Collapse of the dam of a tailings pond

25 April 1998

Aznalcollar

Spain

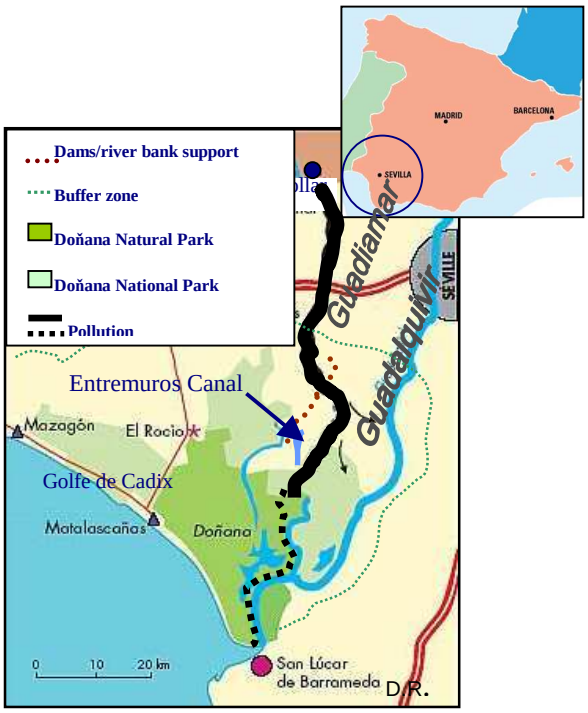
Accidental spill
Tailings
Heavy metals
Acid water
Land slide
Design fault
Water and soil pollution
Animal mortality

Following the collapse of the dam of a tailings pond, 7 million tonnes of acidic tailings containing high levels of heavy metals were spilt and polluted 80 km of river and contaminated nearly 10,000 hectares of land.

Thousand of hectares of land polluted

BACKGROUND AND FACILITIES INVOLVED

- **Aznalcollar** is 45 km north-west of Seville in the region of Andalusia. The region is in the eastern end of the Iberian pyrite belt has a long mining history that dates back to ancient times.
- In 1976, a company set up an open-pit mine in Aznalcollar to mine a pyrite deposit. The company was bought by a foreign group in 1987 and mined out the Aznalcollar open-pit in the end of 1996.
- The company set up another identical mine in **Los Frailes** in 1997 at less than 1 km from the first to extract zinc, silver, lead and copper. Pyrite that also contains arsenic, cadmium, thallium and other metals in low concentrations is crushed and very finely grinded (< 8 µm). The various metallic components are then separated by flotation. The Los Frailes mine that employed 500 persons was at its full yield of 4 million tonnes/year as of end 1997.
- The waste from the process that represents 90 % of the ore treated is emptied into a pond. After decantation, the supernatant liquid is pumped and reused in the process. The liquid is highly acidic (pH<3) and rich in zinc (450 mg/l), copper (17 mg/l) and lead (3.5 mg/l), and contains significant amounts of arsenic (0.2 mg/l).



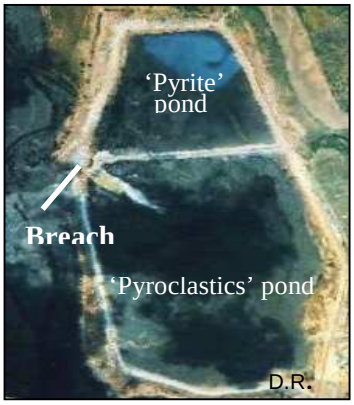
Pollution pathway

➢ A second pond, adjacent to the first one stored waste from the treatment of volcanic rocks (pyroclastics).

➢ This **2 km by 1 km artificial double basin** with a 32.6 million m³ capacity was built in 1976 when the old mine was set up. It is surrounded by a 30 m high **dam** whose height is regularly increased using the material derived from mining activity.

➢ The dam sits on a 4 m thick layer of alluvial gravel that in turn overlies a 70 m layer of blue marl, a sedimentary rock containing lime, and clay in approximately equal proportions.

