USING WASTE WOOD CHIPS TO REHABILITATE LANDFILL SITES

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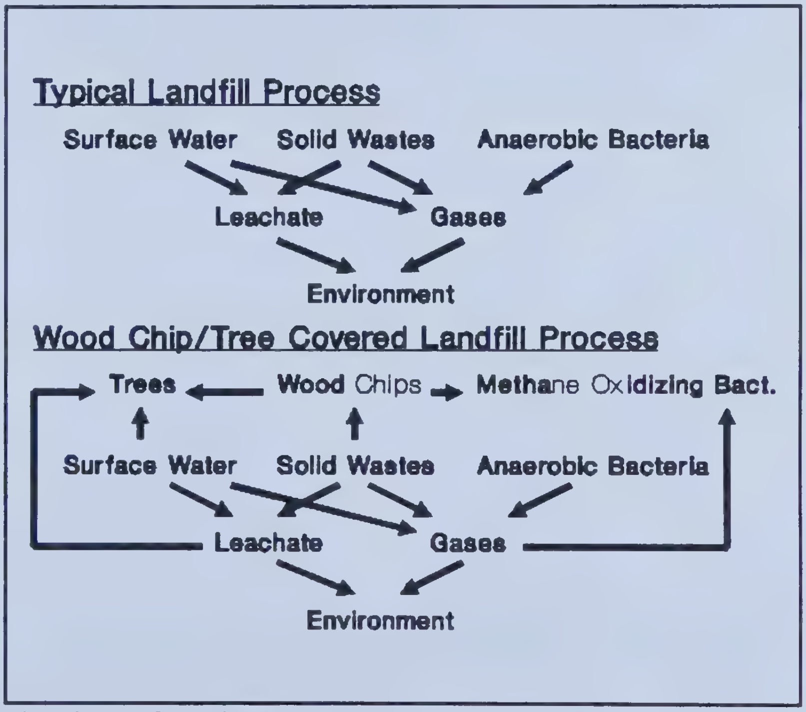
ABSTRACT

Results from the first three years of a ten year study, on the utilization of urban waste wood chips as a mulch and soil aggregate for tree establishment, are presented here. Tree growth trials on a closed landfill site have indicated that waste wood chips (hereafter also referred to as 'mulch') offered a better growing environment through the reduction of mortality and die-back and an increase in shoot and root development. The ultimate aim of this project is to suggest a better method in landfill management through the reduction of wood wastes in the solid waste stream, abatement and redirection of landfill leachate, and an active rehabilitation effort.

<u>Right:</u> Flowcharts indicate how wood wastes can be diverted from the solid waste stream and promote biological activity on an otherwise devoid site.



Flowcharts of Leachate and Gas Migration

Introduction

Waste wood has long been one of the main contributors to the ever increasing demand placed upon our landfills. W.C.I. Wood Conversion Inc., a company dealing with waste wood in the Region of Peel, hypothesized that this waste wood could be processed into wood chips for re-use rather than absorbed by our overburdened landfills.

Landfill sites have long been ascribed to have only a passive use after their closure. They are usually left in a state of open pasture. Reforestation attempts have been made, but mortality of young seedlings is usually found to be quite high.

A project was developed by W.C.I. Wood Conversion Inc., in co-operation with the Regional Municipality of Peel, to determine if waste wood chips (source: pallets, construction wood, tree clippings, etc.), when used as a mulch, could help increase the survival rate of tree plantings. The project was initiated on February 22, 1990 on a landfill site closed since 1980.

Twelve thousand tonnes of waste wood chips were spread on the Chinguacousy Landfill site in the Spring of 1990. That Summer, a preliminary test plantation was established. Results were shown to be very favourable and urged on the planting of some further 16,500 trees. The project results, so far, suggest that processing waste wood into chips, and applying it as a site preparation for tree establishment, would effectively reduce waste and accelerate landfill rehabilitation after closure.

