

ASBESTOS TAILINGS RECLAMATION

IN SOUTHERN AFRICA¹

by
JJP van Wyk²

Abstract. The Institute for Reclamation Ecology of the University of Potchefstroom in South Africa started with research on Asbestos tailings and waste materials in 1982. The major findings were: that the natural angles of repose of tailings and waste materials of Crocidolite, Amosite and Chrysotile were too steep for rehabilitation (reclamation) and should be flattened to 18-20°. That all fibre containing material should be covered with coarse (gravelly) shrouding material to a depth of 300 mm. That storm water should be prevented from running over the treated surfaces to prevent erosion by means of berms and perimeter walls and toe paddocks should be constructed on U S L E principals to reduce run off speed on slopes and contain rainwater falling on the treated areas on the dumps and in the adjacent toe paddocks. (U S L E = Universal Soil Loss Equation).

Revegetation should be in accordance with general climatic conditions, surrounding vegetation type, and land use. Species used should preferably be selected from the local area; and where grazing and access trampling can not be controlled, unpalatable, impenetrable, (preferably non burnable) species with no economic use should be selected to discourage the presence of humans and animals.

Chemical and physical amelioration of tailings is necessary for Chrysotile because of the high Magnesium content, other mineral imbalances and cementing of the surface. Normal fertilization is sufficient for Crocidolite and Amosite.

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Introduction

The objective of the rehabilitation programme is to eliminate the pollution sources and prevent fibre from becoming air born or distributed by water, humans and or animals, by the implementation of research results.

There are three major asbestos producing regions in Southern Africa i.e. The Northwestern Cape Province, Central Northern Transvaal and the Eastern Transvaal (figure 1).

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² Jacobus J P van Wyk (Prof.) Director Institute for Reclamation Ecology, Potchefstroom University, Potchefstroom, 2520, South Africa.

Due to vast differences in climatic conditions, topography, soils, vegetation and land use between the regions/localities, different strategies are employed in the different regions/localities as will be discussed in this paper.

Due to the high cost of earth works and large variation with regards to pollution potential amongst tailings and waste materials, the pollution potential of each fibre containing locality is assessed to determine priorities to decide on the chronological order to rehabilitate in the region/area.

Assessment of Pollution Potential on a score point basis

Localities, tailings and waste materials, are classified (ranked) according to their physical nature from high pollution potential to low pollution potential as 1. Millsites; 2. Cobbing dumps/sites; 3. Waste material with high fibre content; 4. Waste materials with low fibre content.

Secondary sources such as roads, loading/unloading spots, floodplains, agricultural lands (where asbestos was used as soil conditioner or simply dumped), dwellings (built or plastered with asbestos mud and/or cow dung without the use of cement) are also scored according to the circumstances.

Geographical and Topographical configuration

Tailings and other pollution potential localities are ranked with regards to their relative position inside, partially inside, very close to or distant from: 1. Big rivers or water courses; 2. Big tributaries and 3. Small tributaries.

Topographic position (average water speed and flood lines) is super imposed on the geographical position to place a "value" on the pollution potential.

Inherent erosion potential with regards to water, wind, trampling and subsiding (surface sliding)

Surface stability varies from place to place for a number of reasons. Factors such as fibre length, amount of coarse material on the surface, trampling, chemical reactions and cementation by especially Chrysotile, are evaluated for ranking purposes.

General Rainfall Conditions

Weather records are being studied to assess average, and maximum rainfall and excessive heavy downpours to determine flood frequency (200 year floodline) and current and past floodlines.

General wind conditions (direction and speed)

Exposure to wind and general prevailing wind directions is determined from weather station data, and polluted areas are classified and ranked based on their wind pollution potential.

Population Density

The population density and distribution of farms, villages, towns and cities is carefully mapped and scored in conjunction with wind conditions and pollution spreading by means of water (Geographic, Topographic configuration).

Ownership

Ownership is determined where the owner can be identified. Defunct mines and/or closed mines where there is no owner any more, becomes the responsibility of the Government.

Other factors

Various other factors are being assessed to finally round off the determination of priorities. They include such aspects as:

- Condition of access roads

- Accessibility to humans and animals
- Availability of shrouding material
- Availability of accommodation, water and other commodities
- Natural veld types, the condition thereof and land use.

Once all these conditions and/or factors and/or circumstances has been assessed, and ranked (scored) a final figure can be ascribed to each pollution locality indicating its priority for rehabilitation amongst its neighbours (figure 2).

