MINING AND THE ENVIRONMENT IN SWAZILAND

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1. INTRODUCTION

Research in several countries has shown that mining contributes to land deterioration if not properly managed. Land disturbance resulting from mining is related to the mining activities, and the waste products (tailings) emanating from the mining operation. In mining, environmental impacts occur through improper disposal of waste rock, tailings and slurry from cleaning plants (Ripley et al., 1982). The host rock, low grade ore and waste reagents from extraction and processing of minerals undergo some chemical changes on exposure to air. This results in changes in the chemical properties of the surrounding soil and a disruption of the physical properties such as loss of soil structure, nutrient imbalances and increased trace element content. Changes in the chemistry of the surrounding soil lead to poor plant establishment hence erosion of waste piles.

Eventually, the soil components and eroded materials may finally contaminate surrounding water sources. Pollution of water systems is caused by mine drainage from waste streams, ground water seepage or rainfall passing through waste piles. Generally, mine drainage is the primary vehicle through which waste constituents migrate through the soil (Fuller et al., 1976). Apart from high concentrations of elements, mine drainage also contains high levels of suspended and dissolved solids, which are distributed to the surrounding water systems (Bell, 1975). The presence of small quantities of residual reagents and waste material from mining processes can therefore cause serious water pollution.

Changes in soil chemistry and water pollution can affect future land-use systems within inland river basins. In addition, erosion problems within inland mining sites can lead to increased sediment yield. Rapid change in sediment supply in a river causes instability downstream and increased fish kills. Since inland streams and rivers serve as migratory routes for fish, any impacts on inland river basins have serious implications on coastal zone management systems. Understanding the behaviour and movement of material in mine waste dumps is important not only for rehabilitation measures and restriction of inland water pollution but also in the management of coastal areas. This paper outlines the effects of mining on the soil and water quality in Swaziland.

2. MINING AND RELATED POLICIES IN SWAZILAND

Mining is among the main export earning industries in Swaziland. In 1993, this sector contributed 12% of the total (1.9 million) export earnings in the country. Swaziland has been involved in the mining of asbestos (Havelock/Bulembu), coal (bituminous (Mpaka) and anthracite (Maloma), diamonds (Dvokolwako) and iron ore (Ngwenya). In accordance with the fact that mineral deposits are non-renewable, and mines have a finite life, some of the mining operations are now closed. Therefore, it is essential to consider possible environmental impacts which might result from mining activities as well as possible ways to counteract the impacts. However, environmental problems emanating from mining activities have received less attention in national policies in the past.

The most important laws governing mining and the control of environmental impacts in Swaziland is the Mining Act (1958). The Mining

Act (1958) provides for the restoration of land surfaces in mining areas. According to the Act, shafts, pits, holes and other excavations should be filled in within 30 days from the date of termination. To date, not a single mining company has observed this provision. For example Ngwenya iron ore mine ceased operating in 1979, but the land was never restored. The shafts at Mpaka coal mine whose operations were terminated in 1992 are still open. The same applies for Dvokolwako where the waste dumps were not rehabilitated following closure of the mine in 1996. In most cases, the land surface is not restored in the belief that operations are likely to continue in the near future. Generally, most mines in Swaziland are not properly managed or rehabilitated to control the spread of the impacts during operation and after the mine has closed down. This could be because of the perception that mining activities are localised. Such perceptions are unfortunate because "although mines at any point in time are not as widespread in comparison to other land uses, they dramatically change the landscape and tend to leave evidence of the past" (Marshall, 1982).

The Swaziland Environmental Authority (SEA) Act (1992) empowers the Swaziland Environmental Authority, a body under the Ministry of Tourism, Environment and Communication to develop policies and monitor environmental problems in the country. Presently, the SEA is understaffed to fulfil its mandate. For example, although the magnitude of possible environmental impacts emanating from mining are recognised in the Swaziland Environment Authority regulations and procedures on environmental impact assessment and audits (Legal notice no 58, 1996), none of the existing operations have submitted audit reports yet.

3. Environmental impacts of mining in Swaziland

Some studies have been conducted to assess the environmental impacts in Swaziland. For example, Fakudze (1987) looked at the environmental impacts of asbestos and bituminous coal waste in Swaziland. The results of the study suggest that the asbestos tailings are characterised by a high pH, nutrient imbalances and high concentrations of trace elements such as nickel. Increased pH is not favourable for plant growth as it is likely to affect chemical reactions and nutrient availability in the soil (Michaud, 1981). The tailings also have a higher concentration of magnesium (Mg) ions compared to normal soil conditions where calcium is the most dominant cation. The dominance of Mg ions is noted (Adriano, 1986; Pendias and Pendias, 1984) to inhibit the availability of K and Ca to plants. With respect to trace element content, the asbestos tailings have high concentrations of readily available Ni and Zn. As a result of the nutrient imbalances and the high concentrations of trace elements, the low fertility status of the soil is affected. This contributes to poor plant growth and erosion problems on the asbestos tailings. At Bulembu, the erosion problems are manifested by the rills and gullies found on the waste piles.

