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Living in the Shadow of the Asbestos Hills (The Need for Risk Based Cleanup Strategies for Environmental Asbestos Contamination in South Africa)

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Abstract

Asbestos mining occurred in South Africa from 1893 to 2001 resulting in large areas of the Country being made permanently hazardous. In total, an area of many thousands of square kilometers now contains substantial environmental contamination as result of improperly controlled asbestos waste material that is directly attributable to the former mining operations. There is considerable confusion, even in more developed countries, as to how to determine an acceptable level of soil cleanup in areas contaminated by asbestos fibres. A clear standard for soil remediation is needed that is protective of human health. This can only be determined once a clear relationship between residual soil asbestos levels and entrainment of fibres can be established. This report suggests that a Risk-Based Corrective Action Strategy (RCBA) is needed for a safe and sustainable level of rehabilitation. Furthermore, contrary to current practice, rehabilitation should continue beyond the limits of the former mining activity footprint into the adjacent communities where it can be documented that the contamination is the result of uncontrolled fibre release or improper disposal of mining waste. The cleanup strategy should then target those areas that are most likely to lead to exposure such as public places, homes, gardens, pedestrian paths, playgrounds, schools, and roads. Current literature suggests the rehabilitation threshold for soil asbestos contamination in South Africa should be lowered by several orders of magnitude particularly in areas that pose a hazard for human exposure. What is needed most, however, is a comprehensive assessment and cleanup strategy and the funding to carry it out. Lowering of the soil cleanup threshold will no doubt add many hundreds, perhaps thousands of sites that require remediation to the current list. Since the government of South Africa has accepted the responsibility to cleanup the mess left by the mining companies, their work has only just begun.

Asbestos exposure is both an occupational and environmental hazard throughout the world. Crocidolite (blue asbestos), was commercially mined only in Australia and South Africa; however, through the worldwide distribution of products and the natural occurrence of amphiboles, the risk of exposure threatens every corner of the globe. Amphibole asbestos mining occurred in South Africa from 1893 to 1996 and, "Once asbestos was disturbed by mining, large areas of the Northern Cape were made permanently hazardous" (McCulloch 2002:xvii). The purpose of this paper is to discuss an alternate strategy to that currently employed by the South African government for the rehabilitation of derelict and abandoned asbestos mine sites and locally contaminated villages.

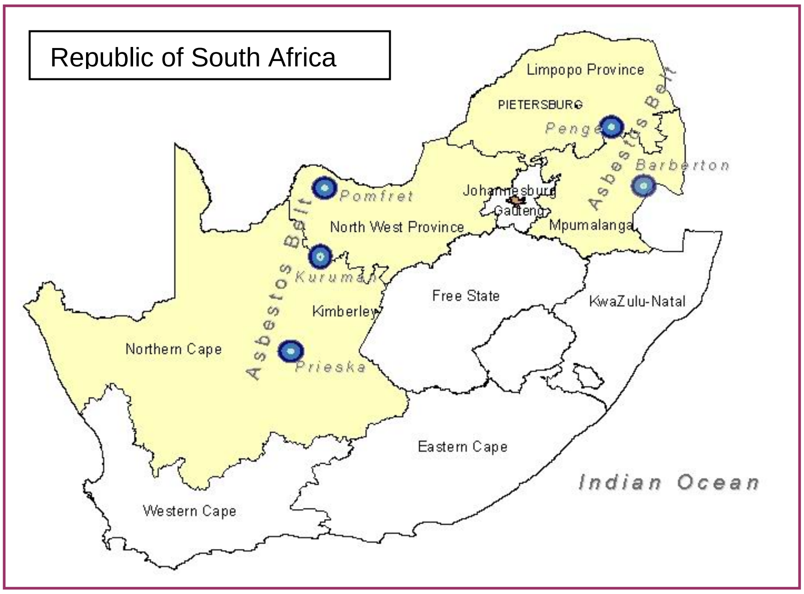
Background

Crocidolite mining in South Africa occurred predominantly in the Northern Cape extending into the Northwest Province. The northwest Cape asbestos belt stretches for over 450 kilometres from south of Prieska to the Botswana border covering an area of approximately 11,250 square kilometres. It was also mined in the Northern Province (the Pietersburg asbestos fields) extending in an 80 kilometre arc from Malipsdrift in the northwest to the confluence of the Olifants and Steelpoort Rivers in the southeast (Hall 1930). According to Castleman, (1996) between 1960 and 1965, a number of articles showed that asbestos caused malignant mesothelioma both in asbestos workers and people with the so called "bystander" exposure and that the "full horror" of asbestos contamination of the environment became apparent in 1960. This was the result of the J.C. Wagner report to the Pneumoconiosis Conference held in South Africa in 1959 (Wagner, et al. 1960). Early reports from the mining sector made scant reference to the occupational exposure of intermittent employees, often woman and their children who accompanied them. Nor did they mention the effect of mining and milling on the local populations. However, documentation produced by the Department of Mines as early as 1963 indicates that the Government of South Africa knew of the dangers of not only occupational exposure, but of environmental exposure to asbestos (Memo from J.S. Nel, Secretary for Mines, South Africa, 4 July 1963)[1]. In addition, in certain areas of the Northern Cape a large percentage of the population was suffering from asbestos related diseases (ARD) in the early 1960s. This information was never made public in South Africa.