Aeration of the soil is one of the major concerns for the Chinguacousy site. Aeration is impeded in heavy compacted clay parent material, particularly under wet conditions. With the added stress of CO_2 (Carbon dioxide) and CH_4 (Methane) development from beneath, oxygen availability will be handicapped. In clay soils, percolation of water into the soil and soil aeration are favoured by aggregated soil particles rather than by a plastic structure or cemented layers of hardpans (U.S.D.A., 1990). Therefore discing wood chips (source of aggregate soil particles) into the clay cap will assist in aeration, while retaining most of the mulches advantages.

As far as the Chingaucousy Landfill site is concerned:

The major goals of this project are:
1) Development of Landfill Management and Rehabilitation
2) Development of Tree Establishment Methods

Other goals of this project are:
3) Promotion of Public Education and Recreation
4) Promotion of Wildlife Diversity
5) Timber Biomass Production

The project is currently concentrating its efforts on proper site preparation (i.e. the first two goals).

Experiment and Results

This project, so far, consists of four experimental components. These experimental components are:

- Preliminary Test Plantation (1990)
- Soil/Wood Chip Interactions (1991)
- Austree Plantation (1992)
- Planting Operation (1993)

Preliminary Test Plantation (1990)

A 234-tree preliminary test plantation was established in 1990. The plantation species included Carolina poplar (*Populus canadensis 'Eugenei'*), green ash (*Fraxinus pennsylvanica*), white spruce (*Picea glauca*), and Austrian pine (*Pinus nigra*). Trees were planted in one five treatments (1- Control/Grassed, 2- 5cm thick mulch, 3- mulch plus nitrogen, 4- tilled soil plus mulch, and 5- tilled soil plus mulch and nitrogen). The plantation sought to demonstrate general trends, and so the treatments were applied in five adjacent blocks each containing 6 individuals * 4 tree species (border row trees excluded).

The hardwoods surpassed the conifers both in survival and growth rate. The overall rankings of the species were poplar, green ash, Austrian pine, followed by white spruce. Due to the calcareous nature of the clay cap, it is not surprising that the hardwoods fared better than the conifers did. Carolina poplar responded well to the mulch and fertilizer treatments. Figure 2 shows actual height growth from 1990 to 1993. Table 1 compares the various wood chip mulch treatments to the control block growth over the past three year period.

Three of the six poplar trees in the control indicated complete mortality with no evidence of new sucker growth. No other treatment block suffered mortality, but die-back was encountered in the blocks that were nitrogen loaded in 1990 and 1991 (i.e. blocks 3 and 5). The application rate of the nitrogen (urea), was excessive (600 kg/ha of elemental nitrogen), so die-back is most likely a direct result of this.

In general, the plantation demonstrated that the urban waste wood improved the physical growing condition for trees. Although, the plantation was small and not of the random block type, it effectively demonstrated that trees achieve better growth rates, and are less susceptible to mortality with the application of the waste wood chips, compared with no mulch application at all.

