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Comparative Study of Traditional and Modern Drinking Water Storage System

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ABSTRACT

Water is essential for life. If any pathogens present in the water they cause diseases. So the water used for the purpose of drinking should have high quality in order to lead a healthy life. Thus this study was taken with the objective to study the effect of storage of natural water in different vessels like copper, silver, brass, clay pot and plastic container by comparing the number of microorganisms present in the water before and after storage. This study proved that copper vessel is highly effective against water borne pathogens and the other vessels like silver, brass and clay pot is also significantly effective against the microorganism. But the plastic container does not have any significant effect on the microorganism. The physicochemical study revealed that there was a significant reduction of electrical conductivity, total dissolved solids, total suspended solids and biochemical oxygen demand (BOD) in the water stored in copper, silver, brass and clay pot when compared to plastic. The dissolved oxygen value is reduced in plastic vessel when compared to that of the other vessel. This study indicates that the water stored in plastic container contains more number of microorganisms when compared to that of the other vessel.

Key Words: copper vessel, natural water purifier, water borne pathogens, biological oxygen demand (BOD) and E.coli.

INTRODUCTION

Water is essential for life. Without water survival of plants, animals and microorganisms on the earth is impossible. Life on earth is unimaginable without precious liquid called water (Sathyanarayana and chakrapani, 2013). But now a day's people are polluting water resources like ponds, lakes, rivers etc. by disposing waste materials into them. As a result the water gets contaminated and turns turbid which cannot be used for drinking purpose (Dave and Katewa, 2012). Pure water does not contain more number of bacteria.

However, it contains very few numbers of actinomycetes, yeasts, bacillus spores, clostridium spores, euglena, paramecium, autotrophic bacteria and etc. Contaminated water has large amounts of organic matter from sewages, faeces and industrial complex. Coliform bacteria a gram negative, non-spore forming bacilli is the most prevalent bacteria in contaminated water (Sharma, 2012-2013). *Escherichia coli,* is an anaerobic bacteria which is more predominant in gastrointestinal tract of human and animals. But this usually does not harm the living organism, but it is also a clinically important bacteria causing a number of diseases (Friedman *et al.,* 2002). Pathogenic microorganisms cause many harmful water borne diseases. They include polio, typhoid, cholera, hepatitis, shigellosis, salmonellosis, diarrhoea etc. (Sharma, 2011).

So the water used for the purpose of drinking should be in high quality in order to lead a healthy life. The quality of water plays a major role in preventing us from water borne diseases (WHO, 2011).

The water has to be treated before the human consumption. Now a days we are receiving well treated water from Municipal Corporation. But there is a chance for contamination during storage at home. So the water has to be stored in appropriate way to prevent recontamination. Ancient Ayurveda suggest the use of metals like gold, silver, copper and brass for maintaining the purity of water by reducing number of pathogenic microorganisms. Our ancestors mostly used copper vessels for storing drinking water.

Copper vessels shows antibacterial effect against most diarrhoeagenic bacteria including *Vibrio cholerae,* Enterotoxigenic *E.coli,* Enteropathogenic *E.coli, Salmonella entericatyphi* and *Salmonella paratyphi* (Preethisudha, 2012). Storing water in brass vessels is also good for health. Since it is an alloy of zinc and copper it protects against illness (Sreedevisarasan, 2013). Silver vessels shows bactericidal effect against *Shigella dysenteriae, Vibrio cholera* and *Salmonella typhi* within an hour of storage. These microorganisms cause life threatening enteric human diseases (Subbannayyakotigadde *et al.,* 2012). Ancient Mediterranean and Asians are used silver vessels to store foods and beverages from spoilage (Thompson, 1973). They also placed silver and copper coins in water to prevent the growth of microorganisms. Silver dollars were also added to milk to keep it fresh (Hill, 2009).

But now a day's plastic containers are widely used for storing water. Plastic bottles are widely used for storing and drinking water. Plastic containers contain a harmful chemicals includes Bisphenol-A which is an endocrine disruptor (Sarah, 2004). These chemicals leads to early puberty in females, reduced sperm count, obesity, breast and prostate cancer and other serious health issues (Della *et al.,* 2006, Gray, 2008, Kabuto, 2004, National Research Council, 1999, Newbold 2004, Patisaul, 2006].