Despite the lack of government attention, secondary exposure to asbestos contamination in South Africa was addressed by Felix (1991) and Randeree (1998). Felix (1991) documented the incidence of respiratory disease in Mafefe, a community of a little over 11,000 people, and environmental exposure related ARD incident rates of 34% and environmental and occupational disease rates of 49%. Her work was highlighted by Flynn (1992). Unfortunately, the scientific publications and media attention led to little change on the ground. Despite publishing the earliest research on the connection of mesothelioma to asbestos exposure, no substantial changes were

[1] As quoted in McCulloch 2002.

made to the asbestos mining industry in South Africa for thirty years. Furthermore, the environmental exposure persists today largely as a result of past industry and government collusion to neglect the affected communities.[2]



The South African Government is slowly coming to grips with the enormity of the problem of derelict asbestos mines and their resultant environmental contamination. According to government contractor estimates, there are approximately 203 known asbestos mine sites in South Africa where crocidolite, amosite and chrysotile asbestos was mined or dumped (Booysen 2004 personal communication). This estimate was generated by the Department of Minerals and Energy (DME) and their private sub-contractor. However, independent evaluation by consultants, researchers and citizens put this number much higher. A total 113 sites of "known mineralization" in the Cape crocidolite fields have been identified but are exclusive of crocidolite mining in the Peitersburg fields, as well as, other commercially mined asbestos types in South Africa (Brown University et al 2001).

The South African Department of Minerals and Energy has undertaken the onerous task of rehabilitating the former mine sites. To date, roughly half of the identified derelict mine sites have been rehabilitated (Brown University et al 2001) at a cost of over forty five million Rands (DME 2000). Attempts by the sole contractor to remediate the abandoned mine/mill sites have made substantial improvements over previous conditions. Yet, major questions remain as to the long-term sustainability of their efforts (Brown University et al, 2001 and unpublished studies). The government's position is that the present rehabilitation method is the only workable solution (Nolk, 2000).

The current methodology for mine rehabilitation begins with the identification of the rehabilitation site in consultation with the Department of Minerals and Energy. This process focuses only on those areas identified as, "derelict and ownerless mines" as it has been determined that the DME only has responsibility to rehabilitate the former

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[2] The links between the Government of South Africa and the asbestos mining industry are documented by Jock McCulloch in *Asbestos Blues: Labour, Capital*, *Physicians & The State in South Africa*, 2002.

mining areas and not those areas outside the permitted mine limits. The limits of rehabilitation are established by determining the point where ambient soil asbestos contamination levels are greater than 1.8 percent ‘free’ asbestos fibres. Those areas falling below this level of contamination are not considered part of the mine complex. The DME established this level by reviewing soil sample results from previous rehabilitation sites and determining an average of residual contamination levels outside the footprint of rehabilitation (Boosyen, personal communication 2004). The identified waste dumps are covered by 300 mm of clean soil typically extracted from a nearby source. The slopes are designed to be no steeper than 12 degrees and may include diversion structures and stone gabions to control surface water movement and minimize soil erosion. The dumps are planted with indigenous plants that are non-edible to discourage foraging and grazing by local livestock. The dumps are then monitored for a period of three to five years to assure their integrity.

Responsibility for soil rehabilitation outside of designated mining sites lies with the Department of Environmental Affairs and Tourism (DEAT). To date, the DEAT has initiated no remediation of asbestos contamination in the vicinity of the former mine sites. However, a study of regional asbestos contamination levels within the vicinity of the former mine and dump sites has been initiated in order to more accurately establish the scope of the problem. Research conducted by the author and others have identified numerous locations outside of the limits of the defined mining sites of obvious soil and building materials contaminated with asbestos that was derived from the local dumps. These reports and studies document, within the limited geographic areas sampled, substantially high levels of contamination and corresponding exposure. However, specific associations between soil contamination levels and exposure rates have yet to be established and are the focus of on-going research by the author.

