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Using steel rods to assess aeration in urban soils

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Summary

Diagnosing the reasons for poor performance of urban trees must include evaluation of soil physical conditions. Soil aeration status can be inferred from the corrosion of steel rods inserted into the ground. The technique is inexpensive, non-destructive and can provide information on the vertical distribution of anaerobic conditions. Practical aspects of the use of steel rods and their interpretation are described.

Introduction

1. Diagnosing the reasons fro poor performance of urban trees must include evaluation of soil physical conditions; sometimes below tarmac or paving. The assessment of soil aeration is notoriously difficult. The conventional methods using an oxygen probe or platinum micro-cathodes each have shortcomings particularly in the urban environment which is characterized by compacted, stony and variable soils; hard pavings; and the risk of interference.

2. In most circumstances, oxygen availability has the greatest effect on the corrosion of mild steel (Hudson & Watkins 1968). Using this fact, Forestry Commission researchers developed a technique using steel rods for the prediction of rooting depth o upland souls (Carnell & Anderson 1986). By recording the pattern of corrosion on mild steel rods the depth of aerated soil and hence the likely depth of tree rooting can be predicted. Department of the Environment funded research using steel rods to evaluate urban soils began in 1982 (Colderick & Hodge 1991). Because of the vertical variability of urban soils a more detailed form of assessment and analysis that adopted for forest soils had to be devised, and tools developed for insertion of rods and their extraction in the urban environment.

Using steel rods

3. A detailed description of the procedure for the use of steel rods is found in Hodge & Knott (in press). The rods used are 60 cm long, 6 mm diameter and made of bright mild steel (EN1A non –leaded, low sulphur content). One end must be pointed, and the other a groove machined to 1mm depth around the rod to aid extraction. Rods are inserted for 3 months and the amount of information obtained is enhanced if two sets of rods are inserted, corresponding to spring and summer. The number of rods inserted into the rooting zone of each tree depends on tree size, site variability and the number of trees in the group being studied. Investigating the soil around a single large urban tree may require 10 rods, whilst determining the reason for poor performance of a newly planted avenue on a homogenous soil may require only one rod per tree.

4. The equipment required for inserting and extracting steel rods is listed in appendix 1 and a guide for safe working is detailed in appendix 2.

5. Rods must be wiped clean of any protective anti-corrosion oil directly before insertion, then driven vertically into the ground. A tool (figure 1) has been developed to prevent vibration of the rod during insertion, thus ensuring good contact with the soil along its length. Rods can be driven through thin layers

of tarmac and hardcore. However, to insert rods through more substantial surfaces, holes must be pre-drilled, with a 6.5mm bit, to the depth of the surface material.

6. The location of each rod must be mapped as public assess to most sites means that rods cannot be flagged. Two tools have been developed to extract rods. The first (Figure 2) levers the rod out of the ground far enough to attach the extraction jack (Figure 3), or locking pliers for rods that are easy to extract. Rod extraction is a very physical job but it must be undertaken with care to ensure that the patterns of corrosion are not damaged.

7. After extraction the rod should be immediately swabbed with a fabric cloth soaked in a 10% v/v solution of ammonia to remove sol and stop further rusting. Te cleaning action must be one of squeezing rather than rubbing. Secondary rusting starts very quickly after extraction so only a few rods should be extracted at a time before swabbing. If possible, rods should not be extracted during wet weather. Once swabbed, each rod should be labelled and kept in a dry atmosphere.

8. If a further series of rods is being inserted their location must be 10 cm away from the hole of the previous rod to ensure good contact with previously undisturbed soil.

Interpretation of rusting patterns

9. Carnell and Anderson (1986) identified five types of surfaces that may be encountered on steel rods extracted from the soil. Interpretation of corrosion types, which was clarified in a laboratory study (Hodge *et al* in press) is:

Red/brown rust: indicates a well aerated soil (plate 1)

Raised black: Occurs where rusting has started but has been interrupted, or where rust has been knocked off during removal of the rod from the ground (plate 2).

Shiny metal: Can indicate the presence of substances (usually polyphenols or oil products) which have protected the rods from rusting. These can arise from organic residues that are under anaerobic conditions. However, in laboratory tests substantial amounts of shiny metal remained after three months in soils with no organic horizon. Its presence seemed to be associated with dry conditions but the precise interpretation is still not known (plate 3).

Smooth black: Occurs where anaerobic bacteria utilize soil sulphates producing hydrogen sulphide, which reacts with the surface of the metal (plate 4).

Matt grey: Indicates total anaerobic conditions (plate 5).

