Impacts of fires on water quality

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Policy brief

February 2018

Fires can have severe impacts on water quality. Fires disturb vegetation cover, create an ash layer rich in potential contaminants, and increase contaminant mobilisation by enhancing runoff and erosion. This may lead to the contamination of surface and groundwater resources with suspended sediments, metals, organic compounds and nutrients. These contaminants can also accumulate in riverbanks, flood plains or at the bottom of streams and reservoirs, creating problems long after the fires end. Fires can have severe and potentially catastrophic consequences for aquatic ecosystems and water supplies, as experienced in Denver (USA; 1996 & 2002), Canberra (Australia; 2003), Fort McMurray (Canada; 2013), and several municipalities of Portugal and north-western Spain (2017). They also can limit the provision of hydrological ecosystem services normally expected from forested and rangeland watersheds.

Water resources often originate in forested watersheds and are therefore vulnerable to post-fire contamination. The Mediterranean regions of Europe are especially vulnerable since these forests experience recurrent fires, as exemplified by Portugal in 2003, 2005 and 2017; but other regions can also be at risk, as exemplified by Belfast (UK) in 2011. These events may preclude the fulfilment of Water Framework Directive goals for forested watersheds and the achievement of the water quality targets of the Sustainable Development Goal 6 for clean water.

Photos: fire by Neil Thomas on Unsplash, water by Ian Keefe on Unsplash.

The understanding of wildfire impacts on water quality and treatability is not enough for efficient water resource management. While many of the potential impacts are known, key knowledge gaps remain on their probability of occurrence, magnitude, and longevity. Water managers around the world are usually required to understand the risks that their systems may face. In Europe, EU Directive 2015/1787 on the quality of water intended for human consumption requires Member-States to assess the risk for water resources, including those caused by fires.

Adequate risk assessments are key to support decision-makers, such as national authorities and water managers, to implement measures that can prevent post-fire water contamination, design effective monitoring systems and responses, and to increase the robustness of existing supply systems. This can be especially important in developing regions countries where adequate water treatment may be limited.

This policy brief is directed to forest, catchment and water resource managers; researchers working on fire and water resources; and funders and managers of research programs in water resources and disaster prevention and mitigation. It is based on discussions between 28 researchers and water resource managers from Europe, the US, Canada, Australia and Israel, during a 3-day workshop held between 14 and 16 February 2018 in Lisbon, Portugal. It was organised by COST Action ES1306 Connecteur and the H2020 PLACARD project, and included a public session involving additional Portuguese researchers and managers.

Key findings

The consensus of the global scientific and practitioner community is that fires can significantly and negatively affect water resources. The processes that must be understood to describe these impacts can be summarised within a general framework for assessing post-fire water quality deterioration (Figure 1). This framework assists in both mitigation strategy identification and risk assessment. It also helps in identifying and highlighting key research and knowledge gaps.

However, there are still important research gaps. There is considerable regional variability between climatic regimes, fire and fuel conditions, contamination mechanisms and pathways, and streams and water supply systems that must be understood. Most current knowledge is derived from fire-prone regions in the US, Canada and Australia, and, therefore, caution is needed when applying it to the European context.

Post-fire risks evolve in a context of environmental change. The study of post-fire contamination must take into account changes in population density, land-use and management, water supplies, socioeconomic conditions, and policies. Climate change might increase the occurrence of droughts, fire occurrence and extent, and rainfall intensity, and therefore has the potential to also increase both short and long-term post-fire contamination risks.

Post-fire contamination of water quality is a multidisciplinary problem. Assessing immediate risks requires knowledge of hydrology, soils, chemistry, biology, and a clear understanding of what the main management vulnerabilities are. Understanding longer term risks requires also knowledge of fire behaviour and regime, as well as forest and landscape management.

Multidisciplinary approaches are necessary, and there is a need for dialogue between researchers and stakeholders so that the main problems, processes, and knowledge gaps are clearly identified. This requires more opportunities for all actors involved in this field to meet, develop a common language and understanding, and define a joint research and management agenda. These actions should be supported by raising public awareness about the risks fires pose for water quality, to promote a consensus on the need to address this issue and a broader discussion of acceptable solutions.

