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>PHYTOREMEDIATION

mark holloway STUDIO 2
the university of sheffield 2003 / 2004

CONTAMINATION PROBLEM>

The parkway area currently is characterised by derelict and disused land. Potentially this land presents an opportunity for development and regeneration. Unfortunately, as a result of the areas industrial past, many of the sites are contaminated with heavy metals, petrochemicals, hydrocarbons and other harmful toxic pollutants. The decline and modernisation of the coal and steel industries respectively has proved economically and environmentally unsustainable leaving both contamination and unemployment.

The level of contamination presents a barrier to development in the area. Decontamination is very expensive (up to £80,00 per hectare) thus making speculative development unattractive. Legally the individual or firm responsible for causing the contamination should pay for decontamination however in reality this proves unrealistic (many of the companies now cease to exist and contamination spreads between sites).

One solution adopted by the neighbouring Lower Don Valley development company was to place the sites in autonomous control, decontaminate on a large scale and then sell the land to developers, this had the advantage of ensuring mass redevelopment with all sites becoming available together. The result has been mixed however with rather low quality industrial developmetns arising and a loss of much of the industrial heritage of the area.

Traditional decontamination processes are very expensive and tend not to be sustainable solutions. There are several basic approaches:
BURYING AND ENCAPSULATING
This involves major site works to create an underground store for the contaminated soil, the contamination remains but is encased in concrete or earth to prevent movement.
BURNING OR INCINERATION
This involves removing the contaminated soil to an incineration site and burning the earth. The contamination is therefore removed from the site however the burning process is energy intensive and may release toxins into the atmosphere. New soil may also have to be transported to the site with an associated high embodied energy.
LANDFILL
This involves removing the soil from the site and burying it elsewhere, once again the contaminants remain but are displaced and new soil may be required to replace that taken away.

An alternative and more sustainable solution may be found in phytoremediation. This process involves the use of plants to absorb and neutralise the contaminants in the soil through natural processes. The technique is experimental so its use would need to be applied and evaluated as a long term process. The biggest disadvantage of the process is the time required, several growing seasons at a minimum. The main advantage however is that the plants deal with the contamination at source in an environmentally sound manner. Effectively they clean the land naturally.

PARKWAY DECONTAMINATION STRATEGY>

- slag heap/landfill contamination
- high level contamination
- medium level contamination
- low level contamination
- railway contaminated land
- area being commercially treated

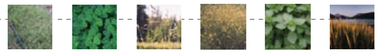
mapping showing probable contamination levels on available development sites, ascertaining the specific nature and extent of contamination would require site inspection and testing.

The parkway area currently has no administrative policy towards decontamination of the derelict land. Responsibility and initiatives rest with existing land owners and developers. The orgreve open cast mine for example is currently undergoing a process of encapsulation and compaction in order to make it ready for large scale commercial and residential development. The lack of any strategy presents an opportunity for the phytoremediation process to be tested. There is very little development pressure evident in the area so the long time scale of the process may not be an issue. Putting the process in place is likely to generate short term employment opportunities for low skilled workers helping to address the areas high unemployment. In the long term the decontaminated land is more likely to be developed thus creating jobs and industry in the area.

PHYTOREMEDIATION PROCESS>

PIONEER

Contaminated soil may initially be too toxic for many remediation plants to establish themselves. It is therefore necessary to begin the process with pioneering plants which can tolerate the soil conditions and begin to reduce the soil contamination.



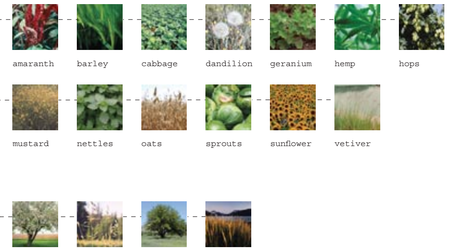
bermuda clover fescue mustard nettles rye

REMEDIATION

Once the land has been prepared for planting a wider variety of remediation plants may be grown to deal with the contamination. Various different processes occur within the plants to deal with the contaminants, and specific plants must be selected to appropriately deal with the various types of contamination.

PHYTO-ACCUMULATION

plants which absorb contaminants and hold them within their roots, leaves and stem. When harvested the materials are disposed of, thus removing the contamination from the site. Some materials (such as metals) may even be extracted through smelting or chemical processes.



amaranth barley cabbage dandilion geranium hemp hops
mustard nettles oats sprouts sunflower vetiver

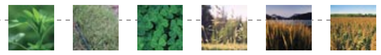
MICRO-ORGANISM STIMULATION

plants which encourage bacteria or fungi to grow around their root zone, these micro-organisms then act upon the contaminants breaking them down into harmless compounds.

appletree fescue mulberry rye

DEGRADATION

Plants which absorb contaminants and hold them within their roots, leaves and stem. Natural processes within the plant break down the contaminants rendering them non-toxic.



alfalfa bermuda clover fescue rye sorghum

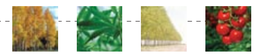
VOLITISATION

Plants which absorb contaminants in the water they absorb through their roots. Contaminants are transported to the leaves and released into the atmosphere through transpiration as a reduced or detoxified vapour.

alfalfa aspen clover fescue rye sorghum willow

STABILISATION

Finally plants are introduced which restore structure to soil helping to reintroduce nutrient sources and natural soil balance. These plants may be put in place as long term vegetation or used temporarily before redevelopment of the land occurs.



aspen hemp poplar tomato

FUNDING AND ECONOMICS>

Despite the relative inexpense of the phytoremediation process compared to traditional decontamination processes (less than 10% of the cost) it is only likely to be adopted by developers if it is sponsored or funded by an external body. The long time scales involved make it a commercial risk so alternative funding may be required.
Two potential sources might be utilised. Firstly conventional funding options might be pursued. The Landfill tax credit scheme for example specifically funds environmentally sustainable solutions, this could be matched by European development funding to cover most of the seed and labour costs.
A second potential source of funding might be found if the process was set up as a research project. Phytoremediation is currently at an experimental stage and university departments studying biology, ecology, plant science, genetics, etc... could all become involved. This would have the duel benefit of generating funding as well as bringing in specialist expertise to the project.