Assessment and presentation of rusting patterns

10. Rods from relatively undisturbed soils can be assessed by determination of the maximum depth of substantial red/brown rust and raised black (indicating conditions conducive to root growth) or the depth of onset of substantial matt grey and smooth black (indicating conditions that are hostile to root growth). However, on disturbed sites such zones may not be readily discernible.

11. For more detailed assessment the rod is laid along a mere rule wit the ground level at 0cm. the assessment made is of two categories; matt grey and smooth black combined, and shiny metal. Te presence of the two categories in patches of more than 0.5cm along a line down the rod is recorded for each 15cm section of the rod. When corrosion down the first line as been recorded, the rod is turned through 180^{o} and the process repeated.

12. The data must then be translated into a numerical score of 0 to 60 (30 c 0.5cm on each side of the rod) for each toed quarter. Initially scores for matt grey/smooth black and shiny metal can be combined to form a score for inhospitable soil conditions. However, if results prove inconclusive, or the presence of shiny metal is substantial, the scores for matt grey/smooth black alone can be used for a reconsideration of the profiles.

13. Generally of most value for practitioners will be a graphical representation of the presence of anaerobic conditions. The comparison of the rusting profiles between seasons has proved particularly useful and figure 4 shows the mean rod profile assessed at 3cm intervals over three seasons for a paved and a gravel

area. The profiles from the paved area show seasonal waterlogging, while those from the gravel area indicate the presence of a compacted layer between 15 and 30 cm. Methods of processing data for statistical analysis have also been developed (Hodge *et al* in press).

Conclusions

14. The steel rod technique is a practical and relatively inexpensive way of assessing the aeration status of urban soils. The technique can be used to examine the distribution of anaerobic conditions down through the soil. Comparison of rod information between seasons can shoe clearly whether anaerobic conditions are due to waterlogging or compaction. The technique can be used to assess aeration under hard surfaces without disturbing the site.

15. Detection of the cause of decline of mature urban trees, or slow growth of young trees, is notoriously difficult. The steel rod technique can provide information on soil conditions that allows precise targeting of remedial treatments. The ability to depict visually the condition of soil that cannot otherwise be observed is a compelling advantage of this technique.

Acknowledgements

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Appendix 1: Equipment for the insertion and extraction of steel rods

For insertion:

Steel rods;

Paper towels (for removing anti-corrosion oil coating from rods);

Insertion tool (figure 1);

Insulated rubber gloves (high voltage specification) (to be worn during the insertion process);

Rubber mat (to stand on during the insertion process for additional insulation);

Cable avoidance tool (CAT) and relevant plans of underground services.

For extraction:
Spade (to find rod tops in soil or turf)

Initial levering tool (figure 2);

Blocks (for increasing fulcrum height of levering tool);

Locking pliers (for rapid extraction of easy to remove rods);

Extraction jack (figure 3.);

Bucket (to hold swabbing solution);

Cloths (for swabbing);

Plastic bags (to hold cloths);

10 v/v ammonia solution (for swabbing);

Quiver and latticed frame (to transport rods);

Labels and indelible pens (for labelling rods);

Protective goggles, rubber boots, rubber gloves and waterproof coverall;

Clean water and eyebath.

Appendix 2: a guide for safe working with steel rods in urban areas

Before starting to insert rods:

i) Obtain a copy of HS(G)47 “Avoiding danger from underground services” (Health and Safety Executive Guidance Note available from HMSO priced £2.25), and the National Joint Utilities Group advice card “Avoidance of danger from underground electricity cables” (from NJUG 30 Millbank, London, SW1P 4RD free of charge).

ii) Obtain maps of underground services (e.g. Electricity, telephone, gas, cable television, water, and sewerage) in the area of work.

iii) Use a cable avoidance tool (CAT) to locate and confirm the position of electricity cables on the site.

iv) Confirm the position of other services on the site.

v) Have contact telephone numbers for underground service companies at hand.

vi) If there are any doubts as to the precise location of underground services, do not proceed.

When inserting rods:

vii) Work in pairs

viii) Keep the public away from the area of work

ix) Wear rubber boots and high voltage specification rubber gloves (4000 volts (working), conforming to BS 697:1986)

x) Stand on a rubber car mat.

xi) Insert rods using the rod insertion tool.

xii) Ensure that the ends of inserted rods, if left protruding, are not a hazard to the public.

When extracting rods:

In addition to vii and to x above

xiii) When using ammonia solution to swab extracted rods wear protective goggles, boots, rubber gloves and waterproof coverall.

xiv) Splashes of ammonia solution on the skin and clothing should be swabbed with clean water.

xv) Carry an eyebath and bottle of eye wash in case of ammonia solution splashing into the eyes.