

# **Evaluating Impacts of Coal Mining in South African environment: a step to actualizing society 4.0**

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## **Abstract**

South Africa is considered as one of the ten largest coal producers and the fourth largest coal exporting country in the world. The above claim perfectly confirms the importance of the coal mining industry to the country economy. With increasing dependency of the country on coal resource for power generation, all indications show that coal exploration in the country will not be abated in near time. The exploration, however, has detrimental effects both on the flora and the fauna as well as the humans. This study, therefore, evaluates the impacts of coal mining in South Africa relative to achieving society 4.0 in the country. Mpumalanga province was used as a case study as mining activities are highly prevalent in this area. Impacts of the mining activities on air pollution and water pollution were reviewed in the study area. The study further develops a roadmap towards achieving Society 4.0 in the era of societal revolution, thus achieving the low carbon global paradigm shift. This study concludes on the need for cleaner substitute for coal in the country as a long-term recommendation and on a short-term sustainability scale, we discourage opencast mining and encourage underground mining of the resource.

## **Keywords**

Coal mining; Environmental degradation; Society 4.0; South Africa

## **1.0 Introduction**

The coal mining industry in South Africa generates more than 77 % of all primary energy needs of the country. It forms the basis of the energy sources for the electricity system of the country and so, its dependency index is higher than other sources of energy in the country. Eskom, the state-owned enterprise manages over 90 % of the country's electricity with a projected installed capacity of 55,112 MW in 2020 when the new coal-fired power plants, Medupi and Kusile are completed (Bohmann et al. 2018). Eskom reports that coal mining industry produces more than 224 million tons of coal per year. In addition, there are an estimated 30 billion tons of coal reserves in South Africa that can produce more energy output for the next 200 years, as the demand for coal will also increase in the future. The coal mining industry is Eskom's main source in energy generation around South Africa. However, coal exploration is its detrimental effects on the environment and climate of South Africa (Dunmade et al. 2019). This environmental contamination and pollution such as found in the soil, underground and surface water, ecosystem, landscape, consequently negatively affect the health of residents in surrounding areas and particularly, the coal mine workers.

The global electricity demand and the role of coal in electricity generation throughout the major coal-producing countries of the world are of great interest to all. This is because of its potential damage to the environment. According to a study by the World Coal Institute (WCI), coal was classified as the cheapest, most abundant, affordable, and safe and secure source of energy (World Coal Institute). Table 1 reinforces some of the main reasons why coal is a preferable energy source in developing countries compared to oil, gas, nuclear and renewable sources of energy.

Table 1: Energy sources distribution types and characteristics [World Coal Institute 2012]

S/N	Sources of Energy	Characteristics	Characteristics
1	Coal	<ul style="list-style-type: none"> <li>Abundant, affordable, safe and secure</li> <li>Easy to transport and store</li> <li>Widely available</li> </ul>	<ul style="list-style-type: none"> <li>The most intensive fuel for electricity</li> <li>Poses technological challenges as part of low global CO<sub>2</sub> growth</li> </ul>
2	Oil	<ul style="list-style-type: none"> <li>Convenient</li> <li>Easy to transport and store</li> <li>No effective substitute in transportation uses</li> </ul>	<ul style="list-style-type: none"> <li>Carbon intensive</li> <li>Price volatility</li> <li>Resource concentration</li> <li>Vulnerable to disruption or geopolitical instability</li> <li>Transport risks</li> </ul>
3	Gas	<ul style="list-style-type: none"> <li>Efficient and convenient</li> <li>The fuel of choice for many uses, such as residential heating</li> </ul>	<ul style="list-style-type: none"> <li>Carbon intensive</li> <li>Expensive and risky to transport and store</li> <li>Requires dedicated, inflexible infrastructure</li> <li>Price volatility</li> <li>Resource concentration</li> </ul>
4	Nuclear	<ul style="list-style-type: none"> <li>Carbon-free generation</li> <li>Few resource constraints</li> </ul>	<ul style="list-style-type: none"> <li>Public acceptability low</li> <li>Waste disposal is problematic</li> <li>Capital intensive – may be uneconomic in some markets</li> </ul>
5	Renewables	<ul style="list-style-type: none"> <li>Low emissions on a life cycle basis</li> <li>Sustainable</li> </ul>	<ul style="list-style-type: none"> <li>Generally high costs and intermittent sources</li> <li>Major expansion will take time</li> <li>Potential siting problems</li> </ul>

Despite its negative environmental impacts such as carbon dioxide emission when coal is combusted, together with the release of methane when coal is mined, coal is still the cheapest, most affordable and widely available source of energy. The positive aspects of coal, as can be seen in Table 1 far outweigh its negative aspects and therefore coal is likely to be the preferred energy source of the near future especially in developing countries. Hydropower might be the cheapest energy source worldwide; however, in South Africa countries neither the terrain nor the rainfall pattern support construction of major hydropower plants.

