Reverse Osmosis: A Key Process for Controlling Drinking Water Quality for Laboratory Animals

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Abstract
Reverse osmosis is a water purification process that removes 95-99% of most water contaminants including microorganisms, organic compounds, and dissolved inorganic compounds. Contaminant concentrations in municipal water supplies have wide seasonal fluctuations. Therefore, simply filtering and disinfecting municipal water may not provide water of reliable and controlled quality for laboratory animals, particularly in animals developed for highly refined applications such as specific-pathogen-free, immunocompromised, transgenic, and knock out animals. Using reverse osmosis, the animal facility can remove contaminants from animal drinking water. Contaminants removed by reverse osmosis include; microorganisms, microbial by-products such as endotoxins and pyrogens, and many carcinogenic compounds. These contaminants add uncontrolled variables to research involving laboratory animals and can adversely affect animal health.

Introduction

Osmosis is defined as the movement of a dilute solution through a semi-permeable membrane into a solution of higher concentration that tends to equalize the concentrations of the solutions on both sides of the membrane[2]. For example, if equal amounts of unfiltered tap water and pharmaceutical water for injection were placed on either side of a semi-permeable membrane, much of the purified water would cross the membrane into the tap water, making the tap water more dilute. Depending upon the permeability of the membrane, some of the contaminants would also cross into the pure water side until both sides had equal concentrations of contaminants that are able to cross the membrane (Figure 1).

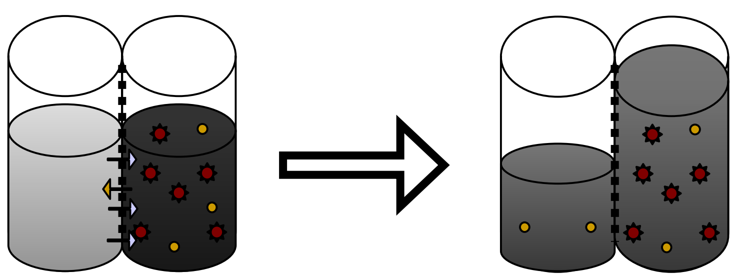

Figure 1. Osmosis. During osmosis, particles pass from areas of high concentration to areas of low concentration as allowed by the pore size of the membrane. Fluid passes from areas of low concentration to areas of high concentration

Reverse osmosis uses the concept of osmosis and applies pressure to the side of the membrane containing the concentrated solution, with the result that the fluid is forced through a specialized membrane. Solution contaminants are removed, resulting in a purified, dilute fluid. Using the above example, if equal amounts of unfiltered tap water and pharmaceutical water for injection were placed on either side of a reverse osmosis membrane, during reverse osmosis, water is forced from the tap water side into the purified water side. However, due to the nature of the membrane and the applied pressure, the contaminants do not cross the membrane (Figure 2). Ninety-five to 99 percent of organic compounds, dissolved ions, heavy metals[8], and microorganisms (bacteria, fungi, and viruses) can be removed from water with reverse osmosis[3].

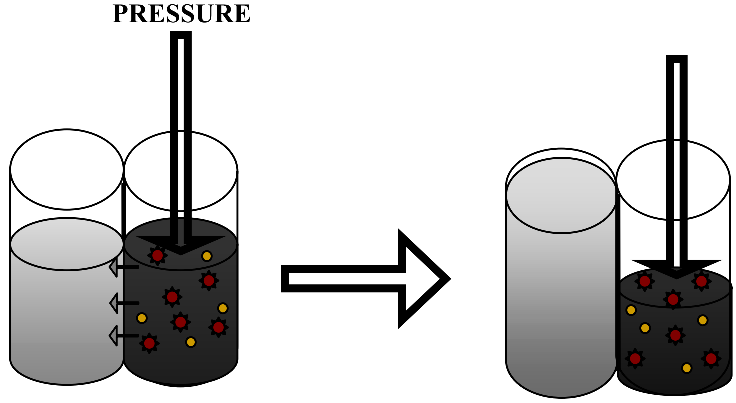

Figure 2. Reverse Osmosis. During reverse osmosis, fluid passes from areas of high concentration to areas of low concentration because pressure forces fluid through the membrane. Because the membrane does not contain true pores, most contaminants cannot pass through the membrane[7].

