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Post-fire water quality in forest catchments: a review with implications for potable water supply

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In many locations fire-prone forest catchments are utilised for the supply of potable water to small communities up to large cities. For example, in south-eastern Australia, wildfires have burned part or all of forest catchments supplying drinking water to Sydney (2001 wildfire), Canberra (2003), Adelaide (2007), Melbourne (2009), as well as various regional towns. Generally, undisturbed forest catchments are a source of high quality water. However, increases in erosion and sediment flux, runoff generation, and changes to the supply of key constituents after wildfire may result in contamination of water supplies. In this review, we present key physical and chemical constituents from a drinking water perspective that may be generated in burned forest catchments and examine post-fire changes to concentrations of these constituents in streams and reservoirs. The World Health Organisation (WHO) drinking water guideline values were used to assess reported post-fire constituent concentrations. Constituents examined include suspended sediment, ash, nutrients, trace metals, anions (Cl^-, SO_4^{2-}), cyanides, and polycyclic aromatic hydrocarbons (PAHs).

Constituent concentrations in streams and reservoirs vary substantially following wildfire. In streams, maximum reported total suspended solid concentrations (SSC) in the first year after fire ranged from 11 to 143,000 mg L^{-1}. SSC is often measured in studies of post-fire stream water quality, whereas turbidity is used in drinking water guidelines and more commonly monitored in water supply reservoirs. For burned catchment reservoirs in south-eastern Australia, peak turbidities increased over pre-fire conditions, as did the frequency of exceedance of the turbidity guideline. NO_3^-, NO_2^-, and NH_4^+ may increase after wildfire but maximum recorded concentrations have not exceeded WHO guideline values. Large post-fire increases in total N and total P concentrations in streams and reservoirs have been observed, although there are no guideline values for total N or P. Studies of post-fire concentrations of dissolved organic carbon are mostly from North America and report generally minor increases after fire, with elevated concentrations reflecting background conditions. The few observations of trace metal concentrations in streams after wildfire found high concentrations that exceeded guideline values for Fe, Mn, As, Cr, Al, Ba, and Pb, which were associated with highly elevated sediment concentrations. In contrast, Cu, Zn, and Hg were below or only slightly above ($\leq$1.2 times) guideline values. Reports of Cl^- and SO_4^{2-} concentrations after wildfire are mostly confined to coniferous forest areas, where maximum sampled values were well below WHO guidelines. Total cyanide concentrations have been observed to exceed guidelines values, although increases are likely to be short-lived. Post-fire stream concentrations of PAHs have been found to increase but were below levels of concern.

In assessing the risk to water supply from wildfires, constituents of concern may be identified according to both the reason for concern (health or aesthetic) and treatability. Determining the risk to human health from short duration exposure to elevated concentrations of many contaminants (such as toxic metals, PAHs) is problematic, given that the guideline values are based on a life-time of exposure. Other constituents may have more rapid health effects from consumption of contaminated water (e.g. cyanides, Cu, NO_2^-) or aesthetic concerns (e.g. Fe, Mn, SO_4^{2-}, Zn). The increased flux of suspended sediment and sediment-associated constituents (particularly metals, nutrients and organic carbon) that can occur after wildfire may necessitate water treatment by coagulation and filtration. At very high sediment concentrations treatment problems may be encountered that reduce or delay the rate of water processing, potentially causing disruptions in supply. For other constituents, such as NO_3^-, NO_2^-, Cl^-, SO_4^{2-}, amenable cyanides, and PAHs, it appears the likelihood that concentrations of concern will occur in water supplies after wildfire is low. However, conventional treatment options are not available for many of these constituents.