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RESEARCH ARTICLE

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HOME WATER TREATMENT FOR HEALTHFUL DRINKING WATER

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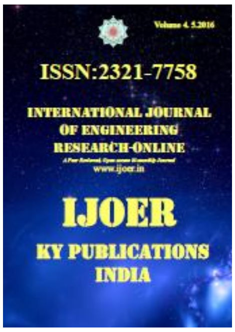

ABSTRACT

This work describes a simple way of treating water in the home. It focuses on the point-of-use treatment for drinking water which involves disinfection and pH control. The old method of disinfecting water by boiling is fast being replaced by new technologies like chlorination, micro filtration, ultra violet radiation, reverse osmosis, etc. This paper however, draws us back to the boiling method and suggests methods of improving this technique to provide safe drinking water. Furthermore, the use of a locally available chemical (potash) for adjusting the pH of water to the level best suited for the human body was investigated. The described processes will ensure that the treated water will be wholesome and healthful.

Keywords - Water treatment, disinfection, pH control, boil order, palm bunch potash.

I. INTRODUCTION

Water treatment involves the removal of impurities contained in water. Such impurities can be in dispersed form or in solution. The dispersed particles include clayey materials, silt, colloidal materials and microscopic organisms. The soluble impurities include salts of iron, magnesium, calcium, sodium, etc. The concentration levels of the impurities are important determining factors for ascertaining the quality of a water sample. Each pollutant has a specified maximum contaminant level (MCL) or maximum permissible level above which it becomes a cause for rejection of the water. In water treatment, the water is made to undergo some treatment processes to bring about complete removal of the contaminants or to reduce them to permissible levels. Water treatment can be done on a large scale in water treatment plants or on a small scale in homes. This paper focuses on point-of-use treatment of drinking water in the home.

A. *Point-of-use water treatment.*

The question that may arise is, why home water treatment when this can be done at water treatment plants? The answer is that treating water at the point-of-use is the surest way to guarantee its quality. This is because already treated water can become re-contaminated during the process of distribution depending on prevailing circumstances such as pipe bursts, back siphonage, contaminated water tankers, etc. It therefore becomes necessary that drinking water is given a final treatment at the point of use. The final treatment being referred to here includes disinfection and pH correction, since the water had earlier under gone the processes of particulate matter removal at the treatment plant. Although the water had also earlier been subjected to the disinfection process and pH control at the treatment plant, it still needs further disinfection at the point-of-use as a safe guard measure, and further pH correction where required. This is what home water treatment is all about; a polishing or conditioning treatment to guarantee the safety of drinking water.

B. Water Disinfection Technology for Home Water Treatment

There are many effective water disinfection options available to the individual home or other small users. These include boiling, chemical feed system, microfiltration, ozonation, reverse osmosis, ultra violet radiation, etc. All these treatment options have their peculiar advantages and disadvantages. The treatment option that will be discussed in details in this work is disinfection of water by boiling.

C. Water Disinfection by Boiling

Raising water to its boiling point will disinfect it. This is because no important water borne disease is caused by spore forming bacteria or other heat-resistant organisms (Fair et al, 1968). Boiling of water where drinking water safety is suspect is therefore a commendable practice as it provides extra quality assurance. According to the Wilderness Medical Society (2014) water temperatures at 160^{o}F (70^{o}C) kill all pathogens within 30 minutes, water temperatures above 185^{0}F (85^{o}C) kill all pathogens within a few minutes. So within the time it takes for water to reach the boiling point (212^{o}F or 100^{o}C) all pathogens will be killed. The moment drinking water reaches a rolling boil; the water has ready become safe to drink. The recommended conditions for disinfection of water by heating are: Retention time of 30 minutes at 160^{0}F (70^{o}C), Retention time of 3 minutes at 185^{o}F (85^{o}C), Instant at 212^{o}F (100^{o}C) (Wilderness Medical Society 2014). However, boiling water may be inconvenient due to problem of time and energy costs. The purpose of this work is to devise a method of obtaining the desirable quality assurance from heating water but at a reduced energy cost and minimum time.

D. Use of Potash (Potassium Carbonate) for pH Control

The chemicals used for control of pH at water treatment plants are acids and bases. Acids are used to reduce the pH of water when it is above 7 while bases or alkalis are used to increase the pH of water when it is in the acidic range that is below 7. The most common situation in water treatment is that requiring an increase of the pH of water from acidic level to neutral or slightly alkaline level. This is so because the treatment of water with aluminium sulphate and chlorine usually results in bringing down the pH of water to the acidic range. Control of pH at water treatment plant therefore usually involves the use of alkalis like sodium carbonate (soda ash) or sodium hydroxide to neutralize the excess acid in the water. For adjustment of pH of drinking water at the point-of-use, expert advice on the dosage of chemical is usually required. In most instances, bottle pH regulators with stipulated dosage requirement are used. These pH regulating chemicals are usually quite expensive (see fig 1).

Fig 1: Sample bottle of potassium hydroxide solution for point-of-use pH regulation of drinking water. Manufactured by Alkalite International, Miami, