Investigation Of Thermophysical Characteristics Of Water In Clay Pot

[1]Jinyemiema, Tamuno k; [2]Ledogo, Leera T; [3]Esukuile, [4]Awajiokinu. J.; and [4]Amie-Ogan, Tekena G
1,2,3& 4. Department of Mechanical Engineering
4, Department of Science Laboratory Technology
Kenule Beeson Saro Wiwa Polytechnic, Bori
Email: kurotamuno2000@yahoo.com, tjinyemiema@gmail.com

Abstract:
It has been observed for generations that water kept in clay pots remains cool and clear, a situation that requires investigation. Hence, this paper seeks to investigate the factors that contributes to cooling of water in a clay pot, rate of cooling, evaporation rate and enthalpy drop with time. Three clay pots filled with water were used for the investigation. They were kept in three different environments of sand, concrete and tiled floors. It was observed that, within 16hrs, the volume by 3 litres, average enthalpy difference in 16hrs stands at 21.5KJ/Kg and average enthalpy reduction rate is 1.375KJ/Kg/hr. Again, at about 18°C the water seems to show some latent heat properties, with reduction in enthalpy without visible reduction in temperature. The results obtained show that the evaporation and cooling rates are gradual, following a near linear relationship, whilst the temperature against the volume reduction shows a parabolic relationship.
Keywords: temperature, enthalpy, rate, humidity, cooling, evaporation

1.0: INTRODUCTION

Water is a major element for human survival, scarcity in any society does not just affect health of humans in the community, but the stability of such society as well. Control over sources of water has been a major source of conflict between communities dating from prehistory times. Consequently, man has devise means for storing water in different containers for household use. Amongst commonly used water storage vessels of aluminum, clay pot, brass, copper, plastics, steel and glass, clay pots are more popular in rural communities. In Benin Republic, 67.9% of rural dwellers store water in clay pots, 23% store drinking water in plastics, 5.7% in jericans and 3.4% in others vessels. Andrea, T, and Hans-Joachin, M. (2015). According to Andrea and Hans-Joachin, drinking water could be stored between 1-3 days in most families, but some extreme cases it could take as much as 30 days. This situation is not peculiar to Benin, but most rural communities across the Globe use clay pots for both water storage and filtration on a large scale, especially with the recent World Health Organisation's (WHO) warning on use of plastics for water storage. Even in Morocco, while rural areas are connected to water supply, its population still prefers spring water that they store in traditional conditions to have some drinking water available. Aghzar, *et, al*(2002). Demand for clay pots for household drinking water storage is gaining wider popularity in many parts of the world, not just in rural communities due to the numerous advantages derived from its usage. Clay pot has been identified as a vessel that makes water cool, clean and clear for

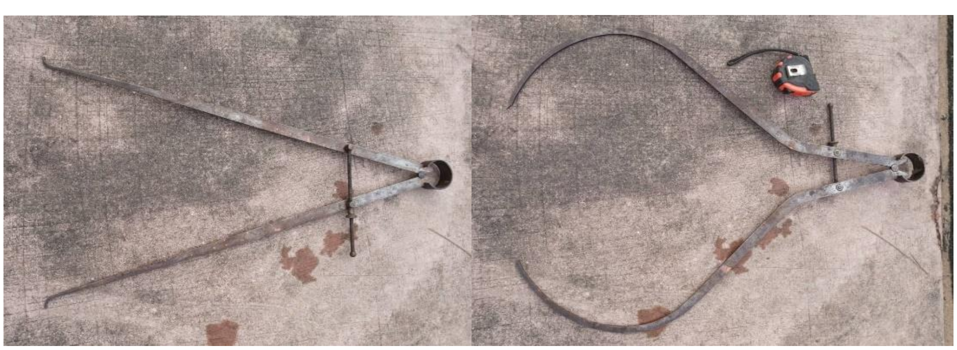
ISSN 2229-5518

generations, clay storage containers maintain low water temperatures than other containers as a result of evaporation through the porous material, Trevett, *et al.(*2004), but beyond that it has some scientific advantages in reducing the effect of coliform in stored water. It is on this backdrop this research is premeditated on. Packiyam et. al (2016), study on "Effect of Storage Containers on Coliform in Household drinking water revealed that; there was no significant reduction of Coliform bacteria in the water stored in glass, plastics, ceramics, coconut shell, aluminium, and stainless steel containers, whereas significant level of reduction of Coliform bacteria was observed in the water stored in mud pots, brass, copper and silver container suggesting that water can be stored in any of these for house purpose free of microbes.

Most authors quoted above have made frantic efforts in identifying suitability of different containers for water storage, conditions and health implications. However, this paper seeks to investigate thermo-physical properties and their relationships. It is obvious from available literature that clay pot has water cooling and purification properties, but these contributing properties interactions needed to be investigated to create a solid data base and compliment other research efforts from science background. It is on this backdrop this paper is anchored.

2.0: Materials and Methods

Three different sizes of clay pots were prepared for this investigation, with the objective to identify the role of pot size on the parameters considered, which are; cooling rate, water evaporation rate, enthalpy drop, effect of ambient temperature and relative humidity on the parameters above. All three pots used for this purpose were earthen pots and water from Polytechnic borehole was used for the experiment. Each Pot dimensions were obtained using outer and inner diameter calipers (see plate 1 for Caliper type) with which the thicknesses were ascertained. Initial water temperatures were recorded before pouring into the pots, with the aid of a meter rule, water depth in each pot was measured and recorded. A mercury in glass thermometer was used to measure the water temperature at 2hrs interval in 16hrs, at the same time relative humidity figures were monitored on weather websites. Pots were placed on different floor surfaces: first on sand surface, later on concrete floor and lastly on ceramic tiled floor, see Plate 2 for Pot materials, sizes, shape and floors conditions during experiments



(a) Internal Diameter caliper (b) Outer Diameter Caliper

Plate 1. Calipers used for ID and OD measurements

ISSN 2229-5518

a) Sand Floor b) Tiled Floor c) Concrete Floor

Plate 2. Clay Pots of Different Sizes on Different Floors

3.0: Results and Discussions

The results of each experiment are shown in Tables 1-4. In all cases, the volume reduction rate through evaporation is almost uniform. Again, from the same tables, it can be deduced that the difference between wet bulb and dry bulb temperature is 1^oc, this indicates that, at midnight humidity is quite high such that it brings down dry bulb temperature very close to the wet bulb value. It is obvious from the four tables that after 16hrs the wall temperature is almost equal to the water temperature, signifying a saturation point ahead. However, despite this equality in temperature observed, there is a constant reduction in enthalpy, introducing some form of latent heat drawn out of the clay pot. This may be the main reason behind the cooling effect of water in clay pots.

Table 1: Values Obtained from Pot 1 Placed on Sand Floor

S/N	Time (hr)	Volume (L)	Atm Temp ^oC	Wet Bulb Temp	Water Temp ^oC	Wall Temp ^oC	Relative Hum %	Enthalpy (KJ/Kg)
1	0	12.0	28	25.8	24.0	25.0	84	79.5
2	2	11.5	30	26.0	23.6	23.9	73	80.0
3	4	11.3	33	26.2	22.9	23.5	59	81.0
4	6	11.0	27	24.8	22.6	22.8	84	75.0
5	12	9.8	25	24.0	20.4	20.5	94	68.5
6	14	9.2	26	21.9	18.8	19.0	70	64.0
7	16	9.0	25	21.2	18.3	18.4	66	58.0

Table 2: Values Obtained from Pot 2 Placed on Sand Floor

S/N	Time (hr)	Volume (L)	Atm Temp ^oC	Wet Bulb Temp	Water Temp ^oC	Wall Temp ^oC	Relative Hum %	Enthalpy (KJ/Kg)
1	0	12.5	27	25.5	24.0	26.0	89	78.1
2	2	11.9	28	23.8	23.4	24.8	72	70.0

3	4	11.4	27	24.8	22.8	23.9	79	74.0
4	6	11.2	25	23.4	22.4	23.2	84	69.5
5	12	10.1	22	21.2	20.0	20.5	94	61.5
6	14	9.8	24	20.0	18,0	18.0	70	57.5
7	16	9.6	25	20,1	18.0	18.0	66	58.0

