

Science breaks new ground in converting coal ash from pollutant to useful products

By [Leslie Petrik](#)

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South Africa has large coal reserves. It mainly burns coal to [produce electricity](#) at 13 existing coal-burning power plants, situated mainly in [Mpumalanga](#), a province in the country's east.

In South Africa, coal power generation results in at least 36 million tonnes of solid waste residue called fly ash being produced [annually](#). That's the equivalent of six dumps each the [size](#) of the Pyramid of Giza. Fly ash is a problem anywhere in the world where coal is burnt, but it is particularly so in South Africa because its low-grade coal has up to 40% inorganic residue that turns into ash on combustion.

Fly ash is made of very fine particles that are corrosive and abrasive, containing many [toxic metals](#) and soluble salts which leach into the environment, polluting surface and ground water. The particles of ash may harm humans if they are inhaled. Toxic metals such as mercury and chromium in the particles also have negative health [effects](#).

In South Africa, fly ash is mostly stored in irrigated ash dumps or dry [dumps](#). The chemical [weathering](#) of dumps leads to extensive dissolution and leaching of major, minor and trace elements, with very low salt capture. Salt leaching is leading to increased salinisation of the country's water catchment areas, rivers, lakes and dams.

Extensive [studies](#) have been carried out on fly ash disposal, management and re-use in South Africa. This research has shown that the huge dumps of waste fly ash at power stations can be turned into value-added products. This has the twin benefits of creating new and useful products while also reducing its harmful environmental effects.

One of the coal-burning power plants in South Africa. [Leslie Petrik](#)

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Uses for fly ash

One use for fly ash is as a simple, low-cost and competitive solution for [treating](#) acid mine drainage. Acid mine drainage forms naturally when water and air come into contact with pyrite or [sulphidic rocks](#) which are exposed during coal or gold mining, forming sulphuric acid. This acid water dissolves rocks and releases toxic metals.

Toxins in acid mine drainage include [radionuclides](#), high sulphate levels and numerous other toxic elements such as aluminium, iron, manganese, mercury and arsenic. It is [highly acidic](#).

Streams, rivers and aquatic life are affected by the water's acidity, toxicity and the yellow coating of iron oxide that deposits and smothers all aquatic life in the water. Polluted water from the mines flows into normal water. This has a harmful effect on people and animals' health.

Fly ash can be used to neutralise and treat acid mine drainage from coal or gold mines, reducing major inorganic contaminants in the water to within water quality specifications.

Fly ash treatment [systems](#) include vigorously mixing the contaminated water with fly ash or allowing gravity flows of the polluted water to run through a bed of fly ash. Studies show that fly ash neutralises the acidity and improves the [quality](#) of acid mine drainage.

It does this by removing almost all sulphate and toxic metals in a one step process. The removal of sulphates from mine water using coal fly ash depends on the amount of fly ash used, the final pH level and the [composition](#) of the mine water.

Mine water of very different quality can be treated successfully with coal fly ash, and a small amount of additional lime and $\text{Al}(\text{OH})_3$. The treatment leads to water that meets target water quality range guidelines for irrigation or drinking water.

Fly ash also presents a route to stop acid mine drainage forming in the first place. After water is treated, the remaining solids can be used to refill mine holes after a mine is no longer in use. This is known as back-filling. These solids have the strength to prevent mines from [collapsing](#).

Backfilling [prevents](#) the formation of acid mine drainage because sealing the mine voids ensures that air and water don't get in.

The next frontier in fly ash recycling

But fly ash can be used for much more. Because it is made of mainly silica (48.27%), and aluminium oxide (30.89%), it can be converted into [zeolites](#).

Zeolites are stable and porous mineral solids that have qualities that make them exceptional as well as incredibly useful. Zeolite minerals form naturally, but can also be made artificially from fly ash. They have very high stability at high temperature and high pressures, they don't burn, don't dissolve in water or organic solvents, and don't oxidize in the air.

A range of zeolites have been [formed](#) from coal fly ash in South Africa. These include high value, industrial [quality](#) zeolite X, hierarchical zeolite X, zeolite A and zeolite [NaP](#).

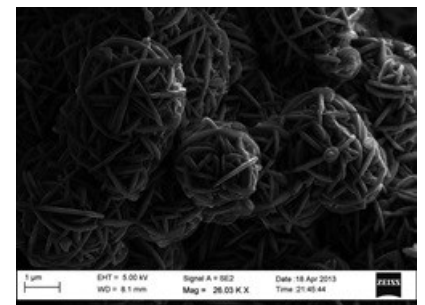
- Zeolite A can be used in everyday products such as washing powder.
- Coal fly ash as well as hierarchical X can be used as catalysts in biodiesel production, significantly lowering processing temperatures and other [costs](#).
- Zeolites A and NaP made from fly ash can be used to [remove](#) toxic metals from heavily polluted [water](#).
- Zeolite A can be used for gas purification and separation.

Other uses of fly ash include using it as a source of [rare earth elements](#). Also, geopolymers - suitable for durable or lightweight concrete replacement materials in [construction](#) - can be made.

These scientific breakthroughs provide further proof that there are multiple uses for fly ash and that, in the medium to long term, discarding this waste in ash dumps can be abandoned.

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Novel patented hierarchical zeolite X made from fly ash. Leslie Petrik

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