Reference

Nunes, J.P., Doerr, S.H., Sheridan, G., Neris, J., Santín, C., Emelko, M.B., Silins, U., Robichaud, P.R., Elliot, W.J. and Keizer, J. 2018. Assessing water contamination risk following vegetation fires: challenges, opportunities and a framework for progress. *Hydrological Processes*, **32** (5): 687–694. DOI: 10.1002/hyp.11434

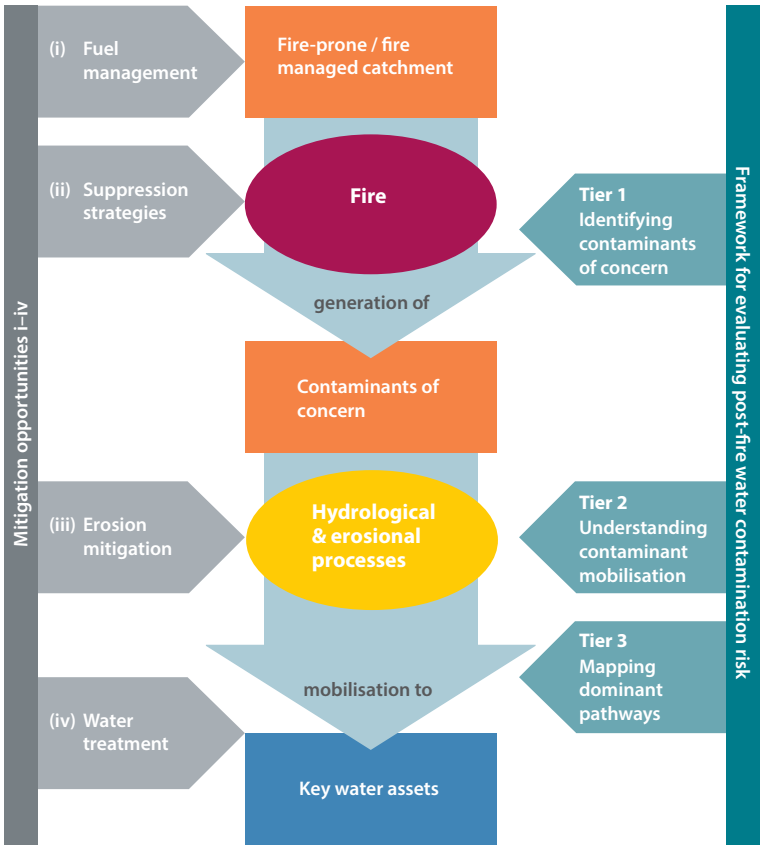

Figure 1. A framework to assess impacts of fires on water quality (Nunes et al.).

Water managers' needs

Managers require support from researchers to quantify post-fire contamination risks. Fire impacts should be integrated in regular assessments of water body status, ecosystem services, and hydrological risks, but taking into account that the impacts of extreme events are more important than long-term average changes. Key management questions include:

- Which water quality parameters should be assessed after a fire? Are there easily measured proxy parameters to account for them?
- Which rainfall and associated runoff events will trigger fire-induced water contamination?
- What is the probability of occurrence of a contamination event with a given magnitude and duration?
- How long would contaminants take to reach a certain water body? How much time would managers have to take appropriate measures? How long would the contamination last?
- How does the management of contamination impacts differ between different water supply sources, such as streams, reservoirs and groundwater?

Managers need support from researchers to identify effective solutions. Immediate post-fire solutions require knowledge on how to mitigate water quality problems at the source through effective post-fire forest management practices; and on which water treatment processes are most effective to address water quality problems which do occur. Long-term solutions include forest and fire management actions which can reduce fire frequency and severity, thereby prevent water quality problems from occurring or mitigating their impacts (Figure 1).

Research needs

Research efforts are still poorly coordinated, limiting the comparability across studies. Post-fire water contamination studies need to be designed inside a common framework, to allow a comparison for different fires and regions, and to support general advances in the understanding of this problem. Recent efforts have addressed this issue (Figure 1) and need to be continued.

There are knowledge gaps which should be addressed to improve risk assessment and management. Despite recent advances, especially on understanding landscape hydrological and erosion processes, there are still key areas which need more research:

- More data is needed, including the regular monitoring of fire-prone watersheds in unburnt conditions, and long-term monitoring after fires to understand legacy contamination.
- There should be a focus on less studied processes, such as the mobilisation of ash by wind erosion, the percolation of contaminants to groundwater, and the interactions between contaminated sediments and the water column in streams and reservoirs.
- The environmental impacts of fires should also be assessed, as well as the interaction between environmental and water supply problems through processes such as eutrophication.
- The economic and social costs of post-fire water contamination should be quantified and compared with the cost of implementing short- and long-term management solutions.
- The enhanced contamination potential of the interaction between fire and other extreme events, such as floods and droughts, needs to be better understood.

Workshop participants

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How to cite this policy brief

Nunes, J.P., Doerr, S., Keesstra, S., Pulquério, M., et al. 2018. Policy brief: impacts of fires on water quality. Results from the Connecteur/PLACARD workshop on Fire impacts on water quality, 14–16 February 2018, Lisbon.

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