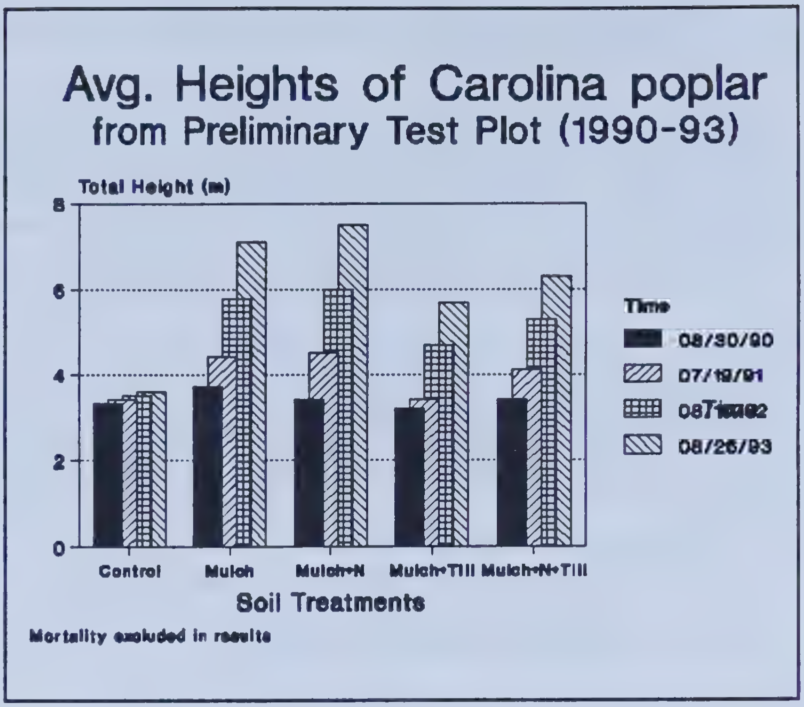


Figure 2

Table 1 Carolina polar Height Growth achieved after 3 years (Control vs. 4 Treatments)

TREATMENT	08/30/90 Ht.	Growth @ (1993)	Height Diff.	+/- (95% C.I.)
Grass/Control	3.3 m	0.3 m	-	-
Mulch	3.7 m	3.4 m	2.9	0.36
Mulch + N	3.4 m	4.1 m	3.8	0.20
Till Mulch	3.2 m	2.5 m	2.2	0.87
Till Mulch + N	3.4 m	2.9 m	2.6	0.15

All individuals encountering die-back and mortality excluded from analysis

Soil/Wood Chip Interactions (1991)

After a year and a half, with the wood chips occupying the landfill site at an average thickness of 20 cm, soil samples were taken and analyzed. Seven grass covered and six 20 cm mulch covered soil samples were tested. Statistical differences (at the 95% confidence level) were found for both manganese and iron. Both elements were found to be elevated.

Table 2 Manganese and Iron levels found on Mulch and Grass Covered Soil

TREATMENT	ELEMENT	ELEMENT LEVEL (ppm)	+/- (95% C.I.)
Grass Cover	Manganese	15.80	8.42
20cm Mulch	Manganese	87.20	29.27
Grass Cover	Iron	49.14	8.44
20cm Mulch	Iron	76.17	7.84

What is the source of these elements if the wood chips themselves possess very low levels of the elements? The factor responsible for these elevated level is due to the rather thick application of wood chips (up to 1 metre in some areas) at the site during this initial period. Wood chips do allow for aeration, but if the thickness is excessive, an oxygen poor environment will develop. In aerated soil, iron and manganese are found in the form of Fe^{3+} and Mn^{4+} (Glinski *et al.*, 1985). Further, Glinski *et al.*, (1985) states that with a lessening of the O_2 concentrations, Fe^{2+} and Mn^{2+} are increased in concentration, and tend to precipitate to the surface. This can be avoided keeping the pure wood chip cover less than 20 cm. If the chips are incorporated into the clay, tree roots can then utilize this medium which is found closer to the surface (see also Planting Operation (1993) and Discussion sections), and thus take advantage of a much improved soil oxygen content.

Austree Plantation (1992)

In June of 1992, a one hectare plot was ploughed and subsequently planted with 1000 Austrees (*Salix alba x matsuda*). The site was then covered with 15 cm of wood chips. On June 21, 1993, a top dressing of various fertilizer treatments were applied. After one month, the following results were produced.