Thus, this study was taken with the objective of analysing the effect of storage of naturally available water in different vessels like copper, silver, brass, clay pot and plastic container by comparing the physico-chemical parameters and number of microorganisms present in the water before and after storage.

METHODOLOGY

Collection of water samples

Three different waters were used for this study; tap water, well water and pond water. The tap water is collected from PSG College of arts and science, Coimbatore. The well water is collected from a well near Thirumuruganpoondi, Tirupur and the pond water is collected from a pond near Sulur, Coimbatore. The samples which are collected were brought to the laboratory for estimation of physicochemical parameters and microbiological analysis.

Storage of Water Samples

Immediately after taking initial microbial count and physico chemical analysis, the water samples were distributed in different vessels such as copper, silver, brass, clay pot and plastic, covered with sterile silver foil and kept undisturbed at room temperature for three days, while the local area average temperature at testing period was 26^{o}C. Water samples were tested for the presence of microorganisms before and after storage.

Estimation of Microorganisms in the Water

Preparation of Culture Media and Sterilization

The culture media was prepared by dissolving 1.4 g of nutrient agar in 50 ml of distilled water. The media and Petri plates were cotton plugged and tied, then kept in autoclave for sterilization.

Sample Dilution
In order to estimate the microorganisms the sample is diluted. 1 ml of the sample is diluted with 49 ml of presterlised distilled water. The contents were mixed well and kept in the laminar air flow chamber.

Inoculation of the Sample
The sterilized petri plates and media were kept in the laminar air flow chamber. 200µl of the diluted sample is transferred aseptically to the 50 ml of the nutrient agar medium when it attains a hand bearable temperature and mixed well. Then the media were poured into the petri plates and allowed to solidify at room temperature.

In all the prepared petri dish were transferred to the incubator to maintain 37˚c for 24 hours. After 24 hours they are observed and the microbial colonies were counted.

Physicochemical analysis of water
PH: To all the samples before and after storage PH is estimated by using PH meter and the PH values are noted.

Electrical Conductivity: Conductivity is measured by using conductivity TDS meter of all the samples and reported at 30˚C.

Total Solids: A clean dry glass beaker is weighed and 50 ml of the sample is transferred to it. Then it is kept in hot air oven and allowed to dry and the beaker is weighed again. The difference between the initial and final weight of the beaker gives the amount of total solids.

Total Dissolved Solids (TDS**):** Total dissolved solids is measured by using conductivity TDS meter and is expressed in ppm.

Total Suspended Solids (TSS**):** The difference between the total solids and total dissolved solids gives the total suspended solids value.

Dissolved Oxygen: The dissolved oxygen value is measured using the Winkler Method and the procedure is as follows

1) The sample is collected in a 300ml BOD bottle and added 2ml of manganese sulfate solution followed by the addition of 2ml alkali iodide azide reagent.
2) Stopper the bottle without the entrainment of air and mix by inverting the bottle at least 10 times. Allow the precipitate to settle completely leaving a clear supernatant liquid.
3) Then 2ml of conc. Sulfuric acid is added along the sides of the bottle. Stopper the bottle and mix thoroughly until dissolution is complete.
4) Measure 100ml of the solution from the bottle and transfer it into a conical flask.
5) Titrate immediately with 0.025N sodium thio sulfate solution using starch as the indicator.

Biochemical Oxygen Demand (BOD): The basic principle underlying the BOD determination is the measurement of dissolved oxygen content of the sample before and after 3 days of incubation at 26˚C.
1)The sample is collected in 300ml BOD bottle and added 1ml of calcium chloride solution, 1ml of magnesium sulfate solution, 1ml of ferric chloride solution and 1 ml of phosphate buffer solution.
2)After three days the final DO value is noted. The difference between the final and initial DO value gives BOD value.

RESULT AND DISCUSSION

Table 1, 2 and 3 showed the physicochemical parameters of water collected from Tap, Well and Pond respectively before and after storage in different storage vessels. The physicochemical parameters include PH, electrical conductivity, total dissolved solids (TDS), total suspended solids (TSS), total solids, dissolved oxygen and biochemical oxygen demand (BOD).