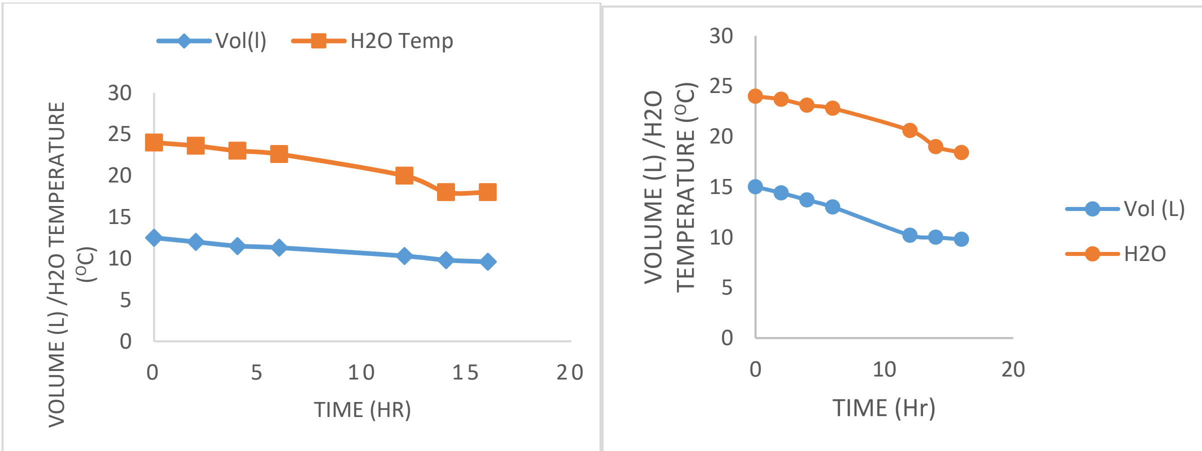
From Figure 1, it can be deduced that, the cooling rate of water in Clay Pots is influenced by environment, it is faster in Clay Pots placed on concrete floor than Sandy floors. For illustration see Figure1 below. There is a common feature from table 1 to 4, no matter the initial enthalpy value, it reduces to 58KJ/Kg after 16hrs of being in a clay pot, enthalpy drop for all cases was 21.5KJ/Kg (see Tables 1-4). This further buttress our earlier submission that there is some latent heat content of the drop in temperature drifting towards refrigeration of water.

Table 3: Values Obtained from Pot 1 Placed on Concrete Floor

S/N	Time (hr)	Volume (L)	Atm Temp °C	Wet Bulb Temp	Water Temp °C	Wall Temp °C	Relative Hum %	Enthalpy (KJ/Kg)
1	0	15.0	28	25.8	24	25	84	79.5
2	2	14.4	30	26	23.7	24	73	80
3	4	13.7	33	26.2	23.1	23.7	59	81
4	6	13.0	27	24.8	22.8	23	84	75
5	12	10.2	25	24	20.6	20.8	94	68.5
6	14	10.0	26	21.9	19	19.2	70	64
7	16	9.8	25	21.2	18.4	18.5	66	58

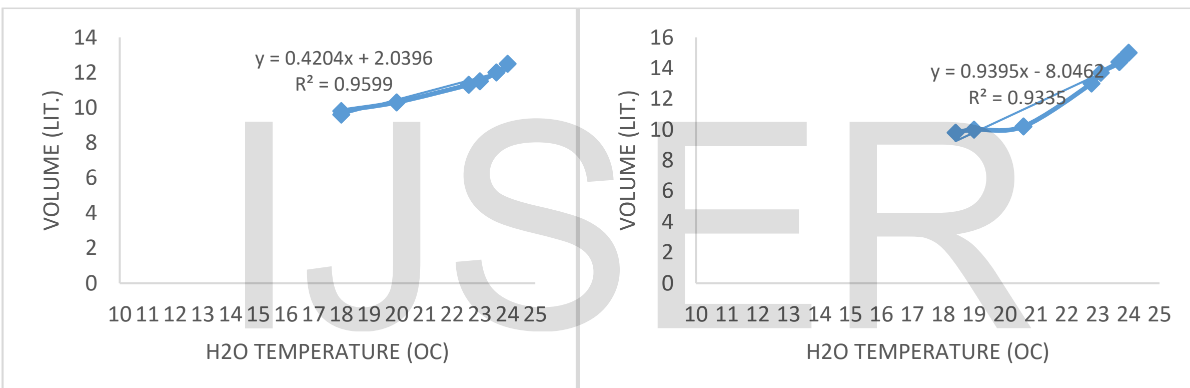
Table 4: Values Obtained from Pot 2 Placed on Concrete Floor