➢ The ponds were along the banks of the river RIO AGRIO that drains 2 km downstream into the GUADIAMAR river. The river crosses fertile agricultural lands (citrus, peaches, olives, sunflowers, wheat, maize, etc.) and reaches swampy areas that surround and make up the DOÑANA natural park. The ENTREMUROS canal deviates the course of the river before it drains into the GUADALQUIVIR at 60 km downstream from Aznalcollar.



Satellite sight of the basins of storage

THE ACCIDENT, ITS CHRONOLOGY, AND CONSEQUENCES

The accident

➢ **On 25 April 1998 at around 2.30 am,** a landslide caused a breach in the dam separating the two ponds, as well as in the 50m peripheral dam. The two ponds contained 31 million tonnes of waste in all. 3 million tonnes of sludge and 4 million tonnes of acid water were released that drained into the RIO AGRIO and GUADIAMAR whose level rose by 3.6 m in 30 min. The suspended matter level in the RIO AGRIO river were recorded at 30 g/l.

Aerial view of the tailings pond

➢ The water level of the GUADIAMAR river rose by 200 to 300 m and flooded 20 km of land, spreading approximately a 10 cm layer of sludge over thousands of hectares. The banks of the pond were covered with an over 3 m thick layer. High levels of lead (8 g/kg MS *), zinc (7 g/kg MS), arsenic (3 g/kg MS) and copper (2 g/kg MS) were detected in the deposited sludge.

➢ The pollutants continued spreading onto the rivers and became a threat to the **DOÑANA National Park** after 7 to 8 hours.

➢ The emergency teams of the Park closed the exits towards the reserve and erected mud walls. At the same time, the authorities built an emergency containment wall to confine the bulk of the pollution to the ENTREMUROS canal. However, several incidents of flooding were observed on the pastures and farms on the banks of the canal.

➢ On **28 April**, the operator successfully clogged the breach and completely stopped the flow. On the same day, the waste that could not be confined to the canal, reached the mouth of the river where a pH of 6.5 was measured (instead of 7.5), and polluted the beaches of the Gulf of Cadiz.

Doñana National Park

D.R

- *It is located in the old GUADALQUIVIR river delta. The region designated as a biosphere reserve by UNESCO in 1980 and then classified as a World Heritage Site in 1994 covers 50,720 hectares.*
- *It is home to several protected animal species (Iberian lynx, etc.) however over 6 million migratory birds using the park as their resting spot account for the natural wealth of the ecosystem.*

D.R.

Travaux de nettoyage

➢ Sanitation operations (removal of toxic sludge and contaminated soil) started a few weeks after the accident, and required 800 persons, 500 trucks and 150 earthmoving and loading plants at the same time. The treatment had to be urgently carried out before the autumnal rains to avoid infiltration of toxic products into the soil. The authorities allowed the waste to be stored in the abandoned mine of Aznalcollar. The authorities esteemed that the operation did not risk contaminating the underground water. In December 1998, 5 million m³ of sludge was removed from the area and 2 million m³ of agricultural soil was stripped off the ground. Some areas were cleaned again in 1999 and 2000.

➢ The 4.5 million m³ of waste retained in the ENTREMUROS canal were treated in a specially built sewage treatment plant and disposed off into the GUADALQUIVIR river.

Consequences

➢ The wave of sludge and acid water polluted 7,000 hectares of pastures and swamps and destroyed 3,500 hectares of cultivated land (rice, wheat, rape seed, sunflower, cotton, fruit trees, etc.). The operator paid 6 M€ as compensation to farmers for the damage caused to their crops. A dozen villages in the GUADIAMAR valley (50,000 people) were directly affected by this disaster. In comparison to the DOÑANA Regional Park, the DOÑANA National Park suffered impacts to a lesser extent.

D.R.

D.R.

