Survival of *Vibrio cholerae* in industrially polluted water, with particular reference to iron concentrations

Mrudula Patel*, Margaretha Isaäcson and Hendrik J Koornhof

Department of Clinical Microbiology and Infectious Diseases, National Health Laboratory Service and University of the Witwatersrand, Faculty of Health Sciences, Private Bag 3, Wits 2050, South Africa

Abstract

High levels of iron are often found in surface waters due to the discharge of iron-containing industrial effluents. The effect of iron as well as pH on the survival of *Vibrio cholerae* (non-O1, El Tor and classical strains) in water samples from 12 points, where selected industrial effluents were discharged into rivers, was studied. All three *V. cholerae* strains survived longest during spring. *V. cholerae* non -O1 survived significantly longer than El Tor and classical strains. At pH 8.0, the survival of *V. cholerae* increased with increase in iron concentration (1 to10 mg/ℓ) of polluted water. At lower than pH 8.0, the effect of iron was not significant. In polluted water, at pH 8.0, the presence of iron resulted in prolonged *V. cholerae* survival at lower concentrations than those required for survival in distilled water. We suggest that chemical contamination of water may be one of the important factors instrumental in the subsequent ability of *V. cholerae* to persist, multiply and survive in the aquatic environment.

Keywords: Vibrio, *Vibrio cholerae*, *V. cholerae*, iron, pH, industrial effluent

Introduction

Industrial pollution of surface and groundwater may pose a variety of health threats, particularly in heavily industrialised areas where the quality of raw water tends to deteriorate. The pollutants are mainly inorganic and organic chemical compounds depending on the type of industries around the water source. It is important to understand the impact of specific pollutants of industrial effluents on plants, animals, humans and micro-organisms. This study has researched only the effect of iron and pH on cholera-causing micro-organisms.

High levels of iron may be found in surface waters as a result of the discharge of certain industrial effluents. Iron often enters streams in a soluble form but rapidly becomes insoluble. In surface waters, iron commonly occurs in two oxidation states, ferrous (Fe^{2+}) and ferric (Fe^{3+}). The redox potential and pH of the aquatic environment play major roles in determining the behaviour of this metal in water. In the presence of oxygen, ferrous iron is oxidised to the ferric state, which precipitates. Iron in surface waters is therefore usually found as a colloid suspension of ferric hydroxide, which may settle out and harden to a cement-like material. However, in the presence of oxygen and pH values of less than 3.0, the soluble ferric state of iron is dominant, while under neutral and alkaline conditions, ferric hydroxide and ferric oxide complexes are formed. In reducing conditions, ferrous iron may persist and occur in high concentrations, provided that sulphides and carbonates are absent (Ford and Dana, 1963; DWAF, 1996).

In a previous study on *Vibrio cholerae* survival in distilled water with pH values between 7 and 9 without added nutrients, except for varying quantities of ferric oxide, increase of the latter was associated with enhanced survival (Patel and Isaäcson, 1995). At pH 7, survival enhancement was optimal at iron levels ranging from 0.1 g/ℓ to 1.0 g/ℓ, whilst at pH 9 it was optimal at iron levels ranging between 0.01 g/ℓ and 0.1 g/ℓ. These findings stimulated the current investigation in which industrially polluted waters from the heavily industrialized Gauteng province in South Africa were used for further study. These waters which contained a wide range of iron and pH levels, were collected and inoculated with *V. cholerae*, the survival of which was then monitored over a period of time.

Methods and materials

Water sampling sites

To monitor pollution, Rand Water, Vereeniging, a major South African water supply company, routinely inspects the catchment areas from which it draws raw water. Regular samples of river water are subjected to chemical, bacteriological and biological analyses. The samples used in this study were collected from these same catchment areas.

Twelve water sampling points where industrial effluents are discharged into rivers or streams were selected to represent a broad range of iron concentrations. These points had shown fairly consistent iron levels during the previous 10 years (Rand Water Board, 1987).

Collection and pre-inoculation testing of water samples

Following a study conducted by ourselves in 1989, which illustrated the effect of iron on survival of *V. cholerae* in distilled water (Patel and Isaäcson, 1995), it was decided to collect water samples containing industrial effluent in order to study the effect of iron under natural conditions. Samples of approximately 5 ℓ water were collected monthly from April through January from each sampling point in chemically clean plastic bottles by Rand Water who also

* To whom all correspondence should be addressed.
☎ +2711 717 2113; fax: +2711 717 2027;
e-mail: Patelms@dentistry.wits.ac.za
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