Chlorine: Is it really so bad and what are the alternatives?

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Abstract

Chlorine disinfection has been practised for over a century and has been credited with saving a significant number of lives worldwide on a daily basis, but it has received a great deal of negative publicity over the past few decades. The discovery in the 1970's that chlorination of water could result in the formation of potentially harmful trihalomethanes (THMs) caused concern amongst the water treatment fraternity and resulted in authorities reviewing chlorination practices in order to minimise THM formation and the United States Environmental Protection Agency (USEPA) setting maximum concentration limits for THMs in potable water. Many of the manufacturers and suppliers of water "purifiers" and alternative disinfectants exploit this information to their own advantage, misinforming the public regarding the dangers of chlorine, but even in the water treatment industry, chlorine is often misunderstood. Based on their experience in both water and wastewater disinfection and on the findings of a Water Research Commission (WRC) sponsored project into alternative disinfectants, the authors discuss the benefits and disadvantages of chlorine disinfection and compare this to the more promising alternative disinfectants. One of the main perceived advantages is the property of chlorine to maintain a residual and although THM formation can occur under these conditions, the compounds produced are perceptibly less toxic than those produced by some of the alternatives. A number of alternatives, including ozone, UV, peracetic acid, bromine and advanced oxidation are compared to chlorine in terms of their disinfectant abilities, residual effect, by-product formation, cost and ease of use.

Introduction

One of the first documented uses of chlorine was in 1850 by John Snow when he used it to disinfect a water supply in London after an outbreak of cholera (White, 1999). Some years later in the 1890s, hypochlorites were used in Europe as a provisional measure against typhoid epidemics (Baker, 1930) and in 1897 hypochlorite "bleach solution" was used by Sims Woodhead to treat potable water after an outbreak of typhoid in Kent, England (Leal, 1909). Continuous chlorination of potable water supplies began in the early years of the 20th Century in Great Britain and resulted in a dramatic reduction in deaths due to typhoid and other water-borne diseases and shortly thereafter, in 1908, Jersey City, New Jersey began chlorinating potable water supplies. Since then, chlorine has become the most widely used disinfectant for water treatment worldwide, because of its potency, relative ease of use and cost effectiveness.

More recently, chlorine has received negative publicity, mainly due to the discovery in the 1970's that chlorination of water containing organic compounds could lead to the formation of trihalomethanes (THMs), which are suspected of having detrimental health effects (White, 1999). Manufacturers and suppliers of water filtration devices and alternative disinfectants have used this information to their advantage, sometimes even employing scaremongering techniques and generally misinforming the general public regarding chlorine disinfection. This paper discusses the benefits and disadvantages of chlorine disinfection, attempts to put the THM concerns into proper perspective and based on the findings of a WRC sponsored project which was recently conducted by the authors, describes various alternative options available for disinfection and how they compare to chlorine in terms of disinfection efficiency and cost.

This paper was originally presented at the 2004 Water Institute of South Africa (WISA) Biennial Conference, Cape Town, South Africa, 2-6 May 2004.

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The importance of disinfection

The importance of disinfecting potable water cannot be underestimated. Life Magazine (*Life Magazine*, 1998) ranked water purification and disinfection 46th in its list of top one hundred advances of the millennium. The true value of disinfection first became evident as early as 1893, when two public health researchers, Mills and Reincke, after studying a large number of communities, discovered that when a contaminated water supply was replaced with a purified water source, the general overall health of the community improved significantly, far beyond what would be expected by accounting for the reduced incidence of typhoid and other typical water-borne diseases. This discovery became known as the Mills-Reincke phenomenon (White, 1999). A few years later in 1903, a pioneer in the water works industry, Allen Hazen, found that when a community water supply of bad quality was replaced by an adequately treated one, for every life saved due to typhoid, three others were saved from death by other causes, many of which were not thought to have any connection with, or to be affected or influenced by, the quality of the public water supply. This change in the death rate once water is adequately treated is known as the Hazen theorem and proves that disinfection of public water supplies far exceeds the effect of controlling water borne diseases (White, 1999).

Numerous references can be found attesting to the significant beneficial effects of disinfection. Figures which put this effect into perspective come from the United States; in 1900 the death rate from typhoid was 36 per 100 000 population, this dropped to 20 per 100 000 in 1910, 3 per 100 000 in 1935 and by 1960 only 20 people were recorded as having died from typhoid throughout the entire USA (Laubusch, 1964; Tiernan, 1948). Today, typhoid is virtually unknown in the USA and other developed countries. This dramatic reduction in the typhoid death rate can be attributed almost entirely