Today, many countries around the planet are concerned about the environment and environmental sustainability and many authors are still debating on the environmental notion until today. For most authors, the environment plays an important role in the life of people (Miller, 2010). This point of view supported by the Department of Environmental Affairs in South Africa defines environmental safety, as the consequence of the perfect interaction between abiotic and the other biotic organisms.

The South African National Environmental Management Act 107 of 1998 designates a safe environment as “the surroundings within which humans can exist”, as follows: (The Republic of South Africa 1998)

- The atmosphere contained in the Earth, lands and any source of freshwater;
- The ecosystem of plants, animals, micro- and micro-organisms;
- All elements belong to 1) and 2) combination and their interrelationships amongst and between them,
- The chemical, physical, aesthetic and all forms of cultural properties and conditions that influence South Africans’ health and their well-being (Bill of Rights, 1996, 1996/1998-10-30).

The environment provides conditions for good development and growth – for both humans and animals (Miller, 2010). That is why across the world, so many conferences on environmental safety are organized each year. For instance, already four critical environmental conferences have been organized around the world. The first one took place in 1972 at the United Nations Conference on Human Environment (UNCHE). Another took place at New Delhi the International conference on global environmental issues took place from March 14 to March 15, 2015, where twenty-two countries around the world participated.

Those conferences involved environmental activists, lawyers, judges, scientists and other members of civil society. They assembled to discuss the key topic, such as unplanned developments, electronic waste disposal, coal waste, water-quality problems, and energy industry, community waste, the ozone problems with high temperatures, the impact of oil spills on the marine environment. These factors all influence the climate negatively. Those conferences highlight the fact that the challenges of keeping our environment clean and safe are increasing faster than ever before. According to Mr Hamid Ansari's speech, the Vice President of India asserts that the lives of millions of people depend on environmental safety issues. So, each country should make sure that the laws, policies to protect and prevent any serious dangers to the environment are implemented and respected, in order to ensure the sustainability of future life.

Coal mining for the long term has been one element that contributes to South Africa's economic development and helps the country to be very strong in term of its economy around the continent. With these coal mining companies established around the country and a coal reserve structured as follow Highveld (31 %), Witbank (30 %) Ermelo (13.8 %), Waterberg (11 %), Vrg.-Sasolburg (6 %), South Rand (2 %), Utrecht (2 %), Klipriver (1.9 %), Soutpansberg (1 %), other (1.3 %), South Africa is considered as the home of coal with an estimation of 3.5% of the world's coal resources. South Africa produces annually 3.3 % of the world, and the coal exportation is estimated at 6 % of the global exports with 31 billion tons of coal reserves, corresponding to 11 % of the global total coal reserves. These results rank the country as sixth country that exports the coal across the world (De Korte 1994; Chamber of Mines of South Africa 2013).

In 2014, the country has produced near 260 Mt of coal and 182.7 Mt. South Africa sold its coal product internally with a value of R54.7 billion 69.6 Mt, worth R46.7 billion have been exported. The coal product provides around 81 % of the energy produced by the Energy Industry in South Africa. The coal-mining sector in South Africa is considered as an important employer, with approximately 460,000 peoples working in that industry and 400,000 are employed by the suppliers of services and goods to the coal-mining sector. South Africa coal product is concentrated in large mines, with at least 8 mines accounting for 61 % of the output (Bredell 1987; Strategic Natural Resources 2012).

## **2.0 Underground Coal mining: Soil and land destruction**

Around the world to find the coal product to be used for the electricity generation, the coal product is gotten often by underground mines. Although underground coal mining centralized on the Highveld, with roughly 60 % of South Africa coal deposit situated in eMalahleni (Witbank) and surrounding area in Mpumalanga, however it is also known for its grain, maize, soya beans and dry beans farming (soya beans 51 % maize 24 % and dry beans 23 %) are produced in the area, push the companies like Sasol and Anglo American Thermal Coal to extract the coal product deeper underground to extract the coal. Two methods to extract coal from underground are always used (Chamber of Mines of South Africa 2013). These methodologies are: firstly, for the surface coal mining the coal extraction is made by the strip mining method. The strip-mining process to extract coal is using draglines to eliminate the overburden and further substitute it in the mined-out surface, or by open casting, with the overburden being substituted and dumped away. The surface mining requirement some important equipment that also contributes to the destruction of the environment.

