Physical and Bacteriological Properties Fluoridated Bottled Drinking Water

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Abstract

Fluoride (F) has a big role to prevent dental caries by strengthening tooth structure. Indonesian community has limited source of F. Fluoridating tap water can be a way to increase F consumption, however, it is currently difficult to apply in Indonesia due to technical reason. The community is increasingly consuming bottled water, therefore, fluoridating bottled drinking water can provide alternative solution. Organoleptic tests showed that consumers can accept the taste, color, and odor that appear at fluoridated bottled drinking water. However, the stability of F in bottled drinking water after storage and exposure to the sun remains to be established. This study investigated, physical and bacteriological properties of fluoridated bottled water stored at room temperature and expose to sunlight. Quasi-experimental research design was made with two groups of bottled water: non-fluoridated and fluoridated, each stored in sealed glasses at room temperature and exposed to sunlight. Measurements of pH, total dissolved solids (TDS), bacterial count, and turbidity were taken at weeks 1 and 4. Independent t test was performed to determine differences in the physical properties of two group of bottled water. No differences in salivary pH, TDS, turbidity, bacterial count between non-fluoridated and fluoridated bottled drinking water. There were differences in the physical and bacteriological properties between samples that were exposed to the sun and those un-exposed. Bottled drinking water stored at room temperature and un-exposed to the sun were performing better. Fluoridated bottled drinking water is safe for consumption based on bacteriological testing and physical properties.

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Introduction

Fluoride plays an important role in the caries preventive measures. Adding fluoride in the oral environment will improve remineralization.[1] Fluoridation can be administered systemically and topically. Based on a research, it was found that administration of fluoride in small doses and given regularly throughout life is the most appropriate method for improved resistance from attack dental caries.[2] In this case, use of fluoride toothpaste and fluoride in drinking water is the most appropriate method.

In Semarang, Indonesia, fluoridation of public water sources remains difficult to implement. The Regional Water Company (PDAM) has not yet possessed the capability to produce stable fluoridated water at affordable price.[3] Fluoridation of bottled drinking water, which is increasingly consumed in Indonesia due to its practicality and affordability, can provide an alternative to the effort to increase F uptake within the community. A previous research showed that concentration of F added to water stored in sealed containers at 0.7 ppm at room temperature remained stable after 1, 4 and 8 weeks, However, those which were unsealed were not stable.[4] Organoleptic tests also showed that the taste, color, and odor of fluoridated drinking water were acceptable by consumers.

Further applicative research needs to be done before fluoridated bottled drinking was to be widely distributed to the public. The addition of fluoride is likely to increase the amount of dissolved solid in water. Fluoridated bottled drinking water is also likely to be stored and exposed to the sunlight prior to distribution. Sun

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exposure could foster growth of pathogenic microbes which may increase pH and turbidity. The study aims to test possible chemical and bacteriological changes in fluoridated bottled drinking water due to sun exposure and length of storage at room temperature.

Methods

Research design used in this study was a quasi-experiment with in vitro approach. Sample size was determined using the Federer formula:

(T-1) (n-1) ≥ 12
(6-1) (n-1) ≥ 12
n = 4

A total of 24 fluoridated bottled drinking water were sample and 24 non-fluoridated bottled drinking water were used as controls.

Variable to be measured were pH, turbidity, dissolved solids, the number of bacteria before and after storage at room temperature and exposed to sunlight.

Data collection

1. Fluoridated bottled drinking water were prepared by adding Na F to raw pure water at 0.7 ppm, filtering the mixture, adding active carbon, micro filler and disinfectant it prior to bottling and sealing.
2. Bacterial counting was conducted following the standard method of SNI 01-2897-1992 (Microbial Contamination Test Methods).
3. TDS was analyzed using method set out in SNI 01-3554 (Drinking water Test Methods).
4. pH were performed using pH Meter following SNI 01-3554 (Drinking Water Test Methods).
5. Turbidity of drinking water was analyzed following SNI 01-3554.

Data Data collection

Factorial ANOVA test followed by Post Hoc Test were used to determine the effect of storage and sun exposure to the bacterial count, TDS, pH, and turbidity.

Results

Water used in this study was made available by JAVA TIRTA, a water bottling company whose source of raw water is that of the Ungaran Mountain in Central Java. Fluoridation to 0.7 ppm was conducted in the Chemistry Laboratory of the laboratory of Poltekkes Kemenkes Semarang.

Figure 1. Drinking Water Exposed by Sunlight.

Figure 2. Storage Drinking Water at Room Temperature.

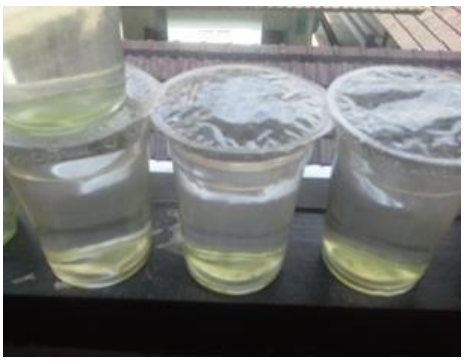

Figure 3. Mushroom at the Plastic Glass.

The results showed that there were no differences in TDS and turbidity between fluoridated and non-fluoridated samples. Escherichia Coly and Pseudomonas sp. were not detected in both groups of water, but there was a slightly differences in total bacterial count, although the difference was not statistically significant (p = 0.15). This result refers to Table 1.