After the chronological order of priorities has been determined, and the applicable strategy for the various priority localities been agreed on, surveys are carried out to determine existing profiles and calculate volumes to be moved (removed). At this point earth moving contractors are invited to tender, or are appointed on a price per volume basis, under the supervision of this Institute.

Establishment of vegetation

Successful establishment of vegetation has been achieved in all three major asbestos mining regions mentioned in figure 1.

Species selection and establishment techniques were all based on basic and applied research findings carried out for at least three years in greenhouses (on campus) and locally in field trials, before rehabilitation was started.

Research

The research entails the following:

Surveys and Species selection. Local botanical survey at each locality with a pollution potential (Mining site, tailings, waste rock, etc.)

Identification of suitable species to be used for rehabilitation. For various reasons, but especially to

prevent excessive trampling and over grazing, which would enhance future erosion, species with the following properties are selected for areas where grazing can not be controlled:

- No, or very low grazing potential (caustic)
- Fire resistant or quick recovery after fire
- Low growing and impenetrable (creepy and spiny)
- Adapted to grow on Asbestos tailings and waste materials containing fibre
- Drought resistant and self maintaining (no aftercare)
- Species with no economic importance to human beings such as wood or edible fruit.

In areas where grazing can be controlled, mainly local grasses and "new ecotypes" of *Eragrostis curvula*, suitable for the particular climatic conditions and growth medium are selected for grassland regions. Local shrubs and trees are also established in Savannah and Woodland areas.

Establishment trials from vegetative material/seedlings/adult plants. Once the suitable species have been identified, seed and other reproductive material are collected and grown in rootgrowth boxes with glass front panels in greenhouse experiments and on the tailings in the various regions.

Root development, phenology and vitality is carefully monitored for at least three consecutive seasons.

Shrouded Crocidolite and Amosite were found to be suitable to carry and maintain vegetation where as Chrysotile had to be chemically and physically ameliorated to establish an acceptable vegetation cover as is mentioned in the paper on Chrysotile reclamation.

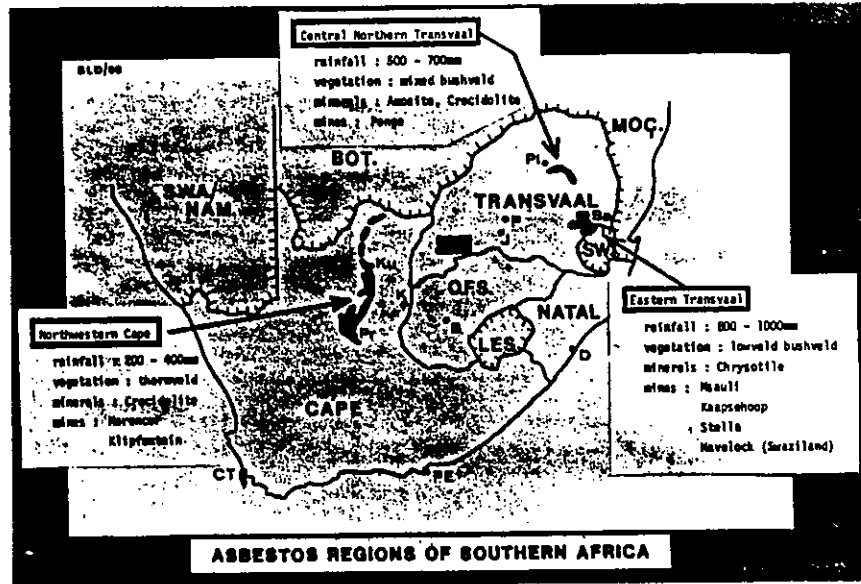


Figure 1.

Asbestos producing regions in South Africa and Swaziland. Crocidalite is mined in the Northwestern Cape, Amosite and Crocidalite in the Central Northern Transvaal and Chrysotile in the Eastern Transvaal and Swaziland.



Figure 2.

A Chrysotile polluted valley in the Eastern Transvaal. The tailings in the centre foreground are filled in over the banks of a large tributary of the Komati (a major) river. The big distant dump is on the banks of the Kamati river, but fortunately above the flood line.

Chemical analyses of the tailings of Chrysotile indicated imbalances of heavy metals and very high Magnesium contents of up to 2 000 ppm.

This led to a number of chrysotile tailings amelioration experiments as is discussed in the Chrysotile paper.

Establishment trails from seed and cuttings. The majority of species selected for asbestos tailings (and waste) rehabilitation has not been cultivated before. Therefore an investigation was concurrently undertaken with establishment trails from seed and cuttings to determine the intricacies of establishment of the selected species from seed and/or cuttings.

Field trials

Field trials are normally started during the second season and are based on the results of the greenhouse experiments of the first season.