Secondly, for the underground coal mining, the coal extraction is made by room-and-pillar support procedure, with the coal being removed between the pillars, which formerly keep on supporting the roof. A minor quantity of coal product is often mined by long walling mines, as soon as all coal product in the seam is removed and the roof is permitted to fall behind the mined-out zone. The strip-mining method to extract coal product is the procedure that the most destroy the South Africa landscape; this destruction decreases the global value of the natural environment in the nearby land. Once land or a zone such as eMalahleni (Witbank) is dedicated to the coal mining activity, farms in the province could be destroyed.

In another side, the impact of underground mining with a method room-and-pillar also creates enormous quantity of waste earth and rock to be brought to the external. These wastes created by the method room-and-pillar once that waste is on the surface and come into contact with external air and water become very toxic substances. Air can become polluted and the quality of water is also affected because of coal extraction procedure room-and-pillar. The room-and-pillar promotes the degradation of the air and increase in water quality problem and causes serious damage to buildings.

## **2.1. Coal Mining and Air Pollution Problem**

The coal mining generates during the coal extraction process the pollution of air, as the toxic gases such as Sulphur ( $\text{SF}_6$ ), Nitrous oxide ( $\text{N}_2\text{O}$ ), Carbon dioxide ( $\text{CO}$ ), methane is all released into the air. For example, the province of Mpumalanga has been recognized as a province where air quality is a huge problem. Presently, because of coal mining, uncontrollable underground fires and power plants coal-burning activity, the province has been declared the worst air quality problem in the world.

The creation of some particulate matters during this process is characterized by such noxious materials as arsenic, lead and cadmium, high level of  $\text{SO}_2$ . Unfortunately, the particulate matters such as  $\text{PM}_{10}$  and  $\text{PM}_{2.5}$ ,  $\text{NO}_x$ ,  $\text{O}_3$ , benzene,  $\text{H}_2\text{S}$  and Benzene have exceeded the limit and have immediate negative impact on people wellbeings such as respiratory problem, emphysema and skin problem. The emission of carbon dioxide into the air generates an increase of climatic trouble like the increase in temperature. The gas-like Methane released during the process of coal extraction and during the geological creation of coal product, once into the air produces the greenhouse problem (GHG) as the methane gas come from the underground mine activities. The methane gas is less predominant in the air than carbon dioxide, but it is 20 times dangerous to destroy the air than the carbon dioxide and participate in climate change in South Africa. Although this methane is often taking and used as town fuel, industrial fuel, chemical feedstock and vehicle fuel, it is occasional that it all gets used. The presence of toxic gas into the atmosphere cause many human problems like cancer, heart problem, and acid rain and be the results of high level of toxic gases into the air (Thomas et al. 2000; Blowes et al. 2003),

## **2.2. Acid Mining drainage Impact on the water quality**

One of the worse impacts of coal mining in the acid mine drainage in South Africa. This acid mine drainage remains the largest effect problem of coal mining around the world but especially in South Africa, where the acid mine drainage has been ignored by the government for over already 100 years. Due to the negative impacts of the acid mine drainage on the most important environment element called water.

Coal mining generates the acid drainage when the water from the underground is mixed with coal product deep in the soil and with rocks unearthed during the underground process of extracting the coal. During that process, toxic substances are created and combined with other heavy metal created the pollution of water underground. This polluted water outflows of closed coal mine continue to contaminate the quality of water underground and groundwater as well streams, soils, plans, human and animal. That situation can change completely the pH water with the presence in the water of the pyrite in the rock increase to water a low pH less than 7.0. the acid from the acid drainage, once in the water-activated the heavy metal from the environment, in the coal mine area or in the near dams or river from the sediments. This case is seen for example in the case of Witbank (The Witbank Coalfield accounts for 40% of South Africa's coal production) where the heavy metals from coal mining engine, steel manufacture, vanadium and chrome are all established already pollute water for five rivers. The colour of water on the blanket colour of the rivers, streams, estuary or sea bed eliminate several kinds of plants and make the surface of water unusable, that water cannot be drinkable by any human or animal (Ata and Soner 2006).

The development of the Acid Mine Drainage (AMD) is a function of the hydrology, geology and coal mining technology working at a coal-mining zone. The prime bases for acid mine drainage creation are sulfide minerals, such as pyrite (iron sulfide) which decompose in water and air. The sulfide minerals come from waste rock detached from the coal mining and tailings. The consequence is once the water infiltrates pyriteladen rock in the presence of the air, water can be acid and put the pH of water become low by two or three than the normal level of the pH of water. The fact that the water becomes acid kill all living organisms, such as corrode culverts, boat hulls, piers, pumps, and often

other types of heavy metal equipment in contact with the acid waters and reduce the water to be used to drink or recreational use by any kind of human (Bell et al. 2001).