PH: The PH value was changed in different vessels but the values are under the permissible limits as given by the world health organization.

Electrical Conductivity: The ability of water to carry electric current is its conductivity. When there is a notable increase in conductivity it indicates that the water might got contaminated with polluting agents (National aquatic resource surveys). The conductivity is minimum in tap water when compared with the pond water and well water before storage. After storage for 3 days in different vessels there was a significant reduction in the electrical conductivity of water stored in copper, silver, brass, clay pot when compared to that of the plastic vessel.

Table 1: Physicochemical parameters of water collected from Tap before and after storage in different storage vessels

Parameters	Before storage	After storage for 3 days				
		Copper vessel	Silver vessel	Brass vessel	Clay pot	Plastic container
PH	7.5 ± 0.9	7.8 ±1.0	7.9 ±1.1	7.8 ± 0.6	7.7 ±0.8	7.9 ± 1.2
Electrical conductivity (mS)	660 ± 22	540 ± 21	530 ± 19	540 ± 23	540 ± 27	580 ± 29
TDS (mg L^{-1})	3.42 ± 0.16	2.89 ± 0.09	2.77 ± 0.12	2.77 ±0.21	1.65 ± 0.11	2.77 ± 0.16
Total solids (mg L^{-1})	28 ± 4	18 ± 2	20 ± 2	20 ± 3	18 ± 2	19 ± 2
TSS (mg L^{-1})	24.5 ± 3.80	15.1 ± 1.81	17.2 ± 2.53	17.2 ±1.08	16.3 ± 1.62	16.2 ± 2.07
Dissolved Oxygen (mg L^{-1})	38 ± 5	26 ± 3	32 ± 3	30 ± 4	28 ± 4	30 ± 5
BOD (mg L^{-1})	8 ± 1	0 ± 0	2 ± 0	2 ± 0	4 ± 0	5 ± 0

(The values are represented in ±SD for 6 duplicate in each category)

Table 2: Physico-chemical parameters of water collected from well before and after storage in different vessels

parameters	Before storage	After storage for 3 days				
		Copper vessel	Silver vessel	Brass vessel	Clay pot	Plastic container
PH	7.3 ± 1.1	7.4 ± 0.9	7.3 ± 0.9	7.5 ± 0.8	7.1 ±1.2	7.0 ±1.3
Electricalconductivity (mS)	700 ± 28	620 ± 30	600 ± 29	640 ± 41	600 ± 38	650 ± 32
TDS (mg L^{-1})	19.4 ± 2.2	11.8 ± 1.4	11.8±1.6	11.6±0.9	1.2 ± 0.2	14.2 ± 1.9
Total solids (mg L^{-1})	199 ± 14	103 ± 7	120 ± 5	132 ± 4	93 ± 4	128 ± 6
TSS (mg L^{-1})	179.6±20.7	91.2 ±6.8	108 ±5.1	120.4±5.6	91.8±6.3	113.8±12.2
Dissolved Oxygen (mg L^{-1})	28 ± 2	26 ± 2	25 ± 1	22 ± 0	25 ± 2	20 ± 1
BOD (mg L^{-1})	6 ± 1	2 ± 0	1 ± 0	2 ± 0	3 ± 0	3 ± 0

(The values are represented in ±SD for 6 duplicate in each category)

Table 3: Physico chemical parameters of water collected from Pond before and after storage in different vessels:

