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City Council
Sacramento, California

APPROVED
BY THE CITY COUNCIL
AUG 30 1983
OFFICE OF THE
CITY CLERK

Honorable Members in Session

SUBJECT: Chlorination Disinfection By-Products - City of Sacramento's Drinking Water

SUMMARY

An overview of the chlorine disinfection process utilized at American and Sacramento River Water Treatment Plants.

BACKGROUND

Prior to 1900, water used for drinking by U.S. Citizens was not disinfected. As a result of this practice, massive outbreaks of water-borne diseases occured in epidemic proportions. The most serious of these were typhoid and cholera. In Sacramento, California there was a massive outbreak of cholera in the 1850's which caused a large number of deaths. People were literally abandoning their families as they fled the City. A mass burial site still exists at the Broadway Cemetary to remind us of the danger of drinking water which is not sanitarily protected.

Since 1900, the practice of disinfecting drinking water by adding liquid chlorine (chlorination) has virtually eliminated typhoid, cholera, and dysentery as diseases of importance in this country. Disinfection is the principal and most common objective of chlorination.

The first chlorination processes used by the City utilized a principle of forming chlorine-ammonia compounds which would kill bacteria and other microorganisms present in the water supply. Although these compounds were effective in protecting the sanitary quality of the water, they also imparted a medicinal taste to the water.

In 1945, the break-point chlorination process was discovered where chlorine is added in sufficient quantity to break down chlorine-ammonia compounds. This results in a free chlorine residual which provides for powerful disinfection without resultant tastes or odors. This process is currently used for disinfecting the City's drinking water (see Exhibit A).

The process has worked well for a number of years. The water is free of organisms and few complaints are received. As with any panacea, it was short-lived. In 1974, new research and improved analytical technology demonstrated that the powerful free chlorine residual reacts with certain natural materials in river water, primarily humic and fulvic acid, to form new compounds. These compounds are collectively called trihalomethanes (THM), and are individually identified as chloroform, bromoform, dibromochloromethane, and dichlorobromomethane. Of these compounds, chloroform is the compound found in the greatest concentration.

HEALTH EFFECTS

Chloroform and other trihalomethanes are now known to be formed without execption during break-point chlorination of drinking water. Because of this, intense international research programs have studied all aspects of the problem.

Research has indicated that these compounds are suspected carcinogens1/. This prompted the Environmental Protection Agency (EPA) to amend the national interim primary drinking water regulations to include a maximum contaminant level(MCL) of 100 parts per billion(ppb) for total trihalomethanes. Drinking water containing less than this level is considered to be free from chronic or acute effects on human health. This is a legal standard and has been adopted by the State of California, Department of Health Services (DOHS).

The City has been monitoring trihalomethane levels for over two years. Results show that we have never exceeded the standard and can anticipate an average concentration of less than 50 ppb at each of our plants and, throughout our water distribution system. Staff will continue to monitor the drinking water for trihalomethanes on a quarterly basis. Results are routinely reported to the State Department of Health Services.

METHODS TO REDUCE TRIHALOMETHANES

The City is fortunate that levels of trihalomethanes in our drinking water are well below the concentration established as a health hazard. Viable alternatives to remove these compounds are expensive and limited. These alternatives are:

1. Changing The Site of Disinfection

   It has been documented that adding chlorine further into the water treatment process is a viable way to reduce the levels of trihalomethane formation. There are a number of reasons for this. The primary one being the precipitation of precursors2/ in the sedimentation basins. This alternative would certainly be the least expensive to implement requiring only the capital expenditures necessary to reroute chlorine to the desired application point. This alternative does have major disadvantages, however, which prevent staff from recommending implementation. Chief among these is the fact that far less contact time of chlorine with water will be allowed for microorganism kill. The disinfection system will be made less reliable, thus the chance for disease causing organisms to remain in the drinking water will increase.

1/ a substance that tends to produce cancer.
2/ a substance from which trihalomethanes are formed.

2. Oxidation of Precursors Prior to Adding Chlorine

Several oxidants have been evaluated to determine whether they would alter precursors so they would not react with chlorine to form trihalomethanes. The oxidants studied were ozone, chlorine dioxide, potassium permanganate, ultraviolet radiation, and hydrogen peroxide. Each of these chemicals had some effect in lowering the trihalomethane formation by altering the percursors. However, it was found that high dosages of these chemicals were necessary making these processes very expensive. It was also found that other by-products were formed which would require thorough research into health ramifications of these unstudied by-products. This approach is in the experimental stage.

3. Adsorption

Because trihalomethanes are organic compounds, adsorption with activated carbon either in a powdered form dosed as a slurry, or as a granular bed is effective in removing these compounds. The principal drawback is the extreme high cost of these systems. If the City implements either granular or powdered activated carbon treatment, it is estimated that the total cost to treat the water would double.

4. Alternative Disinfectants

A great deal of research has been done to evaluate alternatives to free chlorine as a water disinfectant. Free chlorine has many advantages. It ensures the destruction of disease organisms during the treatment process and maintains residual disinfecting powers throughout the distribution system. It is easy to test for both at the water treatment plants and in the water distribution system. Finally it is by far the least expensive method to safely disinfect our drinking water.

Alternatives are chloramines (reverting to the chlorine-ammonia system and resultant bad taste), chlorine dioxide, ozone, potassium permanganate, hydrogen peroxide, bromine, iodine, ferrate, high pH, and ultraviolet radiation. Of these, only chloramines, chlorine dioxide, and ozone have been considered feasible for large scale domestic water disinfection.

The major advantages of using alternative disinfection systems is the ability to lower trihalomethane concentrations to near detection limits. Of these three viable alternatives, chlorine dioxide and ozone are powerful disinfectants, while chloramines are weaker disinfectants which may be barely adequate to ensure sanitary quality.