### **3.0 Roadmap towards reducing the impact of coal mining**

To reduce and resolve the impacts of coal mining in South Africa, the green mining suggestion developed by Professor Qian, a Chinese Engineering Academician suggests solving that problem. The objective of this green mining is the circulation conduct of joints, bed, fractures partings and the seepage flow of the toxic substance such as methane, carbon dioxide and water over wrecked rock strata produced by the coal mining. The green mining methodology or procedure to solve the negative impacts of coal mining on the environment is still in construction. That methodology contains important elements to preserve water quality in the coal mining area, to conserve the coal mining under infrastructures, grouting in the space amongst detached rock layers to lessen surface subsidence, fractional coal extraction and backfill coal mining, instantaneous coal extraction and coal-bed methane, the underground thoroughfare support, the underground discharge of limited coal mining wastes and underground coal gasification (Coetzee et al. 2002; Aken et al. 2012).

#### **3.1. Conversation and Restoration of the mine water environment**

The conservation of aquifers during coal mining is the most important element in coal mine water environmental study. That preservation of water helps the coal mining to preserve water, to manage all water use during the coal extraction process, and provide a solution to water pollution in the coal-mining zone. The conservation of aquifers is a vital element of the green mining procedure. Diverse impacts from the coal mining on aquifers and diverse remediation procedures for dissimilar coal mines that have diverse geological situations. The underground reservoir construction can be a use full technique to preserve water and avoid that water from rivers and stream can be polluted. This technique created an underground reservoir is mostly use to the conservation of water leaking from splintered aquifers that conserve the aquifer in a safe way. Concerning the coal mining around the eastern in Mpumalanga the key strata technique must be controlled to avoid rupture, or be reinstated by grouting after rupture, to avoid water eruption into the coal mine area (AGIS 2011; Blignaut 2012).

#### **3.2. Management of mining waste**

Massive quantities of waste are produced by coal mining; certainly, this is the major cause of solid heavy waste accounting for more 40 % of all solid wastes in South Africa. Heavy materials that should be always detached to have admission to the coal product like topsoil, waste rock and overburden the waste come from coal product preparation and gangue from the underground coal mining characterize this waste. Several successions of accidents in current months have emphasized the implication of reuse of these coal-mine wastes and showing the importance of better take procedures to manage all the waste from coal extraction. This management of coal mining wastes includes their decrease, reuse and recycle waste. The management of wastes from coal extraction involves many procedures like cleaner production, clean technology, pollution prevention, coal waste minimization, coal recycling, resource and residue utilization, the overall resource utilization and total project development. In addition, coal-mining enterprise should always come up with some innovative coal mining procedures to decrease the creation of coal mining wastes. In China, for example, the country manages most than 15% of their coal wastes by using their traditional longwall coal mining procedure. That method can be also used to reduce the dangers of coal mining in South Africa. The waste combustion residues like fly ash, bottom ash or boiler slag should be used for other concern like waste recycle (Bian 2006; Blignaut 2012).

### **4.0 Conclusions**

Coal product is considered as the most important source of energy around the world's and in South Africa near 90% of energy come from coal product. Coal for the next 50 years will remain the most useful product to produce electricity, before that each country develops electricity with natural resources and new technology advanced to generate electricity. The natural resources to create electricity reduces the use of coal product that negatively impacts the environmental elements such as water pollution, soil destruction, land subsidence, air, ecosystem, animals and human being. Since 1993 coal mining plays an important role in the South Africa economy with R37 billion of contribution,

and in 2013 that same industry of coal added R51 billion to the country economy. These statistics rank the country as the seven largest coal producer and one of the top five coal exporting in the international. This indicates that coal mining actions will become very exhaustive and its impacts on the environment will be also increased. Current researches have demonstrated that some solution such as conservation and restoration of the mine water environment,

Management of mining wastes, Treatment of land to re-use and other solution such as the use of natural sources to generate energy can be taken to reduce the impacts of coal mining in the environment before and after a coal mining is in process. This article presents the importance of coal mining industry in South Africa economy, and provide some environmental consequences of that industry in the zone where the coal extraction is done. In other side, the article outlines some procedures on how to reduce or solve the impacts of coal mining on the environment before or after coal extraction is made around the country. The article encourages South African Government to pursue cleaner substitute energy, develops green technology methodology, and clean coal mining techniques to reduce the destruction of the environment by the extensive coal extraction activity around the country and preserve the environment.

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