S/N	Time (hr)	Volume (L)	Atm Temp °C	Wet Bulb Temp	Water Temp °C	Wall Temp °C	Relative Hum %	Enthalpy (KJ/Kg)
1	0	12.0	28	25.8	24	25	84	79.5
2	2	11.5	30	26	23.6	23.9	73	80
3	4	11.2	33	26.2	22.9	23.5	59	81
4	6	11.0	27	24.8	22.6	22.8	84	75
5	12	9.8	25	24	20.4	20.5	94	68.5
6	14	9.2	26	21.9	18.8	19	70	64
7	16	9.0	25	21.2	18.3	18.4	66	58



a. Pot on Sand Floor **b. Pot Concrete Floor**

Figure 1: Temperature and Volume Drop Rate Against Time for Pot 1



a) Sand Floor **b) Concrete Floor**

Figure 2: Volume Drop Rate Against Temperature Drop for Pot 1

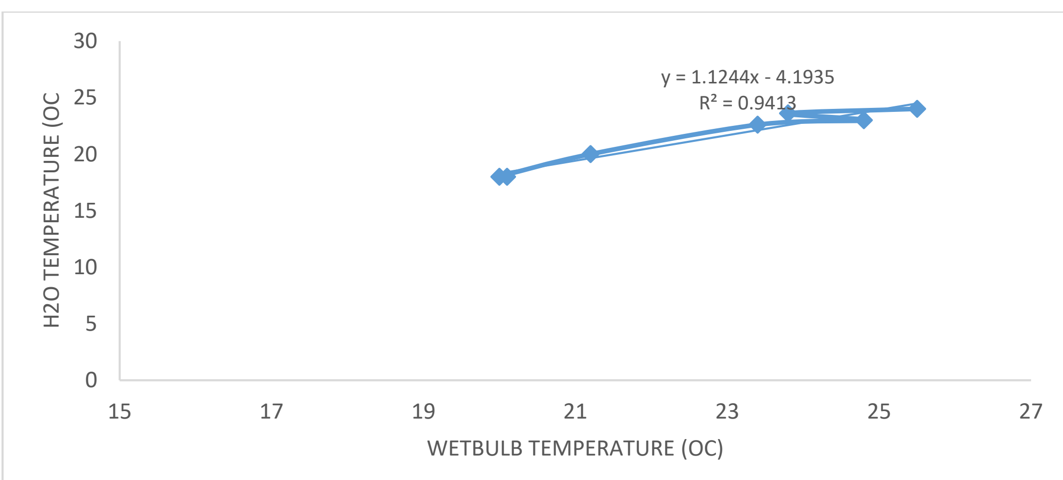
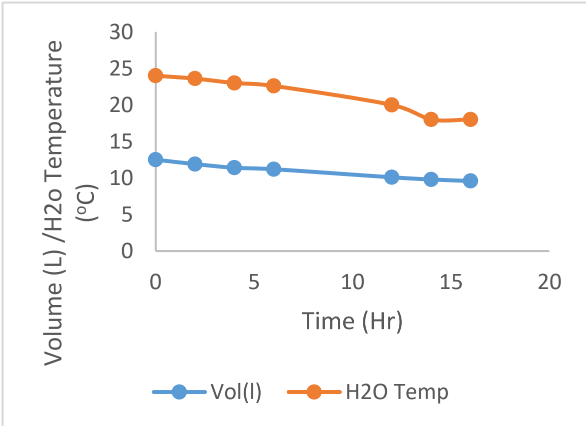
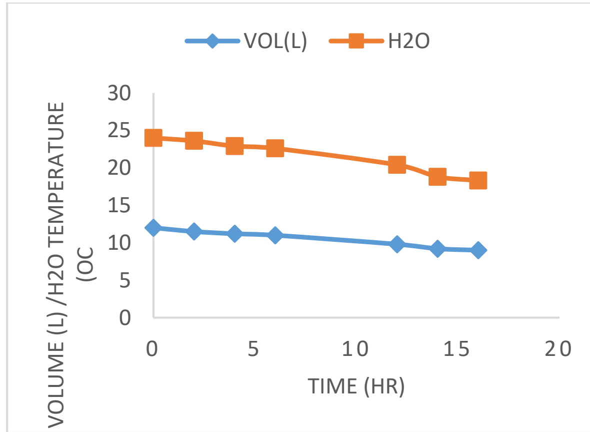


