MODELLING EXPOSURE TO THE INDUSTRIAL ACCIDENTAL RELEASE OF ARSENIC OCCURRED AT MANFREDONIA (ITALY) IN 1976: LESSONS LEARNED

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Introduction

Manfredonia, September 26th 1976. A **mixture containing arsenic compounds** was **released** into the atmosphere due to an accident in a fertilizer production plant.
40 years later, the municipality promoted **an epidemiological study** to investigate possible **long-term health effects** in the population.

Figure 1. Study area

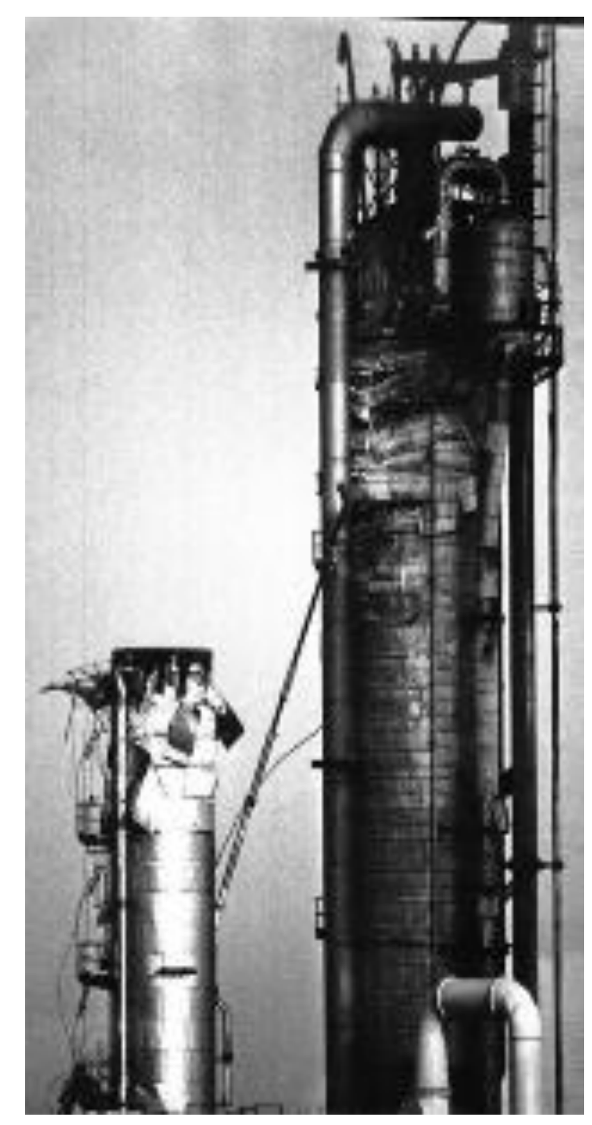
In such cases, exposure assessment has several **critical aspects**.

- **Each accident** is **unique**.
- **During and after** an accident, **focus** is on controlling and **minimizing risks**.
- Seriousness level of accidents is often **downplayed**.
- Meteorological and dispersion **simulations** of **short-time events** have **large intrinsic uncertainties**.

Questions

How to reconstruct the dispersion of the emitted cloud and the extent of contaminated area by a numerical model?
How to take into account uncertainties on the accident dynamics and scarce data?

Data and Methodology



A participatory research model was implemented with citizens. They supported the research, providing data and information.[1,2]

The contaminated area extent was estimated in three steps.

1. The **incident dynamics** was **reconstructed** through industrial process analysis, literature, and direct testimonies.
2. Analysis of **available environmental data** collected in the days after the accident and in following periods.
3. The RAMS[3]/CALMET/CALPUFF[4] **dispersion modelling** system was implemented. **Four nested 3d grids** were used:
   - 672x576 km^2, 16 km grid-mesh;
   - 200x168 km^2, 4 km grid-mesh;
   - 106x70 km^2, 1 km grid mesh;
   - CALMET/CALPUFF ran on an **inner grid 60x62 km^2**.

   25 vertical levels; the first level at 25 m, top height at 22 km.
   The **simulations time** was **three days** (25-27 September 1976).

Data from two meteorological stations (Italian Air Force Meteorological Service) were used to evaluate simulations.

Results

Accident dynamics and arsenic deposition data.
The broken column (40 m high) was operating at standard conditions and contained about 100 m^3 aqueous solution, with about 10 t of different arsenic chemical species. The accidental emission consisted of two components with different fate in the environment (Fig.2) as confirmed by deposition data map (Fig.3)) i) Liquid solution and solid fill material hit the area in proximity of the plant. ii) Gas and droplets cloud (rising up to 200 m) dispersed and wind-transported beyond the plant area.