Table 3 Austree Plantation Fertilizer Trial after 1 Month Growth

TREATMENT	No. Samples	Mean Growth	S.D.of Growth	+/- (95% C.I.)
Mulch Only	27	42.85	20.64	8.18
Mulch + 1N	26	63.58	28.29	11.43
Mulch + 2N	29	54.86	16.72	6.37
Mulch + 2N+PK	30	58.83	20.63	7.68

Note: 1N = 100kg of elemental nitrogen per hectare

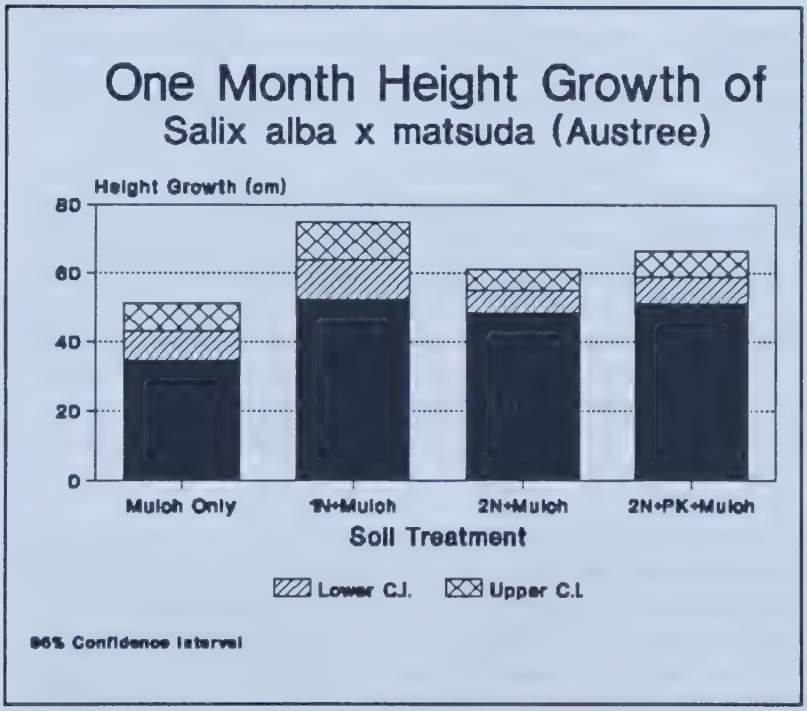


Figure 3

Even after only one month, statistical differences are becoming evident. With wood chips, nitrogen becomes tied up. Examining Table 1 and Table 3, the results indicates that mulch improves the growing medium for tree growth on its own, but with the further addition of nitrogen, at an appropriate level, tree growth is improved by almost 50%.

Planting Operation (1993)

In late April of 1993, a total of 15500 seedlings were planted, 9000 of which were planted in plantations. Site preparation for the landfill included the following: chip grading to a 15 cm thickness; ploughing the chips into the clay soil in October of 1993; and a second ploughing operation in mid-April of 1993. Of the tree species available from, and donated by, the MNR Midhurst Nursery, Carolina poplar (*Populus canadensis 'Eugenei'*), black locust (*Robina pseudoacacia*), and Norway spruce (*Picea abies*), fared the best. Red pine (*Pinus rubra*) and white spruce (*Picea glauca*) are currently suffering, and white cedar (*Thuja occidentalis*) are declining in the exposed areas.

Little analysis, so far, has been done on these newly planted seedlings. Some general comments can be made though. On one black locust plantation half the trees were planted on the mulch preparation medium, while the other half were planted in the grassed medium. After two months since being planted, leaf flushing was shown to be about 95% on the mulch medium compared to a 30% activity rate within the grassed area.

Two healthy Norway spruce individuals were removed, representing both three months growth in grass and three months growth in the ploughed clay/wood chip medium. Nutrient analysis of the plant tissue is currently being processed. Physical inspection of the two individuals indicated the following about the mulch effects on seedling development:

◦ Needle Production - more extensive ◦ Needle Length - shorter
◦ Needle Colour - lighter green ◦ Root Expansion - more extensive

The results indicate classic nitrogen deficiency symptoms, but they also indicate good drainage, aeration, moisture level, weed suppression, and other positive physical characteristics. Therefore, future site preparation, should include the dispersement of nitrogen.