Figure 3: Pot water Temperature Against Web Temperature for Pot 1 on Sand

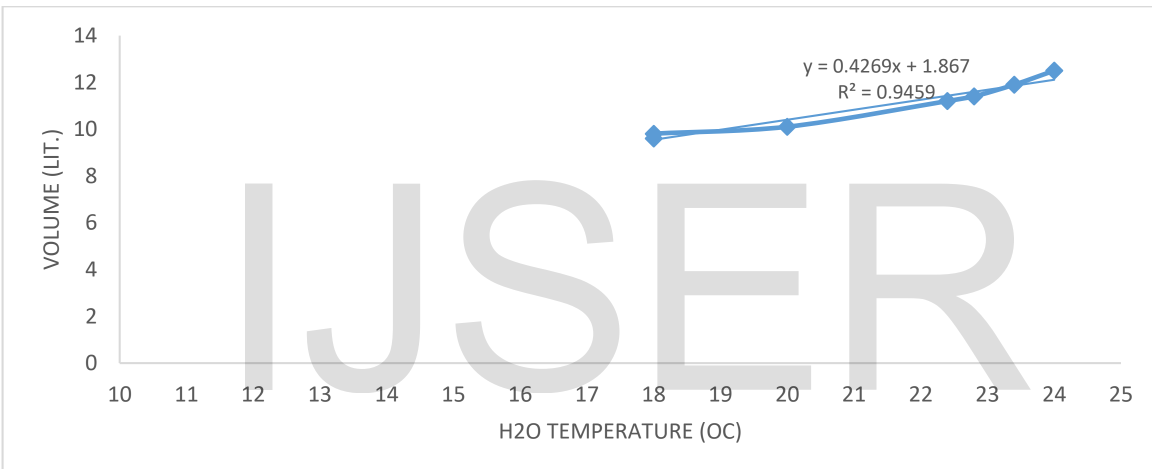
ISSN 2229-5518



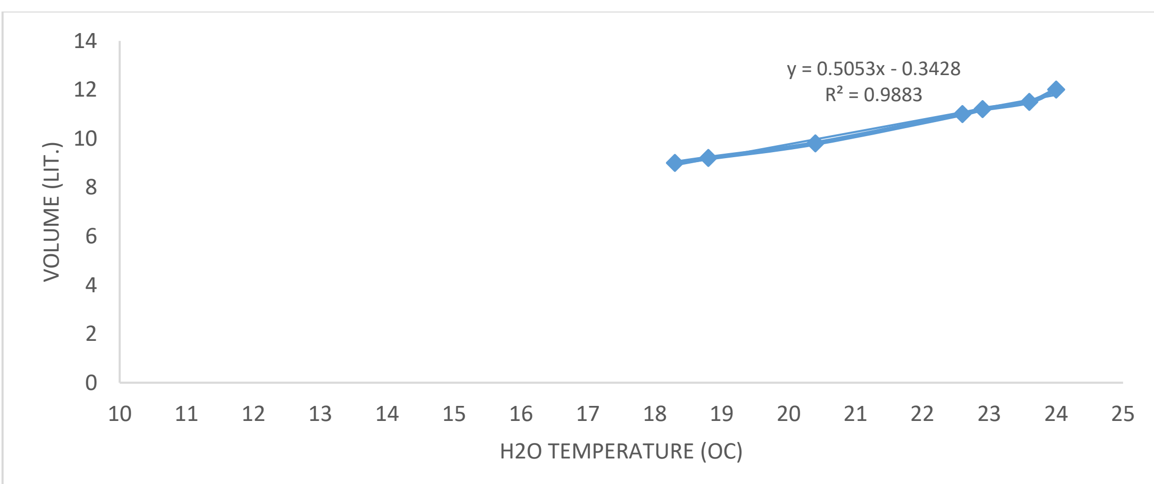


a) Sand Floor **b) Concrete Floor**

Figure 4: Temperature and Volume Drop Rate Against Time for Pot 2 on Sand

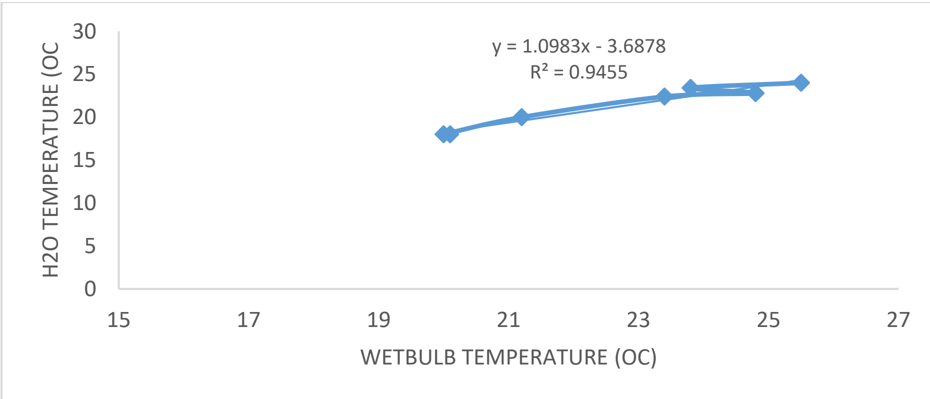


a) Pot on Sand Floor

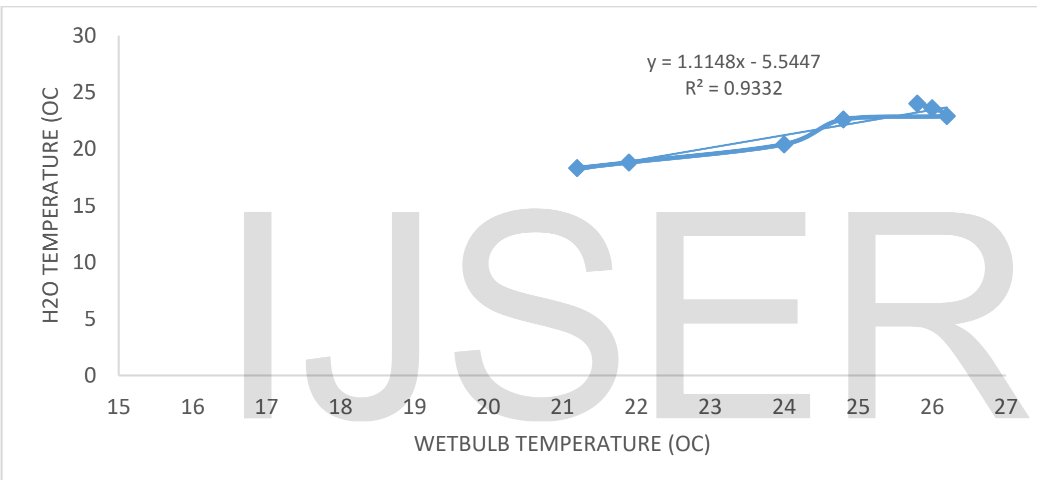


b) Pot on Concrete Floor

Figure 5: Volume Drop Rate Against Temperature Drop for Pot 2 on Sand



a) Pot on Sand Floor



b) Pot on Concrete Floor

Figure 6: Pot water Temperature Against Web Temperature for Pot 2

From Figures 2 and 5, it shows that the maximum evaporation within 16 hrs is 3 litres of water on both concrete and sand floors, except for pot which is larger that produced 5 litres of water in 16hrs. There is need to investigate further for this deviation in evaporation, but that will form part of further work, but it has been observed that the evaporation rate on concrete floor is slightly higher than sandy floor. The volume drop rate has a linear relationship with time, inflexion zone between 14-16hrs as shown in Figures 1 and 4. On the other hand, a chart of the volume drop against the temperature shows a parabolic curve, see figures 2 and 5.

4.0: Conclusion