Advantages of Reverse Osmosis for Purification of Laboratory Animal Drinking Water

According to the Guide for the Care and Use of Laboratory Animals "ordinarily animals should have continuous access to fresh, potable, uncontaminated drinking water, according to their particular requirements"[7]. No other uniform standards exist for laboratory animal drinking water quality. However, current animal research trends demand control of as many variables as possible. Highly specialized animal housing environments have been developed, such as barrier facilities, ventilated housing, and isolator systems. Air, humidity, feed, and lighting are carefully monitored and controlled. Water quality is emerging as another important, and often uncontrolled, variable in research involving laboratory animals. Reverse osmosis is a key process for improving control of water quality.

Drinking water for laboratory animals is usually treated with a disinfectant biocide at the animal facility. Chlorination and acidification are commonly used disinfectants and are effective for controlling most bacterial contaminants of drinking water. However, disinfectants react with organic compounds in water creating disinfection byproducts (DBPs). Many DBPs are carcinogenic (cancer causing), a factor that is important in animals used for cancer and toxicology research. Reverse osmosis removes most organic compounds from water prior to the facility disinfection process, thus reducing availability of compounds to react with disinfectants and reducing the production of DBPs[9]. Similarly, disinfectants kill bacteria causing formation of pyrogens and endotoxins (by-products of bacterial death). Reverse osmosis effectively removes pyrogens, endotoxins, and bacteria from the incoming water, thus, removing bacteria from the product water, and therefore, dramatically reducing bacterial byproducts in the animal drinking water[10].

Although quality of municipal water is regulated, concentrations of contaminants such as total dissolved solids and heavy metals fluctuate considerably. Furthermore, despite treatment, water supplies can become contaminated with microorganisms such as cryptosporidium, giardia, and viruses that cause gastroenteritis[5]. These microbial contaminants are not adequately controlled by chlorination or acidification. Therefore, contamination of municipal water can affect animal health and add an uncontrolled variable to research using laboratory animals. Reverse osmosis removes these microbial contaminants from animal drinking water[3].

Many municipal water systems are quite old. Water mains loose pressure and sometimes even form partial vacuums during breaks, fire flows (water used to fight fires), and other repairs. Loss of pressure causes “back-siphoning” during which contaminants are drawn into the water system[1]. Reverse osmosis purification protects animal drinking water from unexpected contamination due to aging or damaged municipal water systems.

Inorganic compounds and heavy metals such as arsenic, lead, and mercury, as well as residue from pesticides and herbicides, contaminate public water supplies from time to time[4]. These compounds are carcinogenic and introduce an uncontrolled variable into research involving laboratory animals. Carcinogenic compounds could have particularly adverse affects on research data from immunocompromised animals, and those used for cancer and toxicology research. Reverse osmosis purification of drinking water is an effective way to control exposure of laboratory animals to water-borne carcinogenic contaminants.

Water Treatment for Quality Laboratory Animal Drinking Water

Although highly effective for removing contaminants from water, reverse osmosis cannot be used as the sole process for water treatment for two reasons. First, reverse osmosis membranes can become “fouled”. Fouling occurs when organic material in water deposits on the membrane leading to bacterial overgrowth. Hard water causes scale to form on the membrane over time, further contributing to membrane fouling. Secondly, no process can remove absolutely all microorganisms, therefore, bacteria will eventually grow in water tanks and piping even after reverse osmosis treatment. Therefore, an effective water quality program involves pretreatment of water with filtration and disinfection, followed by reverse osmosis, concluding with a maintenance level of disinfectant biocide such as chlorine, acidification or ozone.

Conclusions

Public water supplies contain many contaminants that can potentially affect research involving laboratory animals. Adding chlorine or acid as disinfectants may not adequately control microbial contaminants. Reverse osmosis, combined with pretreatment filtration and post-treatment disinfection, allows the animal facility to provide consistent, high quality drinking water for laboratory animals.

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