The conditions on the waste dumps affect the water quality in neighbouring river systems. In Bulembu, the effect of the asbestos mine waste on water quality is illustrated in the Dvudvusi (or Mzilanti) river that flows below the mine (Table 1, p. 243). Water samples taken below the tunnel contain high concentrations of dissolved solids, suspended solids, alkalinity, hardness, calcium, chlorides and sulphates. According to the production manager at Bulembu, there are sludge dumps constructed to contain the waste material downstream but these fill up with time. Desludging has not been carried out since 1991. The sludge dumps now require some attention since material from sludge dumps is encroaching onto the Mzilanti River. This is clearly demonstrated on the aerial photographs of the area.

The coal tailings are characterised by high pH, organic carbon, salinity, nutrient imbalances and a high iron content. Normally, coal waste is characterised by low pH, especially in the presence of framboidal pyrite minerals

(Caruccio, 1978). At Mpaka, the high pH is due to the presence of carbonate minerals that neutralise sulphuric acid to sulphate salts. This explains the high salinity levels within the waste piles and tailings. Regarding the nutrient imbalances, the tailings had a low magnesium and potassium content hence poor growth of vegetation. However, there were no visible erosion features on the waste piles due to the low rainfall conditions at Mpaka. The main concern would be mine drainage and seepage during heavy rains. Off-site changes in underground water quality were noted at Mpaka (Table 2). Most importantl are the high levels of chloride, sulphates and dissolved solids in the water.

4. Implications for coastal management

Although the waste from the coal mining operations in Swaziland has high pH values, Förstner (1993) notes that when the neutralizing or buffer capacity of pyrite - containing minerals is exceeded, pH values may be lowered. The production of acidity can lead to an increased trace element content in riverine and estuarine sediments thus affecting biota within these systems. Trace elements are also noted to either enhance or inhibit marine phytoplankton growth, as per (Granéli and Haraldsoson, 1993). For example, these authors note that excess iron has been found to limit phytoplankton growth in marine waters. According to

Table 1. Water quality in the Dvudvusi River above and at the mine tunnel (Source: Water Resources Laboratory).

	1984		1994	
	Above tunnel	Below tunnel	Above tunnel	Below tunnel
pH	6.87	9.46	6.83	7.78
Dissolved Solids (mg/l)	29.5	118.56	22	76
Suspended Solids (mg/l)	18.2	100.4	62	183.1
Hardness (mg/l, $CaCO_3$)	22.4	155.7	28	95.8
Alkalinity (mg/l)	17.5	84.1	27	64
Calcium (mg/l)	8.5	59.05	17.8	46.57
Magnesium (mg/l)	1.69	13.41	nd	nd
Chloride (mg/l)	8.9	30.7	2.8	11.1
Sulphate (mg/l)	1.74	21.72	1.1	32.67
COD (mg/l)	10.0	37.6	24.5	34.8

them, excess macronutrient availability also regulates biomass accumulation and species composition in marine waters.

5. Conclusion

Unless serious measures are taken to control the spread of waste material, the impacts of the mines on the environment will be witnessed in distant places, especially estuaries and intertidal zones. Although the waste dumps are partially colonised, the existing plants are not effective in controlling the prevailing erosion problems on the waste dumps. There is need to consider effective policy measures to control the spread of the impacts to neighbouring environmental systems. Mining companies and relevant Government departments should ensure that mine waste and sludge dumps are stabilised and rehabilitated during and after closure of the mines. Chemical processes and the movement of chemical constituents in the waste and neighbouring rivers need to be monitored.

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Table 2. Properties of EmaSwati (Mpaka) coal mine domestic (underground and surface) drinking water sources (Source: Fakudze, 1987).

Parameter	Underground	Surface	Recommended Standard
pH	8.3	7.7	6.0 - 9.0
Conductivity	680	164	250
Dissolved Solids (mg/l)	4 865	1 1182	500
Suspended Solids (mg/l)	16	38	0
Alkalinity (mg/l)	308	530	100
Hardness (mg/l)	1 080	302	200
Calcium (mg/l)	340	140	100
Magnesium (mg/l)	740	162	100
Chloride (mg/l)	1 552	248.2	250
Sulphate (mg/l)	1 599	348.5	250
Sodium (mg/l)	1 199	330.8	50
Potassium (mg/l)	15.3	3.4	10

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