SOIL STERILIZATION WITH SPECIAL REFERENCE TO
USE OF BORATE HERBICIDES

by

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SUMMARY

Subsoil sterilization is an accepted practice to protect bituminous and similar sealed surfaces from damage by weeds.

Non selective herbicides are essential and the various materials available are considered briefly. Many contractors prefer borate herbicides for sealing footpaths, home driveways, parking areas, airfield runways, irrigation ditches, and catchment areas.

Inorganic herbicides do not "break down" in the soil. Correctly used they can protect the surfacing indefinitely - as long as it remains intact - by destroying not only the existing weeds but subsequently germinating seeds as well. Some important weed problems likely to be encountered when sealing are mentioned.

Essential considerations are the preparation of subsoil and the correct application of the selected herbicide.

1. INTRODUCTION:

The sterilization of the subsoil is an accepted practice to protect bituminous and similar surfaces from weed damage. It is this weed damage to unprotected surfaces that has often caused alternative materials to be considered after expensive paving has been destroyed.

For many years arsenical compounds including arsenite of soda and arsenic pentoxide were used. While they are effective for weed control, the hazards associated with all forms of arsenic have caused them to fall into disfavour, and in the United Kingdom they will shortly be discontinued altogether for weed work.
Arsenic pentoxide acts similarly to arsenite of soda but is somewhat faster in its action. The resulting soil sterility from arsenic pentoxide varies greatly with the soil. Where the iron content is fairly high, as often occurs with red soils, the arsenic is "fixed" rapidly and has no further effect on plant life.

Sodium Chlorate can be used for dry application as a soil sterilizer, but due to the extreme fire hazards associated with sodium chlorate, it is usually formulated with calcium chloride. The latter being hygroscopic, lessens the fire danger under suitable climatic conditions. Whilst sodium chlorate is generally a non selective weed killer, at low rates it can act selectively in that Paspalum may be killed, but with Couch recovering.

For soil sterilization the usual applications of sodium chlorate is about \( \frac{1}{2} \) lb per square yard. If sodium chlorate, calcium chloride formulations are used, rates should be adjusted on the chlorate content.

Coarse salt is one of the oldest weed killers but it is not used very much today. At 5 lb per square yard it causes soil sterilization but this high volume under bitumen may have adverse effects on the sealing.

Substituted ureas such as C.M.U. are now well known for their herbicidal activity. Their persistence in the soil is limited by the action of soil microorganisms. (3) A sodium borate substituted urea combination "Ureabor" is formulated to minimise the action of soil bacteria on the organic C.M.U. Under conditions where leaching is slow and micro biological activity high, the borate-substituted urea formulation shows great persistence in the soil. This period herbicidal activity is greater than equivalent rates of straight C.M.U. or borates. Under tropical conditions with concentrated rain fall in the summer, this formulation has not, as yet, been extensively tested. It may be that the borates will leach down fairly rapidly leaving the substituted urea to decompose at the normal rate.

Under a sealed surface the leaching would not be expected to occur and "Ureabor" should then show long term activity as the break down of the C.M.U. would be largely prevented. "Ureabor" containing \( \frac{4}{5} \) C.M.U. and \( 9 \frac{1}{2} \) % sodium borates is supplied as an even mesh granular material for dry application at rates of \( \frac{1}{2} \) - 2 lbs per 100 square feet.

Paspalum dilatatum shows some tolerance to 2 lbs and 2\( \frac{1}{2} \) - 3 lbs are needed to get control of this grass over 12 months on unsealed soil. Skeleton Weed shows some resistance also
possibly due to the ability of this weed to make regrowth from its deep roots.

Ammonium sulphamate is capable of killing annual weeds and scrub but is relatively ineffective on perennials and has no lasting effect on the soil.

2. BORATE HERBICIDES:

During the last five years, over 150 million square feet of bituminous type surfacings have been protected by a prior application of either sodium borates, e.g. Concentrated "Borascu" or borate chlorates, e.g. "Polybor" Chlorate. It is expected that this usage of subsoil sterilants will increase as more and more local Government authorities, architects, engineers etc. specify a weed free subsoil before paving. New applications in industry and agriculture are being found where sealed surfaces, usually of a bituminous or asphaltic type can provide great benefits. Amongst these new developments are the sealing of catchment areas to provide better rainfall run off, and lining of irrigation ditches and drains.

Whenever a surfacing is laid on the soil, whether it be such as above or footpaths, playing and parking areas, home driveways, or airfield runways, it is considered cheap insurance to safeguard the sealing against future destruction by weeds and grasses.

3. MATERIALS:

Subsoil sterilization under a sealed surface makes it almost essential for inorganic herbicides to be used. Organic chemicals are subject to attack from soil microorganisms, which accelerate their decomposition into relatively ineffective materials. The sealing of the surface provides ideal conditions for early microbiological activity as soil moisture, temperature and other limiting factors are regulated. Again these static conditions provide good growing conditions for the regeneration of weeds from roots or rhizomes which may be left in the soil. Weed seeds may find suitable conditions for germination either immediately after the sealing process is completed or at some subsequent time. The correct use of an inorganic herbicide means that the chemical can destroy growth as and when germination or root development occurs. Its herbicide efficiency is in no way limited by the time factor. Sodium borate with the boron trioxide ($B_2O_3$) content being sufficiently high ("Borascu" 63% $B_2O_3$) is used for long lasting results. Borate chlorates of the "Polybor" Chlorate type are equally effective. In case of borate chlorate with 49% $B_2O_3$ and 25% $NaClO_3$ the chlorate molecule is surrounded by the
boration molecule thus giving the effectiveness of both materials, without the dangers inherent in sodium chlorate.