Further incentive to pursue a phytoremediation strategy may be found if revenue can be generated from the plants which are grown.
Unfortunately food production is not viable due to the danger of contaminants entering the food chain (Note: there is some concern about insects eating the plants and contaminants entering the food chain, however research suggests plants containing contaminants are avoided by most creatures). There are however many non-food alternatives. Sunflowers and geraniums, for example, could be grown as flowers and sold to florists. Another option would be harvesting the crops for energy in a biomass gassification plant - a carbon neutral system whereby the CO2 released burning the material equals that absorbed whilst it grew (Note: as a sustainable solution a separate long-term biomass supply would need to be found to justify the initial investment for when the decontamination process, and therefore biomass supply, finished). Finally trees might be grown and coppiced for timber or hemp harvested for its fibre which may be used for building material, textiles and paper.

BIODIVERSITY>

One further consideration in the decontamination process is the value of the current land in non-commercial terms. Brownfield land may be seen as wasted development land or alternatively as highly valuable ecological land in terms of biodiversity and plant / animal habitats. The nature of contaminated land often means that rare species flourish where they would usually lose out to competitive species. As a result a sustainable strategy should attempt to ensure at least some land remains to preserve this ecosystem. Ecological footprint analysis suggests that 10% is an appropriate figure to maintain current global biodivesity levels.

>HEMP YIELD POTENTIAL

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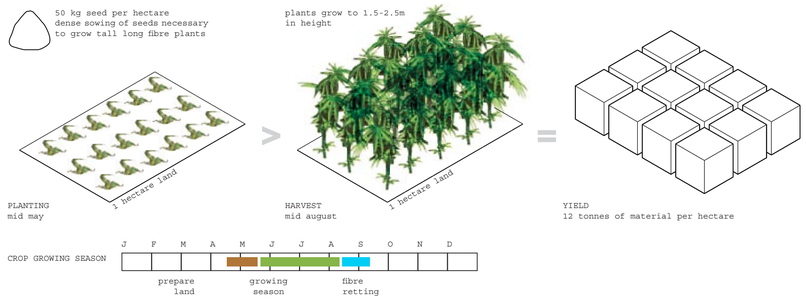
HEMP>

Hemp s a highly versitle crop which may be used in the phytoremediation process. The plants are not affected by pests so no pesticides are required, and they grow extremely fast smoothering any competing weeds. In addition to the employment generated during the remediation process the hemp may also be harvested and used to generate new long term industries. The fibre yielded may be used for textiles, paper or as a low embodied energy building material and therefore employment opportunities can be created in the production, processing and manufacture of hemp based products such as housing, clothing and paper.
The spin-off industries created should become economically sustainable helping to regenerate the wider area. Hemp branded products may command a premium using eco-friendly marketing to inflate their value and therefore ensure a postion in the marketplace.

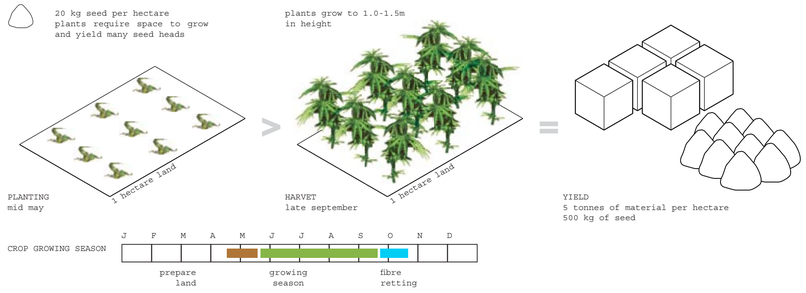
PLANT STRUCTURE>

cross section through hemp stalk, diameters range from 10-50mm

FIBRE PRODUCTION>



SEED PRODUCTION>



PROCESS>

RETTING
When harvested hemp needs to be dew retted to help seperate the fibres. This is done by lying the stalks parallel in the field for a period of 20 days.

STACKING
The stalks need to be turned every 4-5 days. Once retting is complete the process is stopped by stacking the stalks upright to allow them to dry.

DRYING
The hemp stalks must be dried for a several days in the field and then transported to a processing plant. The stalks are bundled to aid transportation.

FIBRE SEPERATION
Fibre types must be seperated at the plant. This is done by breaking the stems, scutching fibres appart followed by hackling or combing fibres into sliver for spinning.

STORAGE
Hemp is a bulky crop, so transportation is inefficient and storage needs to be local to growing and processing sites. The hemp needs to be stored in a dry place away from vermin.

CROP YIELDS>

ROTATIONS>

In order that a sustainable supply of seeds may be acheved 10% of a hemp cultivation should be devoted to seed growing. This ensures that enough seeds will be produced to replant in the following year.
Hemp takes minimal nutrients out of the soil but like most crops it benefits from a rotation system rather than monoculture cultivation. A rotation is required at least once in every five growing seasons. This may be achieved through a periodic total change of crop [system 1] or through a constant proportional rotation [system 2].