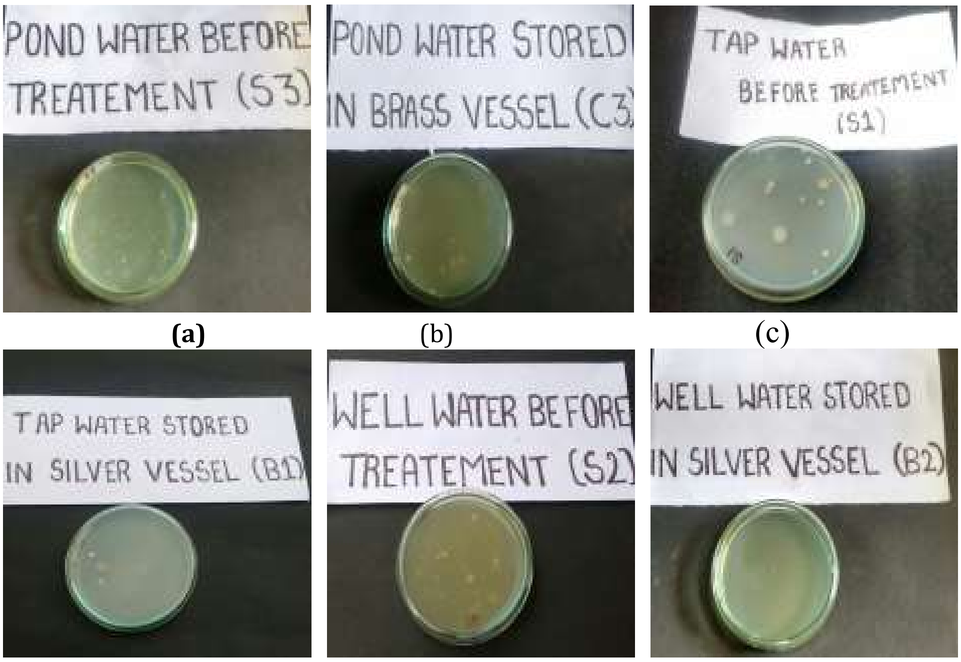
Parameters	Before storage	After storage for 3 days				
		Copper vessel	Silver vessel	Brass vessel	Clay pot	Plastic container
PH	7.7 ± 0.8	8.2 ± 1.2	7.8 ± 1.3	8.4 ± 2.1	7.9 ± 1.8	8.3 ± 1.9
Electrical conductivity (mS)	830 ± 57	750 ± 42	760 ± 38	760 ± 60	750 ± 56	780 ± 62
TDS (mg L^{-1})	88.5 ± 4.2	76.7 ± 3.8	73.2 ± 5.1	78.2 ± 6.8	74.2 ± 11.1	79.3 ± 10.6
Total solids (mg L^{-1})	630 ± 48	600 ± 27	590 ± 26	610 ± 32	580 ± 29	620 ± 32
TSS (mg L^{-1})	541.5 ±46.7	523.3±28.9	516.8±32.7	531.8±31.6	505.8±20.2	540.7±30.8
Dissolved Oxygen (mg L^{-1})	12 ± 2	10 ± 1	10 ± 2	8 ± 2	9 ± 0	3 ± 0
BOD (mg L^{-1})	9 ± 2	3 ± 0	5 ± 1	6 ± 1	6 ± 1	7 ± 1

(The values are represented in ±SD for 6 duplicate in each category)

Table 4: Number of microbial colonies in different water samples before and after storage for three days

Type of storage vessel	Number of microbial colonies per 1ml (from dilution factor) of the water sample		
	Tap water (ordinary)	Well water	Pond water
Before storage	**10,750 ± 220**	**66,750 ± 360**	**75,000 ± 6,000**
After storage			
Copper vessel	3,750 ± 68	8,250 ± 187	14,750 ± 1,200
Silver vessel	4,200 ± 125	12,500 ± 1,100	48,000 ± 627
Brass vessel	7,750 ± 268	15,750±987	53,000±1,607
Clay pot	7,500 ± 800	33,000 ± 2,000	56,500 ± 2,678
Plastic vessel	11,250 ± 231	68,200 ± 1,516	81,500 ± 1,891

(Values are represented as ±SD for 6 duplicate samples)



(a) (b) (c)

(d) (e) (f)

Fig.1: **Number of microbial colonies (per mL) in different water samples before and after storage for 3 days**