The disadvantages of using alternative disinfectants is that they are all oxidants which will produce by-products which may be as undesireable as chloroform. Thus, while the trihalomethane level is lowered, the overall water quality may not be improved because the health hazard of the new organic by-products have yet to be evaluated.

Finally, none of these alternatives has the advantages of chlorine in terms of reliability and cost to safely disinfect drinking water. Additionally it may be extremely difficult to persuade the regulatory health agency (DOHS) to allow use of alternative disinfectants.

FINANCIAL

There is no financial liability or cost associated with this report.

RECOMMENDATIONS

I recommend that the current practice of break-point chlorination for disinfecting the City's drinking water be continued since it is the most cost effective and reliable method to achieve drinking water which is free from disease causing organisms. The by-products of the current disinfection process are well below the levels considered to be a health hazard.

Respectfully submitted

John F. Varozza

John F. Varozza
Director of Public Works

Recommendation Approved:

Solon Wisham Jr.

For: Walter J. Slipe, City Manager

LH:rg
attachment

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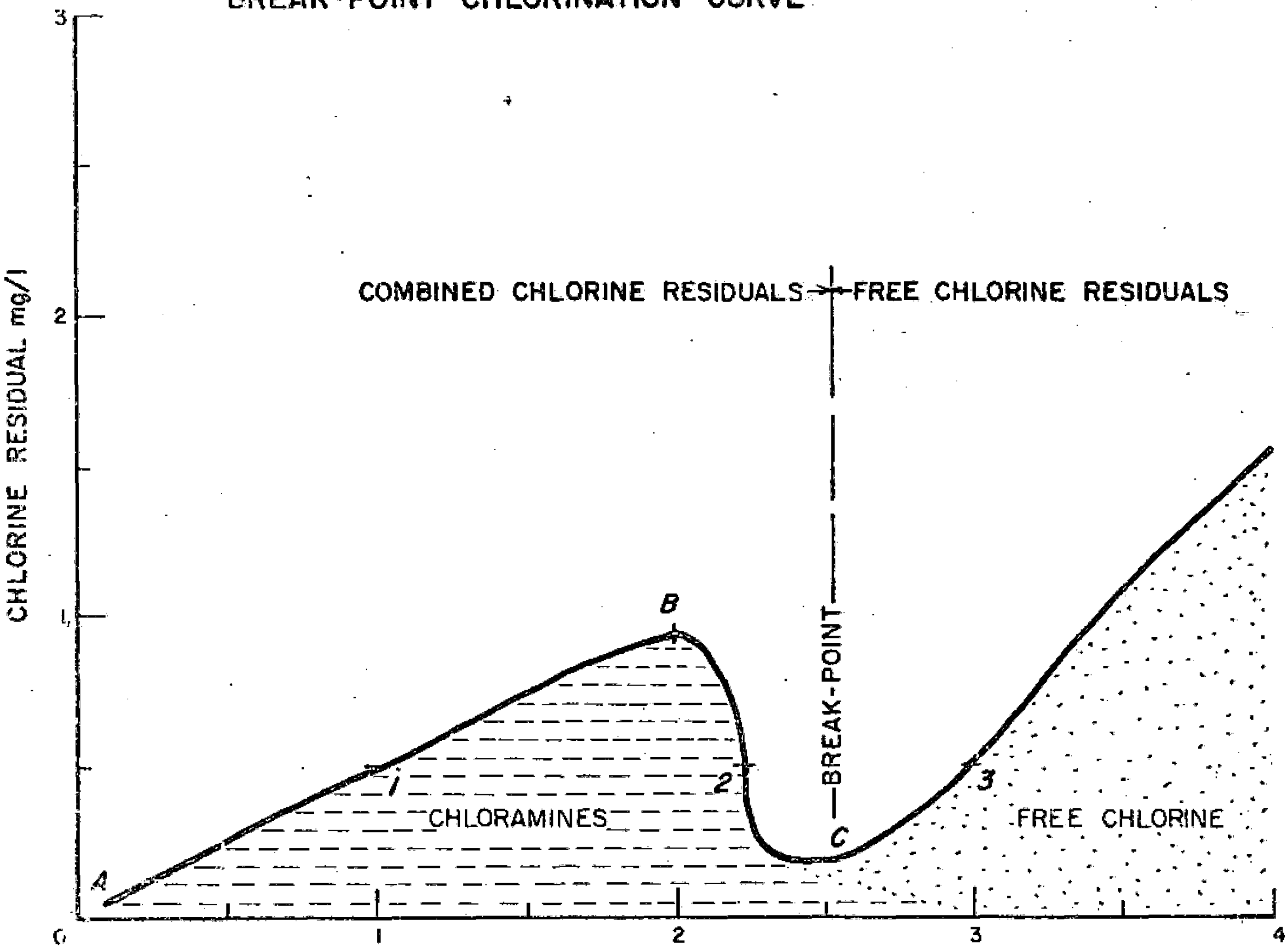
August 30, 1983
All Districts

BREAK-POINT CHLORINATION CURVE



mg/l = Milligram per liter

From point *A* to *B*, chlorine is in a combined form as chloramine.

At point *B* sufficient chlorine potential is present to break apart the combined form.

At point *C* the oxidation-reduction reaction is complete, most of the chlorine being consumed and no longer showing any appreciable residual.

At point *1* is the region of possible taste and odor difficulties.

Point *2* is in the region of chlorine utilization.

Point *3* represents optimum chlorine dosage after "break-point" at point *C*.

Note: The average concentrations of chloramines and free chlorine residual present in city drinking water.

	Chloramine mg/l	Free chlorine mg/l
American River plant	0.03	0.30
Sacramento River plant	0.03	0.35