Journal of Environmental Sciences Vol. 15, No. 6, pp. 863—864, 2003

ISSN 1001-0742
CN11—2629/X

Article ID: 1001-0742(2003)06-0863-02 **CLC number**: X830.2 **Document code**: A

Development of thermochromic strips as a water pasteurization indicator

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Abstract: Boiling of water, for purification, commonly practiced in the world, has many problems associated with it like danger of scalding, scaling in the vessels, removal of useful minerals and blandness of taste etc. Water can be made safe for drinking simply by heating at 65℃ for 6 minutes. A colour indicating strip was developed which changes colour from red to purple at 67℃. Use of this strip can help in pasteurizing water without the above problems and with considerable energy saving.

Keywords: thermochromic strips; pasteurization indicator; Pakistan

Introduction

According to the United Nations Children's Fund(UNICEF) about 60% of rural families and 23% of urban families in developing countries are without safe drinking water and in some areas the water supplies may be heavily contaminated with pathogenic organisms. Outbreaks of water borne of infectious diseases like hepatitis are thus common in many parts of the world(Hammer, 1996).

Diarrhea, a common disease of children in the developing countries, is caused by the use of microbially contaminated water. Dehydration, resulting from diarrhea, is the leading cause of death in children, under the age of five, killing an estimated five million children annually(Andreatta, 1994).

Microbially contaminated water is usually boiled to make it free of microbials and safe for drinking. Boiling of water, commonly practiced, has many drawbacks associated with it, like danger of scalding, scaling of the boiling vessels, removal of useful minerals and blandness of taste(caused by the removal of minerals and dissolved oxygen).

It is generally known that heating water at 65℃ for six minutes will kill most of the microorganisms (Andreatta, 1994). The process is known as pasteurization a term is usually associated with milk. Pasteurization of water, performed at a lower temperature than boiling, can result in considerable savings in fuel costs with associated economic benefits.

In order to do this, however, we need to have a convenient method of knowing, if and when, the water being heated has attained the critical lower temperature of 65℃. The present work describes the development and use of an indicator strip for this purpose that has been found to be very convenient and effective in use.

1 Methods

1.1 Thermochromic indicator strips

Paste of a thermochromic compound was prepared by following the method of Hughes(Hughes, 1998) by using sodium metabisulfite as the reducing agent. The thermochromic paste was then applied to an ordinary filter paper and dried. The dried paper was cut into strips, which were subsequently laminated with plastic. The result was a low cost, plastic coated strip, which would change colour from "red" to "purple" at 67℃. The change is very sharp, easily noticeable and totally reversible. These characteristics make the strip an ideal indicator that can be conveniently used in monitoring the pasteurization temperature (65℃) of water.

1.2 Pasteurization of water

500 ml of tap water was heated on a Bunsen burner. The temperature was frequently monitored by dipping the above mentioned strip in the water. When the strip exhibited a colour change from red to purple the flame intensity under the water was reduced. This temperature monitoring was continued for 6—7 minutes, in order to get pasteurized water. The procedure was applied to a number of water samples for replication purposes.

1.3 Standard coliform test

The standard total coliform test was performed on all the "pasteurized" and "unpasteurized" water samples, using the Standard Membrane Filtration Method(Eaton, 1995).

1.4 Dissolved oxygen determination

Dissolved oxygen contents of both the "pasteurized" and "unpasteurized" water samples were determined by "Oximeter Oxi538 WTW". Before DO determination pasteurized water was given sufficient time for cooling(approximately one and a half hour).

2 Results and discussion

An average of twenty nine coliform colonies(in the incubated petri dish) along with other non-coliform colonies were observed for "unpasteurized" water samples, whereas, no such colonies were present in the dish prepared by "pasteurized" water samples. This shows the effectiveness of the process.

In general, heat kills microorganisms by denaturing their proteins. Above 50℃ most of the protein molecules become denatured. The denaturation of essential proteins, such as enzymes, hormones, antibodies, transport and structural proteins by heat are well known(Levinson, 1996). Heat disrupts "hydrogen bonds" which hold protein chains together in their secondary and tertiary structures. Loss of tertiary structure of a native protein results in loss of biological activity of the microorganisms and their death(Sleigh, 1994).

The pasteurization process, which is used primarily for milk, is equally effective in killing germs present in contaminated water. Pasteurization of water consists of heating a water sample to 65℃ for 6 minutes, or to a higher temperature for shorter time. This much heat is sufficient to kill the vegetative cells of most of the microorganisms including pathogens.

The solubility of oxygen in water reduces considerably with the rise in temperature and is almost nil in boiling water. If the dissolved oxygen(DO) and minerals in water are removed, the taste of water becomes undesirable. As expected, our investigations show that loss of DO in "pasteurized" water samples, heated only to 65℃, is far less than that of boiled water samples, where almost all the DO is removed. Obviously, if the pasteurized water is given sufficient time for cooling it re-dissolves oxygen from air more quickly than the boiled water. In our study 500 ml of pasteurized water achieved the value of DO equivalent to normal tap water(7.8 mg/L) in approximately one and half hours. This period is almost 2.5 times less than that required by the same volume of boiled water to achieve the same DO level. Hence, pasteurized water is not spoiled in taste or appearance.

3 Conclusions

The plastic coated colour-indicating strip developed by the authors is very efficient in identifying the water pasteurization temperature. Use of, these strips could help in providing good quality, palatable water to the user with considerable energy saving. The strips could also find application in effective disinfection of water through solar heating, replacing the Soya been fat filled tube plastic tube, generally recommended for this purpose(Andreatta, 1994). As such, these could be of immense value to the relief workers in times of crises resulting in overcrowded situations following floods, earthquakes or influx of refugees and so on.

Acknowledgements: Mr. Muhammad Basharat and Mr. Idrees Ahmed, IESE members of the laboratory staff are to be thanked for their assistance.

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(Received for review August 5, 2002. Accepted September 8, 2002)