4. METHODS:

Sodium borate "Borascu" is a crystalline material. Its colour permits visual observation assuring even distribution on the subsoil immediately to paving. It is usually spread by hand out of a bucket, but for larger areas, a fertilizer spreader is employed. Often the spreader is mounted on the back of a truck. The soluble borate chlorate is dissolved at 2lbs per gallon in the water normally used to wet down the finished grade. The importance of the water is detailed in Table 1., and the addition of $\frac{1}{2}$ " (or more) greatly increased the efficiency of all chemicals used in this trial.

5. RESULTS:

Effective results are dependant on technically correct applications. One of the most important aspects is getting the herbicide into the soil horizons where weeds and grasses have their feeding roots. Various weeds likely to be encountered need this consideration. A series of field trials were carried out by U.S. Borax Research Corporation in 1958/59 to determine the relative effectiveness of various herbicides in preventing the emergence of Cynodon dactylon through a thin asphalt coating. The trials were carried out on a uniformly dense stand of Couch grass with scattered annual broad leaved weeds on a silty clay soil. All top growth of the Couch was removed with a minimum of root disturbance and the soil consolidated by rolling as in commercial practice before the applications of herbicides on October 29th and 30th, 1958. Dry materials were applied by hand and spray materials with a knapsack sprayer using one gallon of water per 54 square feet plot.

Subsequently water was applied at two rates to leach the herbicides into the soil. A light asphalt surface was applied by commercial contractors on October 31st, 1958, hot asphalt being sprayed at the rate of 0.116 gallons per 10 square yards followed by 28.23 lbs of No. 4 crushed rock per square yard and subsequently rolling with power roller. Light surfacing provided a critical test for the herbicide used, compared with a typical hot asphalt mix of two or more inches in thickness which tends to inhibit the regeneration of some species of vegetative growth. While the principal investigation was concerned with Couch grass, it was noted that a few broad leaved weeds appeared on most plots receiving Dalapon or T.C.A., but not on the other plots. The relative effectiveness of the various herbicides and the influence of water on performance are indicated on the attached table. The list of common names or abbreviations used are approved by certain weed control councils or weed societies but are repeated, CBM ("Polybor" Chlorate) BMM ("Ureabor").
<table>
<thead>
<tr>
<th>Herbicide</th>
<th>1bs. per Acre</th>
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<th>1/2&quot; water applied</th>
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<tr>
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<td>1 1 0</td>
<td>0 0 0</td>
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<tr>
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<td>8 8 9</td>
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<td>Simazine</td>
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<td>8 9 8</td>
<td>8 8 8</td>
</tr>
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<td>17.4</td>
<td>6 6 7</td>
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<td>1 3 3/ 7</td>
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<td>-</td>
<td>8 8 7</td>
<td>5 8 6</td>
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x: stand ratings are 0 for no stand to 10 for solid stand.
1/ CBM ("Polybor" Chlorate) - disodium octaborate 73%, sodium chloride 25%
Concentrated "Borasou" - Anhydrous borax 94%
BMM ("Ureabor") - Disodium tetraborate pentahydrate 63.2%, disodium tetraborate decahydrate 30.8%, monuron 4%
Sodium borate - TCA complex-Boron trioxide equivalent 53%, trichloroacetic acid 15%

2/ Annual broad leafs present on each replicate. 3/ Annual broad leafs present on two replicates.
4/ Annual broad leafs present on two replicates. (on 1 replicate.
5/ Treatments with 3/16" water in duplicate; with 1/2" water are single plots.
6. OBSERVATIONS:

In the case of "Borascu", BMM, TCA, Monuron and Simazine, the chemical has little or no contact effect and death of the plant results from the roots taking up the chemical from the soil solution. The significance of ½" water as compared with 3/16" is interesting, but of course, refers primarily to Couch grass. TCA, Sodium borate, and other materials, CBM, and Sodium chlorate have both contact and root effect, whereas 236-TBA and Dalapon are looked upon as herbicides depending for their effectiveness on leaf absorption.

In the case of this trial, all top growth was removed prior to applying the herbicides and the results from the latter two materials do not appear to have been influenced greatly by the water application.

A consideration when determining the desirable amount of water to add to corrosive materials such as TCA or sodium chlorate is the possible adverse effects on underground pipes, cables, etc., if a sufficient concentration is used. Whilst sodium chlorate is capable of giving excellent total weed control it is generally used in a formulation with calcium chloride, when it is relatively safe from fires, but may be even more corrosive and capable of "shorting" electricity, or with borates. With the latter if used in adequate proportions the herbicidal efficiency of the sodium chlorate is increased, the fire and corrosive effects completely removed together with dangers from electrical cables.

