berg and McClaugherty, 2003, Plant Litter, Springer).
During decomposition of *P. pinea*, *P. laricio* and *P. sylvestris* the absolute amount of N (Fig. 2) increased. In *P. nigra* litter N content increased during the early 34 days of decomposition and was released thereafter, reaching about 60% of the initial value at 633 days. N is a nutrient that strongly controls the growth of microrganisms (Berg and McClaugherty, 2003, Plant litter, Springer); infact it was immobilized in the litters with low initial concentration, and released in *P. nigra* that had initial N content 5 times higher than the other litters. N amount was positively correlated ($P<0.05$) to mass loss in *P. sylvestris*, the litter with the lowest N concentration and negatively correlated to mass loss in *P. nigra* the litter with the highest N content.
K is a very mobile element; generally it is released during decomposition. In the studied litters K dynamics was controlled by the initial litter concentration. Thus *P. sylvestris* litter, with a low initial content, increased the absolute amount of K during decomposition and the absolute amount was positively correlated to mass loss ($P<0.05$).
Mg was accumulated in all the studied pine litters; the highest increases of Mg absolute amounts were observed in *P. sylvestris* and *P. nigra*. The Mg immobilization was evidenced by the positive correlation ($P<0.05$) with mass loss found in all litters.
Mn is essential for lignin degrading enzymes (Archibald & Roy, 1992, *App. Env. Mic*., 58). Mn dynamics showed different patterns in the four litter types depending on the initial concentration. *P. laricio* and *P. sylvestris* needles had high initial Mn concentrations and released Mn during decomposition, while *P. nigra* and *P. pinea* needles, with low initial content, accumulated Mn.

Negative correlations were found between Mn and mass loss in *P. laricio* (P<0.01) and *P. sylvestris* (P<0.05) litters, while a positive correlation was observed in *P. nigra* litter (P<0.001).

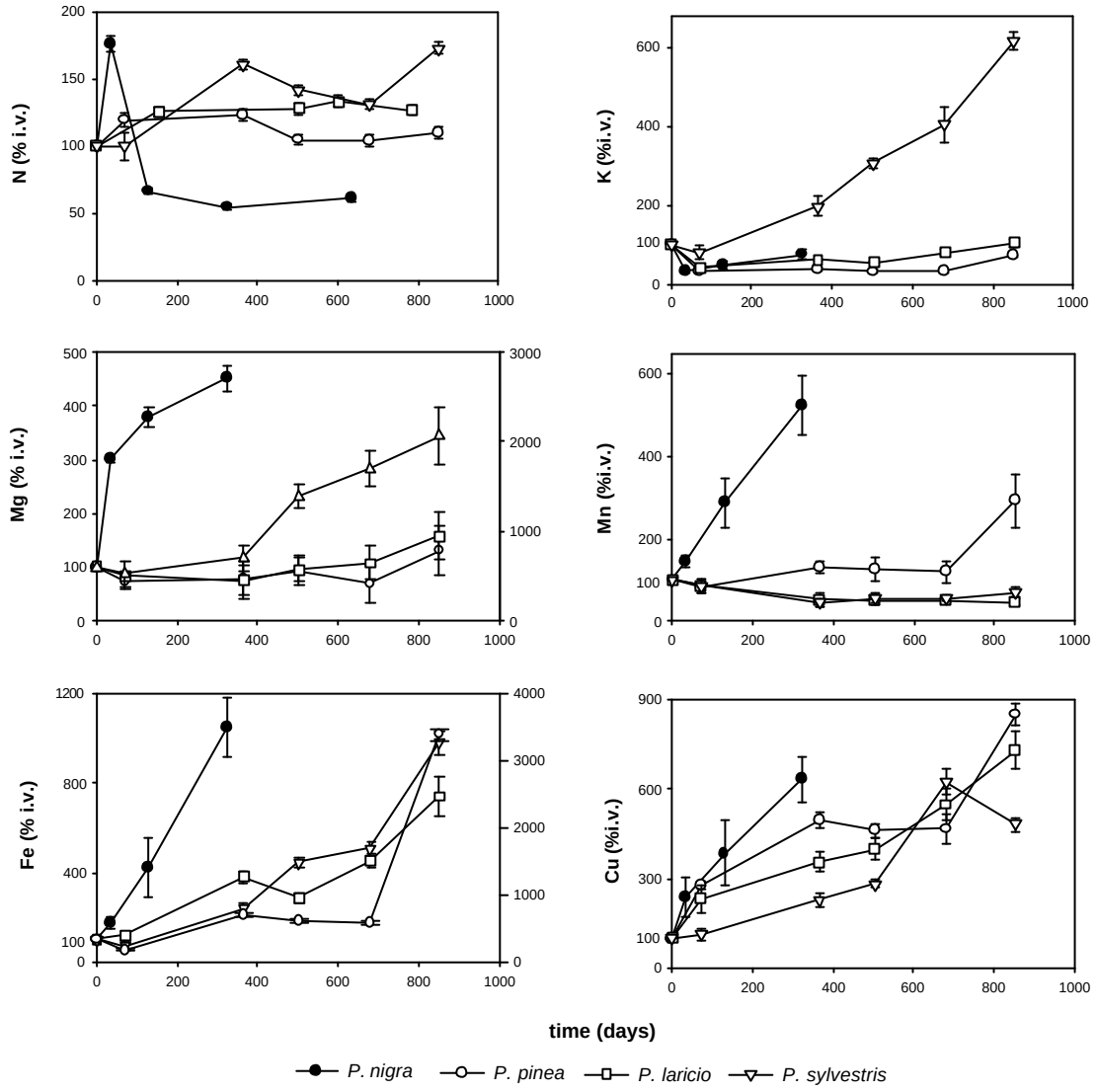

Figure 2. Changes in absolute amounts of N, K, Mg, Mn, Fe and Cu during decomposition of *P. nigra*, *P. pinea*, *P. laricio* and *P. sylvestris*. In Mg sub-graph values for *P. nigra* litter are on the left axis. In Fe sub-graph values for *P. nigra* and *P. pinea* litters are on the left axis.

Fe and Cu are micro-nutrients/heavy metals. They may be immobilized during decomposition and even imported from the soil through the fungal mycelium. Besides their ions may form stable complexes with humic compounds (Stevenson, 1982, Humus chemistry, Wiley & Sons). The absolute amounts of Fe and Cu increased in all four litter types, especially in *P. nigra* needles. Absolute amounts of Fe and Cu and accumulated mass loss were significantly and positively correlated (P<0.05) in all litters.

The data presented suggest that nutrient dynamics in studied litters is regulated by the initial content with immobilization or releases respectively for poor and rich litters during decomposition.