They include the establishment of the selected species from transplants from the local vicinity, establishment by means of seedlings and/or cuttings and establishment from seed.

Micro habitat climate manipulation such as the placing of rocks around the seeding points, shading of seeding points, creating depressions at seeding points, etc. forms part of the exercise.

Species performance in pure and mixed stands is also carefully monitored during various stages of development and through consecutive seasons.

Implementation of revegetation

Once the research has reached the point that the results can be implemented, and enough vegetative material, seed or cuttings are on hand, surfaces where the earth works has

been completed are revegetated with suitable species for the particular environmental configuration.

Implementation strategies (a few representative examples)

The case studies represent rehabilitation procedures, carried out initially with limited funding in the early stages to adequate funding, currently.

Malips river, Central Northern Transvaal

In this case the tailings could not be removed from the river bed as the continuous dumping over approximately 30 years caused the river to gradually widen to the opposite side of the fill - thus changing its course. The tailings currently does not interfere with the current flow as the new channel has widened and deepened to allow two meter high by 60 meter wide floods before reaching the base of the tailings (figure 3).

There was also no suitable place to dump the tailings, when removed from the original part of the riverbed, and also no suitable shrouding material in the vicinity.

As all the dwellings and gardens of the mining town were earlier demolished, (to prevent people from living amongst un rehabilitated dumps) stone for cladding was in abundance available.

It was therefore decided to flatten the river facing slope to 18 - 20°, construct a foundation two meters wide, starting down on bedrock and building it up to 2 - 3 metres above the river bed.

The flattened tailings was shaped level with the top of the foundation wall, stone cladded (stone pitched) and sealed with a cement-sand mixture.

A perimeter wall was constructed at the top end of the stone pitched area to allow water from the rest of the dump to run into the river after being filtered through specially constructed stone filter walls.

Storm water from the adjacent mountain was channeled sideways before reaching the tailings.

Rabe's Kloof Large Tributary (Central Northern Transvaal)

In this case the tailings were dumped inside and on one bank of the large tributary of the Malips river over a distance of roughly one kilometer. The height of the tailings varied from 20 to 70 metres (figure 4).

The side on which the tailings were dumped was generally wide enough to allow for the removal of all the tailings from the bed and "contaminated" bank and mountainside and also to leave "clean" space of 20 metres for the construction of the toe dams, adjacent to the stream. The rest of the tailings was flattened to 18 - 20° except for one locality where mill tailings and waste rock were mixed. Due to space limitation and the high rock contents this area (10 % of the total) could only be flattened to 25 - 30°. The total area was shrouded with clean, coarse gravelly alluvial material. The highest portion of the tailings stretches about 250 metres up the side of the mountain.

During construction a cloud burst of 10 inches (250 mm) of rain within three hours occurred, and caused the stream to totally overflow its banks with some damage to the earth works in progress.

It was decided to widen the streambed to three times its original dimensions. Due to the fact that the newly created bank between the tailings and the stream consisted of loose alluvial material it was decided to build a foundation, anchored in bedrock where possible at the base of

the wall with a one metre high wall on top of it. The bank was shaped to join the top of the wall. The total surface of the bank is currently being stone clad and sealed with a cement-sand mixture. The cement mixture is coloured with oxide to blend with the brown colour of the cladding stone. Gutters are being provided to allow runoff from the rehabilitated surface to enter the stream under controlled circumstances.

Due to the altitude difference of ± 250 metres between the top and bottom, horizontal stone walls were constructed at 20 metre intervals to reduce the speed of the surface runoff water.

Berms were constructed around the top perimeter of the rehabilitated area to prevent runoff from the rest of the mountain from reaching the rehabilitated surface.

Revegetation was done by hand, using cuttings and seed of selected species with the characteristics mentioned earlier. (A species list is provided later in this paper.)

Schegters Kloof Small tributary (Central Northern Transvaal)

The tributary was filled with tailings over a distance of 200 metres to an average height of 3 - 4 metres (Figure 5).

The mountain sides on both sides of the stream consisted of deep "clean" alluvial material.

The tailings could easily be removed from the streambed and buried on both sides of the stream.

Stone walls were packed in the stream bed at 25 - 54 metre intervals. Berms were constructed around the upper perimeter of the rehabilitated area to prevent runoff from higher terrain reaching the rehabilitated area.