This table gives the results of one series of trials on Couch grass, but other species or combinations are frequently encountered in Australia on areas which are to be sealed. It has not been possible, as yet, to carry out detailed work on all likely weeds, as occurred with Couch grass, and the observations made largely apply to borate based herbicides only.

7. CHONDRILLA JUNCEA (SKELETON WEED):

Many plots on Skeleton weed have been established in New South Wales, Victoria and to a lesser extent in South Australia and Queensland to determine the effectiveness of various herbicides including borates.

Typical results were those obtained from Gulgong, N.S.W., where various materials were applied on 20th August, 1958. The infestation could be described at 100% of ground cover and the soil a light brown loam. An inspection was made after thirteen months on 9th October 1959, during which period 23 inches of rain had been recorded. Sodium borate (Concentrated "Borascu") at 4 lbs per 100 sq.ft. resulted in 99% control. Higher rates
showed no material advantage. "DB" Granular a sodium borate, 24D complex applied in dry form at 2 lb per 100 sq.ft. resulted in 95% control, with 1 lb giving 90% results. Lower rates were ineffective but little advantage was observed by applying more than 2 lbs "Polybor" Chlorate at 2 lb/gal./100 square feet resulted in 90% control but even 4 lbs/100 sq. feet did not achieve total elimination of Skeleton Weed. The observations were that the control of patches of Skeleton Weed, particularly where sealed surfaces are to be laid as may well occur on watersheds and catchment areas, "Borascu" at 4 lbs per 100 square feet is capable of killing 3 - 4 year old plants and preventing regeneration from seedlings into the second growing season. "DB" Granular at 2 lbs gave no significant difference. "Polybor" Chlorate would be excellent when immediate destruction of the plant is required especially to prevent seeding and to provide a residual effect. Other chemicals, some even at massive rates were relatively ineffective and did not give such long term results.

8. HYPERICUM PERTOPATUM (ST. JOHN'S WORT):

Is a plant susceptible to low rates of borates and relatively resistant to hormone type chemicals in the Autumn and Winter. With a view to determining the most effective rates for patches of St. John's Wort (as distinct from broad acres) a series of trials were established at Mudgee on 21st May, 1958. On 9th October 1959, during which period 30 inches of rain-fall was recorded, the observations showed 99% control from 2 lbs "Borascu" per 100 sq.ft; "DB" Granular at ½ lb., gave 98% control, and "Polybor" Chlorate at ½ lb. gave similar results. Lower rates than as given, gave fair to good control for some months but by the end of a year some germination was observed. It is desired to point out these are not "soil sterility" rates. They are effective on St. John's Wort, but monocotyledons and some dicotyledons are comparatively unaffected.

9. CAPDARIA DPABA (HOARY CRESS):

This is a plant on which borates have given variable results. Apparently the soil type has a considerable influence and plots on alluvial flats may have permitted rapid leaching and partial or complete recovery of the weed. On other soils much better results have been achieved but as yet, in Australia, there is difficulty in giving an accurate recommendation.

10. CYPERUS ROTUNDUS (NUT GRASS):

Is a plant frequently seen destroying bituminous surfaces. Sometimes this is the result of disturbance to the soil in preparation for sealing and new plants growing from the
detached underground storage organs. Where the weed is growing on an area to be sealed, good results have been obtained from borate soil sterilants if the recommended procedure is followed. This involves the removal of top growth and surface soil prior to applying the metal. At the same time the dormancy of the deeper "nuts" is broken and their feeding roots then take up the excess boron in the soil.

11. PTERIDIUM AQUILINUM (BRACKEN):

Has been found to be susceptible to "Borascu" at 2-4 lbs per 10 square yards. "DB" Granular 1-2 lbs per 10 square yards. (2)

Again these rates were effective on a specific weed but if mixed vegetation is present as is likely before an area is sealed, "Borascu" at 5½ - 6 lbs or "Polybor" Chlorate at 4 lbs per 100 square feet are recommended.

12. DISCUSSION:

The preceding data gives results on specific weeds, but frequently sealed surfaces have to be laid on soil previously growing mixed annual and perennial monocotyledons and dicotyledons. Some propagate by seed, others by vegetative means and a non selective, residual acting inorganic herbicide is then essential. "Borascu" is not poisonous to stock and run off water into dams will not be affected. It is not flammable or corrosive and underground water pipes will be unaffected. It is capable of killing most, if not all, vegetation, and applications should not be made under the drip line of desirable trees or shrubs.

There have not been observed any cases where lateral run off in the soil of "Borascu" impregnated soil water has caused damage to crops; in the few cases where run off has occurred, application rates were high and rain fall excessive.

Except under sealed surfaces, the "Borascu" is eventually vertically leached out of the soil rather than laterally leached. There is not much evidence of borates being tied to clay colloids.

More knowledge is desirable on the physiology of plants, particularly as to where the soil, and the different species absorb by osmosis most of their nutrients.

13. REFERENCE:

(2) Edwards and Montgomery "Chemical Control of Bracken"
Pest Technology, February, 1959.