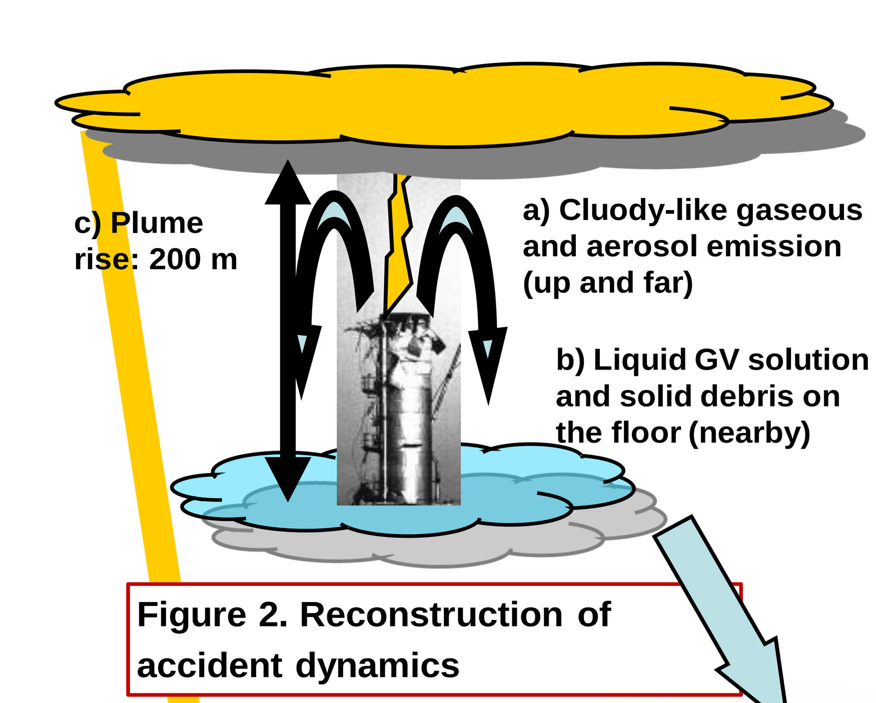


Figure 2. Reconstruction of accident dynamics

Figure 3a and 3b Deposition data

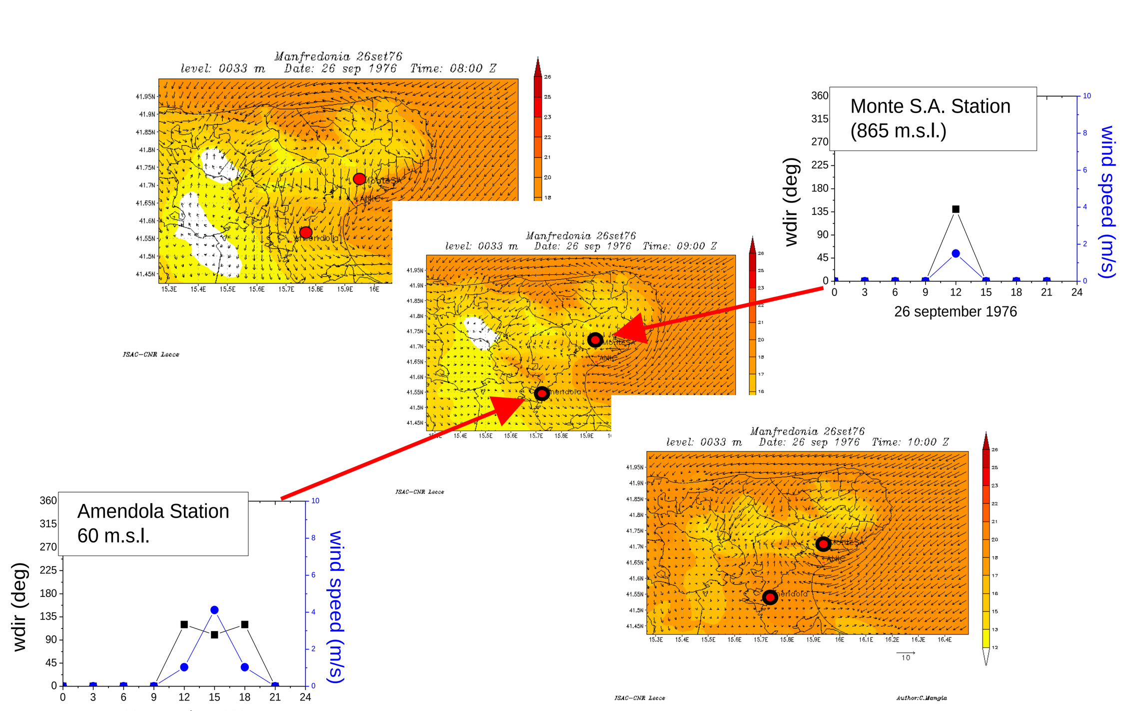


Figure 4. Sept. 26, 1976. Simulated near surface wind fields (m/s) and temperature (°C) at 8:00, 9:00, 10:00 GMT and wind data measured at the two Air Force meteorological stations.

