The effect of logging residue removal for bioenergy on soil fertility and nutrient leaching from the organic soil layer

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Introduction

All the mechanized timber harvesting in Finland is done with a single-grip harvester and a forwarder. In a conventional single-grip operation branches are delimbed in front of the machine and the branches are dropped on a strip road. As machines pass over the residues they will be contaminated by soil making it unsuitable for a chipping operation. To avoid this problem the accumulation of the branches along the strip road is a prerequisite for the recovery of logging residue for fuelwood. This is carried out by the machine delimbing the branches beside the striproad. As a result the residue heaps alternate with the roundwood logs and bolts for easy recovery by a forwarder. A recovery rate of 70 % of the green mass is a norm.

In Finland, the use of logging residue for bioenergy is currently about one million green tonnes per annum. The concern on environment and sustainability of forestry may restrict the removal of logging residue in the future. Sustainable forest management requires that site productivity is maintained. It is widely recognized that logging residue removal could deplete forest soil nutrient pools because nutrients released from the logging residues may be an important source for soil fertility. In Finland the most common growth limiting nutrient in mineral soils is nitrogen. On the other hand, excess nutrients released from the logging residues may leach out and impair the quality of runoff waters. The aim of this work was to study the effects of logging residue removal on soil fertility and nutrient leaching from the soil organic layer on a Norway spruce clearcutting area.

Material and methods

Study site was located in central Finland (61?47' N, 24?45'E). The site covers 6 ha and carried a Norway spruce (*Picea abies* (L.) Karst.) stand which had a timber volume of 315 m^3/ha prior to clearcutting. The annual mean precipitation in the area during May-September is 320 mm and the mean effective temperature sum is 1200 ?C. The soil type is haplic Podzol and texture type is sandy till. The site was clearcut with a single-grip harvester in early June 1999 in a fashion mentioned above and the experimental field was established in the following two weeks. Logging residues were left on site after cleacutting in heaps arranged into zones. The distance between heaps was 9-16 m. The mean thickness of the heaps was 40 cm. The mass of logging residues was 62 oven dry tonnes/ha and the are covered by residue heaps was 17 % of the total cutting area. The experiment was established in the form of randomized blocks with three treatments and two replicates. The blocks were delimited in order to include two logging residue heap zones into each block. The treatments were 1) no removal of logging residues 2) removal of logging residues immediately after clearcutting in early June 3) removal of logging residues after seasoning in August. The plots were 25x 25 m in size. In the treatments 2 and 3 the logging residue removal was 87 %.

Soil leachates were collected by zero tension lysimeters below the logging residue heaps of as well as the organic layer. In the plots with logging residue heaps, three lysimeters were installed directly below the heaps and three lysimeters below the organic layer. Three lysimeters were also installed below the organic layer between the heaps in each block. In the plots with logging residue removal three lysimeters were installed. Volumes of percolation water were recorded and soil leachate and bulk precipitation samples were collected in two to six weeks intervals depending on the volume of precipitation between May and October in 1999 and 2000. The three replicate leachate samples were bulked for each plot

proportionately according to the volume to give a sample for nutrient analysis. Leachate samples were analysed for total dissolved nitrogen, nitrate, ammonium, phosphorus, potassium and calcium. The fluxes of nutrients through the logging residue heaps and organic layer were calculated using measured water volumes and nutrient concentrations. For calculating nutrient fluxes for the total treatment area on hectare basis, nutrient flux in plots without logging residue recovery was calculated summing the flux of the area covered by logging residue heaps and the flux of the area without logging residue heaps.

Results

During the first summer following clearcutting, between June and October, total nitrogen concentration in the logging residue leachate was on average 8 mg dm^{-3}. During the second summer total nitrogen concentration varied from 5 to 25 mg dm^{-3}. The major nitrogen compound in the logging residue leachate and in the organic layer leachate was organic. The organic nitrogen concentration in the organic layer leachate increased in the fall during the first growing season. Ammonium concentration increased in the organic layer leachate after first two months. This was particularly pronounced underneath the logging residue heaps. Nitrate concentrations in the logging residue leachate and in the soil leachate remained very low (<0.2 mg dm^{-3}) during the first summer and slightly increased during the second summer. Potassium and phosphate concentration in the logging residue leachate increased markedly in the fall. In the organic layer leachate, potassium and phosphate concentrations remained at the same level over time.

The significance of the logging residue heaps as a nitrogen source was low because the total amount of released nitrogen was only 0.4 kg/ha during the first growing season and 0.8 kg/ha during the second. In the logging residue heaps the storage of total nitrogen was 280 kg/ha. In the precipitation the annual nitrogen input was 4 kg/ha. From the organic layer, the total amount of leached nitrogen was only 3 kg/ha after first growing season and 6 kg/ha after the second growing season. The storage of nitrogen in the organic layer of soil was 1600 kg/ha. Potassium input from the logging residue to the organic layer was 5 kg/ha after the first summer and 3 kg/ha after the second summer. The same amounts also leaching from the organic layer. Phosphorus input from the logging residue and output from the organic layer were both around 1 kg/ha.

Conclusions

The decreased water flux through the organic layer underneath the logging residue heaps reduce the total nutrient flux despite of the increased nutrient concentration in the soil leachate. Nitrogen was released slowly from the logging residues but the release of potassium and phosphate was markedly faster. The results from this short period of time show that removal of logging residues does not effect nutrient leaching from the organic layer when the results are expressed over the total harvest area. Therefore, the removal of logging residues has no short term effect on soil fertility.