Rehabilitation efforts to date have only focused on the former mining areas, including the more significant and obvious waste disposal sites. These sites have been estimated at 121 countrywide, a number many believe is substantially lower than the reality (Brown University et al and others). However, the more ubiquitous secondary sites may number in the thousands as a result of decades or poorly controlled waste disposal practices, including using waste asbestos in local building materials. Studies within certain mining areas have shown that 36% of the homes and 53% of the public buildings contain asbestos (Felix 1997). The South African government has estimated that over one million low cost homes within South Africa contain asbestos cement sheet products (DEAT nd).

Discussion

This author suggests that a Risk-Based Corrective Action Strategy (RBCA) is needed for a safe and sustainable level of rehabilitation of derelict mine sites. No distinctions should be made between the limits of mining and adjacent contamination when it can reasonably be shown that the contamination is the result of uncontrolled fibre release from the mine site or improper disposal of mining waste. In addition, current literature and research being conducted by this author suggests that the current rehabilitation threshold level for soil contamination should be lowered by several orders of magnitude in areas that pose a hazard for exposure. Table One compares selected fibre size distribution in a gram of soil (WHO 1986) to the cleanup threshold level established by the South Africa Department of Minerals and Energy and the excess cancer risk determined to be 10^{-6} per the U.S. Environmental Protection Agency (1997). Selected fibre sizes represent those most likely to be counted using polarized light microscopy (PLM). Within South Africa, regulated asbestos fibres have an aspect ratio of >3:1, a diameter of <3µm and a length of >5µm. Therefore, the following table has taken fibre unit counts of select sizes that approximate those that are considered 'regulated' by South Africa. The number of fibres per selected fibre size has been modified from the original document using the average mass for crocidolite. Crocidolite has an average mass of 3.4 g/cc (column 2) as compared to chrysotile that has an average of 2.5 g/cc (WHO 1986).

Table One: Fibre Concentration Estimates

Select Fibre Size Diameters	# of Fibres (2.5 g/cc)/ng (1)	# of Fibres (3.4 g/cc)/ng	Conversion Fibres/gram	Crocidolite fibres/gram of soil	Comparison to EPA Risk Level (2)
1 µm dia 5 µm length aspect 5:1	100 f/ng	73.5 f/ng	73.5E+9 f/g	13.2E+9	44x higher
0.125 µm dia 5 µm length aspect 40:1	6,400 f/ng	4,704 f/ng	4.7E+11	84.7E+9	282x higher
0.031 µm dia 5 µm length aspect 160:1	102,400 f/ng	75,264 f/ng	7.5E+13	1.35E+12	45,000x higher

(1) Source of information is United Nations World Health Organisation International Programme on Chemical Safety Environmental Health Criteria (EHC) Number 53, "Asbestos & Other Natural Mineral Fibres" published 1986, Section 2.3.4.

(2) Source of information is, "Superfund Method for the Determination of Releasable Asbestos in Soils and Bulk Materials" Interim Version, US Environmental Protection Agency (USEPA) document 540-R-97-028 dated 1997 page 2-2. The estimate for the total asbestos structures per gram (s/gm) of soil that exceeds the USEPA Cancer Risk Level (1 x 10E-6) is 0.5 billion and for structures greater than 5 µm in length is 30 million.

Fibres <0.25 µm to <0.3 µm cannot be seen by light microscopy (WHO 53, 1986 and Berman 1999). However, "for respirability, the most important single property of both asbestos and other fibrous minerals appears to be the fibre diameter. The smaller the fibre diameter, the greater the particle number per unit mass of dust; the more stable the dust aerosol, the greater the inhalation potential and penetration to distal portions of the lung" (WHO, 53 1986). In addition, the upper limit of the geometric diameter of respirable asbestos fibres is 3 µm (WHO 1986). However, more recent analysis has placed the relevant size range for fibres at 0.02 to 2.0 µm diameter and >5 µm up to approximately 200 µm for length (Berman 1999). Given this information, the identification of “regulated fibres” in South Africa may be adequate for protection of human health if the appropriate level of microscopic analysis is performed to adequately define all countable structures (down to the smallest diameter that still exceeds 5 µm in length).