Meteorology and dispersion modelling.
A fairly **complex flow** at the time of the incident (Fig.4) with a wind calm situation around Manfredonia town; development of more intense winds from east in the aftermath.
Predicted deposition maps (Fig.5) in the first two hours after the accident show how the cloud, due to the wind calm conditions, laid the city of Manfredonia, then moved northwest pushed by a southerly wind.

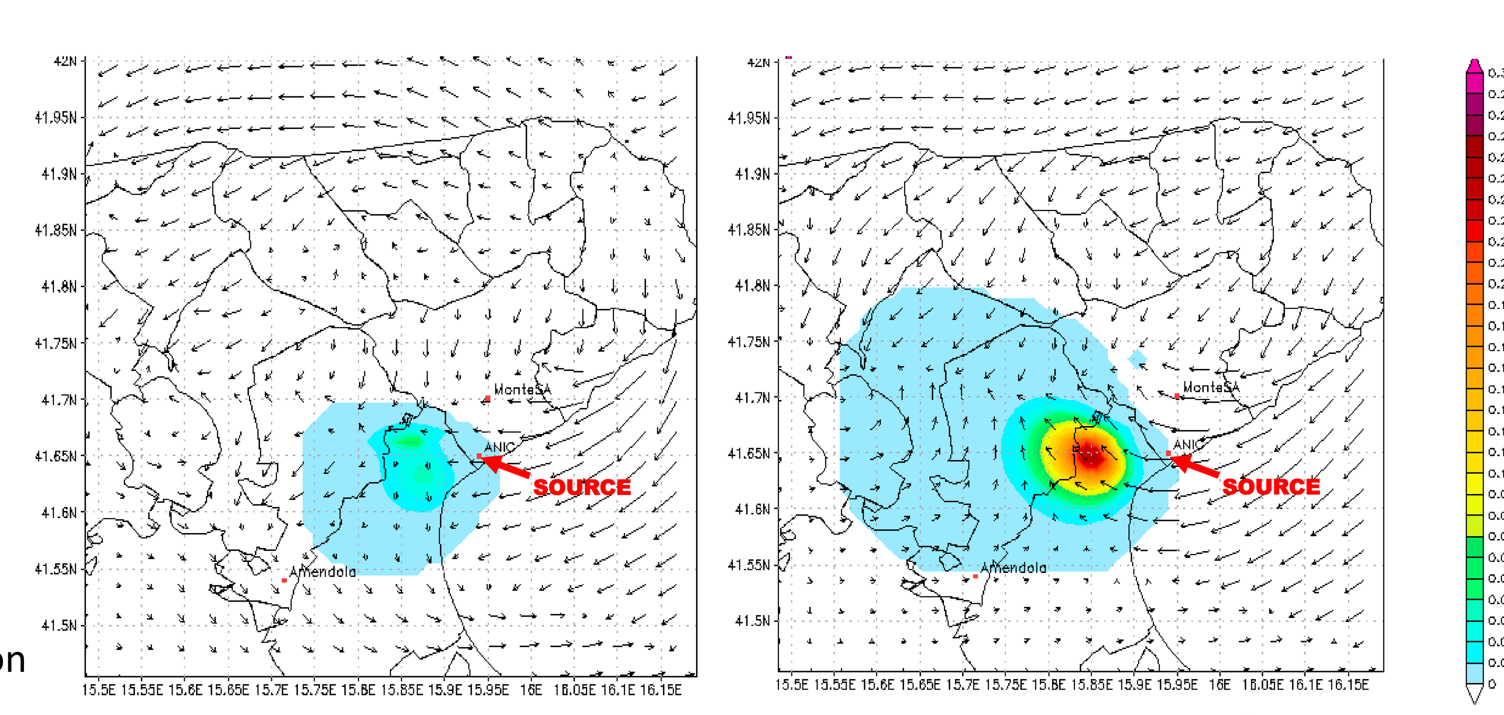


Figure 5. Predicted deposition of Particulate Matter maps on 26 September 1976 at 9:00, 10:00 GMT. Unitary emission

Conclusions

- ❑ The simulated impacted area is larger than it was supposed to in the days following the accident and outlined by ground surveys made in the first months after, but somehow agreed with the next measurement campaigns that assumed a wider sampling area and registered in a confidential report.
- ❑ The case study confirms the need to run a dispersion model during the early phase of an accident and to collect contamination data consequently. Otherwise, the real extent of contamination can be underestimated leading to a misclassification of exposure.
- ❑ Participatory approach allowed a better reconstruction both of meteorology and accident dynamic.
- ❑ Nevertheless, because of the long time elapsing, some uncertainties still remain and should be taken into account in the epidemiological study.

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