Drinking water	pH± SD	TDS	Turbidity (JTU)	Bacterial Test		Bacteria count ± SD (CPU)	Independent t test (*p*)
				Esch Coli	Pseudo sp		
NaF	6.94±0.05	40	0.1	Neg (-)	Neg (-)	0.94 ± 0.09	0.07
Without NaF	7.02±0.06	40	0.1	Neg (-)	Neg (-)	1.04 ± 0.09	0.15

Table 1. Mean ± Standard Deviation (SD) of Parameter Measurement of NaF Drinking Water and Without NaF (n = 5) First Week.

The results were following the physical, chemical and bacteriological requirement for drinking water quality.[5] Water turbidity which is measured by a scale turbidimeter with NTU (Nephelometry Turbidity Units), for example, according to the Indonesian Ministry of Health, should be a maximum of 5 NTU.[6]

In this study, the fluoridated and non-fluoridated drinking water has very small levels of turbidity, hence safe for consumption prior to storage. After storage, the turbidity levels remained low. Nonetheless, this study showed that turbidity of fluoridated drinking water exposed to sunlight increased, while those un-exposed to the sunlight.

Discussion

Drinking water's pH is also an important quality indicator. Water acidity can affect water circulation in the body. The level of water pH is strongly influenced by its mineral concentration and compositions. Standard water pH is 6.5 -8.5, below which is considered acid and above which is considered alkaline.[7] The initial pH of both fluoridated and non-fluoridated water samples was 7, most likely due to the properties of the source water. The spring in the Ungaran Mountain where the water came from was quite pristine, uncontaminated and fresh with neutral pH.

After storage of one month, a significant change in pH was recorded. The pH of fluoridated water samples' stores at room temperature and un-exposed to direct sunlight rose to 8.2. At these pH levels, the water remained safe to be consumed. In contrast, the pH of water samples that were exposed to sunlight rose to around 10, which is unsafe to be consumed. Elevated pH in water to > 8.5 indicates an increase in solids that can provide medium for bacterial growth. Fluoride with form of varnish can protect teeth surface from demineralization process by inhibit bacterial growth and increase remineralization.[8] A research conducted in Wajo district found high level of fluorine at cooked water consumed by community has effect of gingivitis even severe.[9] Likewise, if the water is too acidic i.e. pH below 6.5, it can also be detrimental to human health, with symptoms including indigestion, fatigue, pain in the joints. This result refers to Table 2.

Drinking water	pH ± SD	TDS ± SD (ppm)	Turbidity ± SD (NTU)
1. Na F at room	8.14± 0.05	57.5± 9.6	0.13± 0
2. Na F exposed sun light	10.01± 0.13	100± 0	0.16± 0.006
3. Non Na F at room	8.15± 0.06	62.5± 9.6	0.29± 0.03
4.Non Na F exposed sun lig	9.75± 0.2	102.5± 5	0.16± 0.005

Table 2. Mean ± Standard Deviation (SD) of Parameter Measurement of NaF Drinking Water And Without NaF (n = 5) at Week 4.

Our study also found the growth of molds in the walls and bottom of the water containers that were exposed to sunlight. Obviously, the stimulate the growth of mycelium in the fungi growth mechanism.[10]

The absence of Escherichia coli and Pseudomonas sp in sealed water samples indicates the lack of contamination. This is following the microbiological; requirement of drinking water standard which must be void of pathogenic bacteria. Drinking water is safe for consumption if it has negative bacterial content (0 cell), with values of TPC < 102 CPU/ml, and bacterial pathogens must be 0 or nil. This emphasized the need for bottled drinking water to be tightly sealed prior to storage. This result refers to Table 3.

This study, however, showed that the bacterial count increased with time. After 4 weeks of storage, the fluoridated bottled drinking water contained more bacteria than before, from 1 CPU/ml t0 1.3 CPU/ml in exposed to sunlight samples. In the non-fluoridated samples, the increase in bacterial count was more extreme after 4 weeks of storage, from 1 CPU/ml to 102 CPU/ml, which exceed the standard requirement for drinking water. Total Dissolved Solid (TDS),

which represents the concentration of ion including salts and minerals, is an important indicator of water quality. The maximum ion content in solution is 500 ppm, above which is considered harmful for consumption, especially if the minerals are dissolved hazardous materials such as arsenic, nitrates etc.

Drinking water	Bacterial test		Microba amount ± SD(CPU)
	Escherichia Coli	Pseudomonas sp	
Na F at room	Neg (-)	Neg (-)	1.33± 0.23
Na F exposed sun light	Neg (-)	Neg (-)	20± 6.9
Non Na F at room	Neg (-)	Neg (-)	120± 0
Non Na F exposed sun	Neg (-)	Neg (-)	112± 49.9

Table 3. Mean ± Standard Deviation (SD) of Parameter Measurement of Microba Amount at Week 4.

We observed an increase in TDS in both fluoridated and non-fluoridated samples after 4 weeks of storage. In samples that were stored at room temperature and un-exposed to direct sunlight, increased from 40 ppm to 57 ppm. TDS of the samples that were directly exposed to sunlight increased from 40 to 100 ppm after 4 weeks storage. This emphasizes the effect of direct sunlight to TDS content in the bottled water. Longer time of storage, therefore, could be assumed to increase TDS even more.

Fluoride modalities in Indonesia develops nowadays, besides water fluoridation another form such as Na F implant and Na F patch has been investigated. Implant is difficult to be applied to children, patch is easier.[11]

Conclusion

This study indicates that fluoridation of bottled drinking water is possible to be applied in Indonesia. However, proper packaging and storage are important to ensure that the physical, chemical and bacteriological requirements for drinking water quality are met quality of the water. Proper sealing, minimum exposure to sunlight and minimum time of storage are desirable.

Competing Interests

No competing interest of all authors.

Author's Contributions

All authors have made substantive contribution to this manuscript, and all have reviewed the final paper prior to its submission.

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