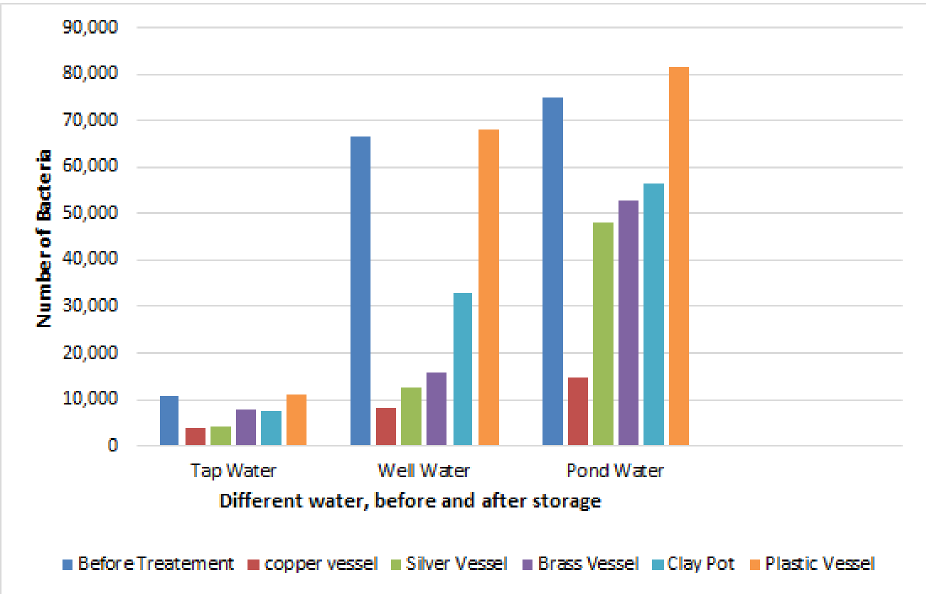


Fig.2: Number of microbial colonies (per mL) in different water samples before and after storage for 3 days

Total Dissolved Solids (TDS)**:** When the concentration of TDS is elevated in water it will affect the persons who are with heart and kidney diseases (WHO guidelines for drinking water quality). The amount of TDS also vary in all the storage vessels. There was a notable decrease in the amount of total suspended solids after storage in vessels like copper, silver, brass and clay pot when compared to that of plastic.

Total Suspended Solids (TSS): Total TSS are solids in water that can be trapped by a filter. Pathogenic microorganisms will get attached to the suspended particles which are entered in water. When these suspended particles are from sewage and decaying organic matter, there is more possibility for the presence of microbes like bacteria, viruses etc (Ehsanmousavi, 2016).

After storing water for 3 days in different vessels, especially in copper, silver, clay pot, brass there is a significant fall in the total suspended solids value which indicates that these vessels has the ability to kill the microorganisms.

Dissolved Oxygen: There was a significant reduction in the dissolved oxygen value for the water stored in plastic vessel which indicates that the water in plastic container contains more number of microorganisms when compared to that of the other vessels where the dissolved oxygen is higher.

Biochemical Oxygen Demand: More pollutants especially organic matter in water cause an increase in biological oxygen demand (Kulkarni, 1997). The BOD is less in water stored in copper, silver, and brass when compared with the other vessels which indicates that the number of microorganisms was reduced in these vessels.

Microbial colonies count: Fig. 1 a, b, c, d, e & f; Table – 4 and Fig. 2 show the number of microbial colonies in different water samples before and after storage. The number of microbial colonies is expressed per 1 ml of the various water sample (ran each with 6 duplicates).

From this study, observed that the numbers of microbial colonies were decreased largely in the water stored in the copper vessel. There was a significant reduction in the number of microbial colonies of water stored in silver vessel, brass vessel and clay pot. But plastic doesn't show any considerable effect on the microorganisms.

CONCLUSION

The present study shows that the copper vessel is highly effective against water borne pathogens and the other vessels like silver, brass, and clay pot is also effective against the microorganisms. At present plastic containers are widely used as the vessel to store food and water. However, it doesn't have any effect on the microorganisms.

Plastic, one of the most preferred materials in today's industrial world is poisoning and serious threat to environment and affect consumer's health in many direct and indirect ways. Exposure to harmful chemicals during manufacturing, leaching in the items which are used to store food such as plastic packages or chewing of plastic teethers and toys by children are linked with severe adverse health outcomes such as cancer, birth defects, impaired immunity, endocrine disruption, developmental and reproductive effects etc. So, the usage of plastic should be avoided.

Now a day's people are spending more money for the water purification for domestic use. But our Indian traditional method of drinking water storage system using copper vessel, silver vessel, and brass vessel, clay pot is cost effective and promote health.

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