Given the range of fibres available in the soil and their tendency to become airborne from disturbance by various activities, the current South African soil rehabilitation level (1.8%) is not protective of human health under most circumstances. In fact, there is considerable confusion in the literature as to what the appropriate level of soil cleanup should be. For instance, in the United States, there is no clear and consistent standard utilized for determining to what extent soil contaminated with asbestos should be remediated. For example, the City of Cambridge, MA has determined that [only] soil found to contain greater than 1 percent asbestos fibres by mass is “dangerous to human health” (City of Cambridge 1999). And, according to a U.S. Environmental Protection Agency (EPA New England 2000) press release, “As a point of reference, EPA considers soil samples with one percent or less asbestos to be an acceptable level.” However, it appears that these standards may be based more on analytical methods for a determination of bulk materials than actual risk assessment procedures. Recent studies show that soil tremolite asbestos levels as low as, 0.08% are found to generate airborne exposures exceeding the U.S. occupational exposure limit of 0.1 f/cc (Miller 2003). According to the California Department of Toxic Substances Control, low levels of asbestos in soil can yield significant air emissions as a result of soil-agitating activities (Collier 2003). This position is corroborated by the Agency for Toxic Substances and Disease Registry (ATSDR), wherein it describes the 1% level as not a health-based standard, but representing the practical detection limit in the 1970s when OSHA regulations were created and that studies show that disturbing soils containing less than 1% amphibole asbestos can suspend fibres at unhealthy levels (ATSDR 2003). According to other USEPA correspondence, cleanup thresholds should be established based on “background” levels, which may vary from rural to urban areas (Toland 2004 personal communication).

There is little confusion as to the impact of asbestos contamination on the local populations of former mining villages. Exposure assessments conducted by Felix (1997) indicate elevated airborne concentrations for selected activities in areas contaminated by asbestos dust. For instance, children playing had a mean concentration of 0.02 f/cc and within classrooms the levels were 0.013 f/cc (taken from personal air pumps) (Felix 1997). The samples were analyzed via light microscopy, which, in all likelihood did not count fibres under 0.3+/- µm in diameter even though the respirable range is at least one order of magnitude smaller (Berman 1999). While these concentrations may not seem high as compared to occupational exposure levels, this type of comparison is problematic. First, the time period of exposure is intermittent but is initiated at a much earlier age in school children as compared to occupational exposures. Second, the school exposures are then followed by the home exposures that lead to an almost continuous assault on the lungs. Thirdly, activity exposure, such as children playing, implies the high probability of open mouth breathing which may substantially increase the respirable diameter for fibres (Berman 1999). Fourth, the results may not accurately reflect exposures to children since they are more likely to disturb soils and dust contaminated with fibres (ATSDR, 2003). Soil samples were not collected at the same locations as the air analysis; therefore, correlations between soil asbestos levels and air concentrations cannot be made.

Preliminary unpublished research conducted by the author and others indicates that soil contamination levels for crocidolite contain anywhere from nearly 100 percent fibre concentrations at the former unrehabilitated mine waste sites to non-detectable levels in the general environment. In addition, soil asbestos concentrations within the vicinity of permanent settlements range from none detected to 16% with a mean average of 3.43%. These sites are highly variable depending mostly upon the method and amount of asbestos deposition and the manner in which it arrived. Fibres levels that have likely been deposited solely by airborne deposition are much lower than those from anthropogenic sources, i.e., carried by hand, vehicle or draft animal.

Conclusions

Even in more developed countries such as the U.S., there are no clear guidelines for determining an appropriate cleanup strategy with respect to asbestos contaminated soils. This lack of standards has been elucidated in the recent EPA conference (EPA 2003) in Colorado. It was acknowledged at this conference that the use of the 1% cut-off may not be protective and that the lack of standards is a hindrance to project evaluation. The need for sampling methodologies, fill material assessment, uniform testing methodologies, a low cost test procedure and soil to air correlations was identified. With no clear guidelines for soil remediation, the South African government is using a “default” threshold that is not based on any human health risk standards and is therefore not likely to provide adequate protection. Albeit, lowering of the soil cleanup threshold will no doubt add many hundreds, perhaps thousands of sites that require remediation to the current priority index. Since the government has accepted the responsibility to cleanup the mess left by the mining houses, their work has just begun.

Three circumstances have brought a pittance of hope to those communities facing such unfortunate circumstances. First and foremost, is the worldwide rejection of asbestos products in general, and crocidolite asbestos in particular. This has led to the decline in demand, which has forced the closure of all asbestos mines in South Africa. Second, is the end of Apartheid and the beginning of a democratic society wherein the lives (and environmental health) of all citizens are given protection under the law. Third, is the recent success with civil litigation (outside of South Africa) on behalf of former South African asbestos mine workers that has spawned additional attempts to hold the former mining companies and the government responsible for the damages to the surrounding communities.

What is needed most, however, is a comprehensive assessment and cleanup strategy and the funding to carry it out. Hot spots of contamination and residual source points need to be identified for priority outside of the defined mining sites. A clear standard for soil remediation is needed that is protective of human health. This can only be established once a clear relationship between residual soil levels and re-entrainment of fibres can be established on a scenario specific basis. Methods such as the Berman elutriator and the glove box technique may yield useful correlations though much more research and field verification is needed. The cleanup strategy should then target those areas that are most likely to lead to exposure such as public places, homes, gardens, pedestrian paths, playgrounds, schools, and roads. Current research being conducted by the author hopes to shed additional light on this topic.

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