Discussion

Clay caps of landfill sites are rather poor environments for tree establishment to begin with. The cap is usually a hard clay, designed to restrict water penetration into the underlying garbage. Any root systems of planted trees on such clay caps will have severely impeded root development. This is because the medium is very compact in nature and lacks good soil aeration and drainage.

Landfill sites exude a multitude of gases from below, with the largest fraction being methane and carbon dioxide. Physically, methane would displace most of the atmospheric oxygen found in the root zone. Since methane is a non-polar molecule, chemical effects on plant growth are negligible due to it being relatively nonreactive.

The first major step in the rehabilitation process is to promote oxygen penetration into the root zone of the clay. Further, weed competition should be checked with mulch, but at a thickness where it does not hamper oxygen infiltration. Therefore, it would be advantageous to have wood chips spread on top of the clay cap and subsequently ploughed into the clay. This would create paths for oxygen absorbtion, and as well, help inhibit the establishment of weeds.

Obviously, decomposing wood will demand an amount of nitrogen. Bergman *et al.* (1974) found that most deterioration of wood chips occur in the first three months of storage. It is therefore suggested that the wood chips be allowed to decompose for one or two years before any planting operation is initiated. The chips could be stored at the site in question, or at an aging yard. Another option is to compost the chips through the addition of a nitrogen source (eg. chicken manure, fertilizers). However, if weed control is the key issue, then it would be better to forego the addition of any nitrogen until just before the tree planting operation.

Observations so far indicate that leachate production has not increased since the wood chips placement. It was speculated that the chips, with their affinity for moisture, would promote water infiltration into the cap (since any captured water would be released at a slower rate compared to the sole compacted clay cover which would direct any precipitation rapidly off the locale).

Further study regarding mulches effects on leachate production will persist. It is felt that increased water and oxygen infiltration will help rehabilitate the site. Radnoff (1992) asserts that by restricting the infiltration of water into the landfill, biodegradation of organic materials in the refuse will be inhibited due to lack of moisture. Further soluble compounds that leach out of the wastes will do so at a much slower rate but at a higher concentration. Radnoff (1992) maintains that for long-term leachate management, it is better to increase water infiltration to enhance biodegradation of the organic component of the wastes while flushing out soluble contaminants. Contaminants will be leached out of the refuse at an earlier stage in the lifespan of the landfill and can be dealt with by treatment or other measures. This will ensure that the majority of the leachate is produced while the engineering systems are still functioning (Radnoff, 1992).

Reports have been written by Morley (1984), Ehrenfeld (1987) and Cureton et.al. (1991) that show that trees can be used to remove excess nitrogen from household effluent, industrial effluent, and landfill leachate. Morley (1984) found that effluent increased poplar tree growth by 120% in comparison to the control. Leachate recirculation trials will be addressed when plantation trees have reached free to grow status.

Conclusions

The major concerns of a closed landfill site are the production and release of leachate and greenhouse gases. Other concerns include the erosion of the cap, long terms of costly surveillance and continued maintenance, and also the inability to amend the idle locale.

The conclusions that can be drawn from the presented results and others not mentioned here are the following:

Waste Wood Chips:
◦ improve survivability and growth of seedlings ◦ retain soil moisture, allows for better root growth ◦ reduces rodent damage, (exposed to potential predators) ◦ reduces weed competition ◦ adds organic matter, decomposes in a few years ◦ creates better soil structure (drainage, aeration) ◦ protects against soil erosion ◦ removes the need for herbicides ◦ diverts waste wood from landfill solid waste stream ◦ improves soil microbial population ◦ acts as a temperature buffer ◦ produce tannin, a by-product of wood decomposition, which has an affinity for heavy metals in landfill leachate ◦ Tie-up of some soil nitrogen

It is suggested that creating a pasture or golf course can only be, at best, a band-aid solution. Real steps must be taken to redirect present waste streams and accelerate existing landfills amelioration, or we shall remain stewards of not only our garbage but our parents garbage for all time. Improving the soil structure, and tree growth medium, in general, is a step in the right direction.

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