Based on the results obtained above, it is obvious that there is relationship between the thermophysical properties of water in a clay pot. Some have linear relationships such as the volume against time, while others like volume against temperature shows a parabolic relationship, same is true between the water temperature and the wet bulb temperature. Another, major observation is about the enthalpy against time, enthalpy value for all pot sizes and conditions investigated show a gradual drop in value until it eventually gets to 58KJ/Kg after 16hrs of consistence stay of water in the pot. The average enthalpy reduction rate stands at 1.375KJ/Kg/hr

5.0: References

Aghzar, N., Berdai, H, Bellouti, A., Soudi, B. (2002). Pollution nitrigue des eaux souterraines au Tadla (Morroc). Revz des sciences de l'eau / journal of water sciences (15[2];459-492)

Andrea stocker and Hans-Joachin Mosler (2015). Contentual and Sociopsychological factors in predicting habitual cleaning of water storage containers in Benin journal of water resources. American Geophysical union 10:1002.

Neethu, M. Manju, E.K., Jacob, S. (2017). The effect of different types of storage vessels on water quality. International Journal of Water Sciences 6(10) 362-368.

Packiyam, R., Kannan S., Pachaiyappam, S., and Narayanan, U. (2016). Effect of storage containers on Coliforms in household drinking water. International Journal of curremt Microbiology and Applied sciences, 5(I): 461-477.

Trevett, A.F, Carter, R.C and Tyrrel S.F. (2004). Water Quality Deterioration: A study of household drinking water quality in rural Honduras. International Journal of Environmental Health Research. 14(14): 273-283.