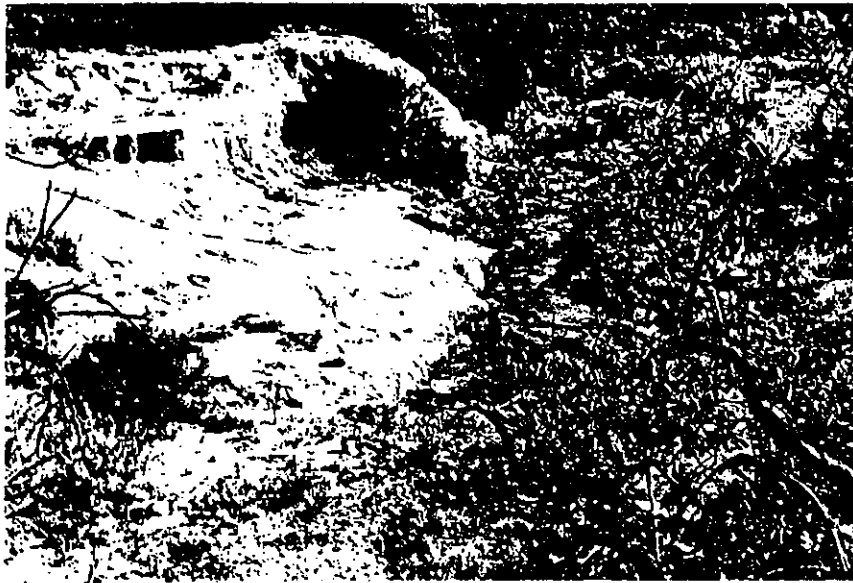


Figure 3.

A situation similar to the Malips river where tailings was dumped on the bank and over the bank into the streambed of the river.



Figure 4.

Rabes Kloof site in the process of rehabilitation. Tailings has been removed from the streambed, flattened to 18-20°, shrouded and planted with selected species. Stone pitching is in progress.

The species used in all three cases are the following:

- Acacia hebeclada*
(spinescent, low spreading shrub)
- Acacia schweinfurthii*
(spinescent scrambling shrub)
- Aloe davyana*
(succulent with low palatability)
- Aloe immaculata*
(succulent with low palatability)
- Aloe longibracteata*
(succulent with low palatability)
- Aloe mutans*
(succulent with low palatability)
- Euphorbia cooperi*
(caustic spinescent unpalatable succulent)
- Euphorbia ingens*
(caustic spinescent unpalatable succulent)
- Sansevieria aethiopica*
(fibrous unpalatable succulent forming clumps)
- Sansevieria hyacinthoides*
(fibrous unpalatable succulent forming clumps)
- Senecio longiflorus*
(fibrous unpalatable succulent forming clumps)

Floodplain Geminy Central Northern Transvaal

This project is in its exploration stage due to the fact that local inhabitants live and farm (under irrigation) on the contaminated flood plain. The long narrow plain is about 60 hectares in size (1 ha = 100 x 100 metres) and rises 1 - 4 metres above the normal water level of the river.

According to the local farmers the plain, or part of it, floods bi-annually (figure 6).

The depth of the tailings on top of the surface varies from 0,5 - 4 metres on dwelling sites, and from 300 mm to ploughing depth below the surface in the agricultural lands. Most of the tailings have been dumped

during mining operations and the rest has deliberately been spread by the farmers as a soil conditioner.

As soon as the inhabitants can be convinced by their local Government and Chief to temporarily evacuate the area, the rehabilitation will begin by means of removal of slimes where it has been dumped on the surface and not ploughed into the soil.

The rest (80 %) of the area will be cleaned up by means of a mini open cast mining operation where the contaminated soil and surface tailings will be buried and clean soil from the sub surface will be brought to the surface and spread over the contaminated buried material.

The area will be contoured to prevent erosion in case of future flooding.

The existing canal irrigation system will be improved, re-designed and constructed.

Conclusion

This Institute has successfully rehabilitated asbestos dumps since 1986 and has now been asked to estimate the total cost for a National Clean up of Asbestos pollution in the Republic of South Africa and Swaziland (figure 7).

Although all the mining sites are well known and documented, the extent of secondary contamination surfaces surrounding those areas, has never received attention.

It is estimated at this point in time that a national clean up could cost between R250 - R300 million rand.

The current asbestos mining companies also use this Institute as consultant and rehabilitation is ongoing on a large scale.



Figure 5.

Schegters Kloof after rehabilitation.
The treeless portion indicate the
rehabilitated surface. Note the stone
walls in the streambed.



Figure 6.

Fruit and vegetable farming on the Gemeni
floodplain.

Reference

Van Wyk, J.J.P. and Dawson, B.L. 1985.
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Figure 7.

A Rehabilitated tailings dam two seasons old.
Note the natural veld with big trees in the
back and branch fence to keep animals out
during establishment.