Carp buried below sludge

➢ From RIO AGRIO to the mouth of the GUADALQUIVIR, the ecological disaster had taken its toll on around 80 km of river. Pollution control teams collected around 30 tonnes of dead fish (carps, barbels, eels, sculpins, etc.), 220 kg of crabs and shrimps, as well as frogs, rabbits, goats, horses, etc. Some 12,000 birds such as geese, storks, etc. died in the accident. According to a report prepared by the Scientific Research Council in May 1999, 11 % of the birds in the DOÑANA Park were contaminated subsequent to the accident of 25 April 1998.

(*) MS: Dry Matter

- A water table that supplies the DOÑANA National Park was polluted by a toxic flood. Fresh water supply was threatened in Seville.
- Consumption of well water, as well as activities such as hunting, fishing, farming and livestock breeding was forbidden for over 5 months.
- Several people sustained light burns due to the acid water while trying to save their pet animals and cattle.


D.R.

GUADIAMAR 26 April 1998


D.R.

GUADIAMAR 4 May 1998

- The total cost incurred due to the accident is assessed at 240 M€ including cleaning operations, water purification, restoration of banks and the purchase of the contaminated land by the authorities. The expenses are shared by the European Union (100 M€), national and regional administrations (90 M€) and the operator (50 M€ from the disaster relief fund).
- The accident also entailed **indirect consequences:** fishermen were out of business, agriculture marketing cooperatives refused to buy products from market gardeners along the banks of the rivers and cancellations were made in hotels.

European scale of industrial accidents

By applying the rating rules of the 18 parameters of the scale made official in February 1994 by the Committee of Competent Authorities of the Member States which oversees the application of the 'SEVESO' directive, the accident can be characterised by the following 4 indices, based on the information available and the assumptions retained while estimating the quantity of dangerous materials released.

The parameters that comprise these indices and the corresponding rating method are available at the following address: http://www.aria.ecologie.gouv.fr

The dangerous materials released index was rated at level 6 and reflects the spillage of **2,400 tonnes of lead,** a product classified as very toxic for aquatic organisms according to the 96/82/CE directive called 'SEVESO 2'. The quantity of lead released was estimated from the concentration of lead measured in the sludge deposited along the banks of the GUADIAMAR and is expressed as g/kg of dry matter. Due to the absence of additional information, the calculations retained an average dryness of 10 % for 3 million tonnes of spilt sludge (Q1 parameter).

The 'human and social consequences' index was rated by default at level 2 due to the slight burns sustained by several residents (H5 parameter).

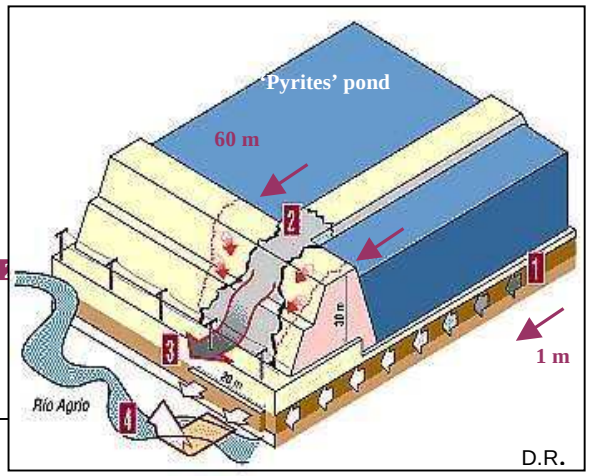
The **10,000 hectares of polluted soil** explains the level 6 of the 'environmental consequences' (Env 13 parameter).

Lastly, the environmental rehabilitation measures (≥20M€) **are characterised by the level** 6 of the 'economic' consequences' index (parameter €18).

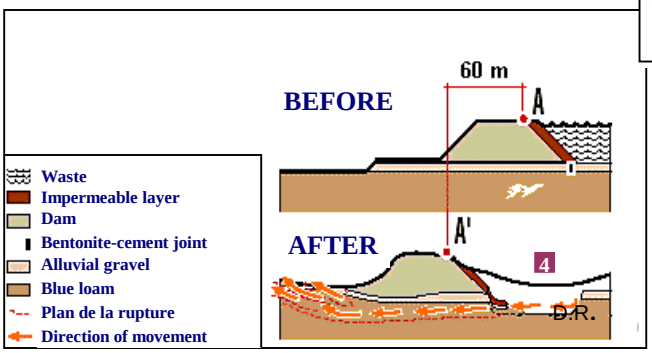
THE ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

➢ The accident took place in 3 phases:

- the separation barrier cracked when a 30mX20mX14m alluvial and marl plate located at the junction of the two tailings ponds slid over 1m, 1
- the supernatant waste in the 'pyrite' pond infiltrated the crack. The increased pressure on the peripheral dam along with a decrease in the resistance of its foundation accentuated the original sliding phenomena causing the main dam to slide up to 60m sideways, its deflection at 2-3m,, several cracks and spillage of waste, 3
- the waste flooded below the dam 4 , that collapsed at a 50m section releasing the sludge and acid water.



Sources El Pais 14 mai 1998



➢ The collapse of the dam could have been due to the combination of several factors:

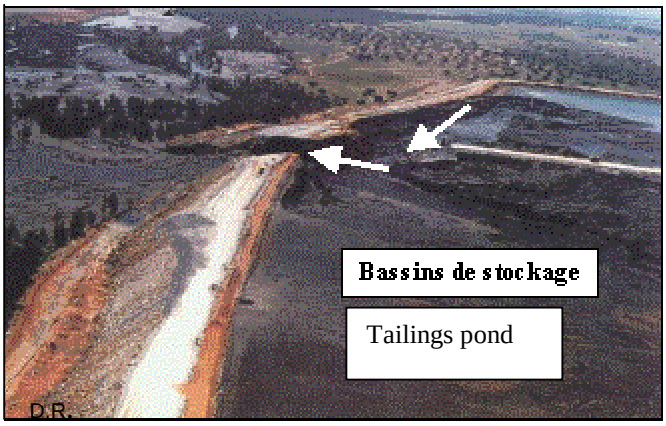
- Design and construction flaws,
- Degradation of the clayey subsoil exposed to acidic waste and further strained due to the high pressure resulting from the water and sludge,
- overfilling of the tailings ponds

➢ In 1995 and 1996, expert reports revealed the instability of the dam (leakage, landslides, etc.).

The operator had then improved the tightness of the dam and implemented a device to detect its movements

In 1997, in light of these measures and despite deformations recorded by inclinometers, the authorities permitted the operator to take measurements of the dam with a view to increase the capacity of the tailings pond.

Few weeks before the accident, an inspection of the tailings pond by the regional Andalusian authorities did not reveal any major defect.



ACTION TAKEN

➢ The authorities implemented monitoring programmes coupled with restoration and surveillance of:

- water quality at 70 sampling points spread out from RIO AGRIO till the mouth of the GUADALQUIVIR,
- soil quality: high iron sulphide, acidity problems (treatment with lime), high concentrations of arsenic or zinc (treatment with iron oxyhydroxide), etc.

➢ The Los Frailes mining activities stopped for 12 months leaving 500 people technically unemployed/ In May 1999, the local Andalusian government authorised the reopening of the mine, with the temporary storage of waste in the old Aznalcollar mine. The Los Frailes mine permanently shut down in September 2001. The Swedish-Canadian group presented a site abandon and environment rehabilitation plan estimated at 50 M€.

➢ With financial aid from the European Union, the authorities undertook in 2004 a programme to re-plant Mediterranean vegetation and a "green strip" along the banks of the effected rivers (cost estimated at 150 M€).

Impact of pollution on soil (4/5/98)

LESSONS LEARNT

➢ Two years after the Aznalcollar accident, the collapse of a tailings pond was once again the source of serious pollution in Europe (**Baia Mare** – Romania – ARIA no. 17 265). The gravity and the repetition of such type of accidents led to the reinforcement of European legislation on mine waste management.

- **Modification of the « SEVESO 2» Directive** on 16/12/2003 to explicitly include treatment of ores (and especially mine waste settling basins) or dams used for this treatment and issue of the **Directive no. 2006/21/CE on 15 mars 2006 on the management of waste from the mining industry.** The directive especially aims to provide for:
  - Waste description and their classification (health and environmental risks, etc.)
  - Geological and hydrogeological studies (stability of soil and sub-soil, adaptability to waste types and quantities stored, proximity to water table, etc.),
  - Safety management system (featuring a detailed assessment of risks based on the various possible accident scenarios: subsidence, land slides, floods, collapse of dam, etc.)
  - Contingency plans indicating measures to be taken by the operator and the authorities within and outside the site to minimise the health and environmental impacts of the accident.
- Issue of the **Environmental Responsibility Directive** to prevent and repair environmental damages (Directive no. 2004/35/CE of the European Parliament and Council of 21/04/04).
- Drafting within the framework of the IPPC directive (Directive no. 96/61/CE of the Council of 24 September 1996 on prevention and reduction of pollution), a NOTE on the **Best Available Techniques** that bring down ordinary pollution and prevent accidents in the non-ferrous metal mining sector and minimise its effects.

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OTHER ACCIDENTS AFFECTING TAILINGS PONDS

Borsa Accident in ROMANIA (10/03/2000 – ARIA no. 17425)

Due to heavy rains and melting of the snow, a breach (25 m wide, 10 m high) in the dam of a settling pond of a lead and zinc mine released 20,000 tonnes of sediments rich in heavy metals (Pb, Zn, etc.) into the VISO river and then into the TISZA and the DANUBE. The pollution reached Ukraine and Hungary through the rivers that pass through these countries and then Yugoslavia and Bulgaria where the rivers run alongside. A polluting slick spread over 50 km was observed after fours days at 200 km from the mine. A new breach (50 l/s) appeared 16 days later due to the poor quality of repair carried out. Luckily, in the middle of April, an exceptional flood (once in every 500 years) of the TISZA in its Hungarian part reduced the effects of the pollution.

Baia Mare Accident in ROMANIA (30/01/2000 - ARIA no. 17265)

A dyke on a settling basin for mining tailings collapsed after formation of a 25-m long crack. A total of 287,500 m³ of effluent laced with cyanide (115 tons) and heavy metals (Cu, Zn) spilled, contaminating a 14-hectare sector and polluting the SASAR River. A 40-km "cyanide wave" swept through the LAPUS, SZAMOS and TISZA Rivers before finally reaching the DANUBE. The cyanide concentration rose as high as 50 mg/l in the LAPUS, 2 mg/l in the stretch of the TISZA running through Yugoslavia (on February 12) and 0.05 mg/l in the DANUBE River Delta, some 2,000 km downstream of the Baia Mare site (February 18). Romania, Hungary, Yugoslavia, Bulgaria and the Ukraine were also affected by the accident. High cyanide concentrations were measured in privately-owned wells, and the health of several individuals was adversely affected after ingesting contaminated water. Water consumption and fishing activities were banned in the accident zone. Wildlife and vegetation were destroyed over an area extending hundreds of kilometers: a total of 1,241 tons of dead fish were recovered in Hungary alone, and thousands of dead animals were found (swans, wild ducks, otters, foxes, etc.). The authorities of countries located downstream were quickly informed and could hence take effective preventive measures, including: dam runoff, notification sent to all water supply utility operators. Dam design flaws (excessive proportions of fines), poor weather conditions (heavy rains and snowmelt resulting in a rise in basin water level, and a thorough soaking of dam components causing structural weakening) and organizational breakdowns (absence of effluent transfer procedures) all played a role in the accident. The reasons behind the high fish mortality rate could not be clearly established since a very high quantity of bleach might have been used to neutralize the cyanide. After the accident, the basin operator set up a cyanide waste treatment plant, along with a 250,000 m³ holding basin to collect overflow from the settling basin before neutralization and discharge back into the natural environment. The accidents at Baia Mare and Aznalcollar (ARIA file 1831) have led to reinforcing European legislation on waste handling within the mining industry. It should be pointed out that major leaks had already been observed on the dam two months prior to the incident.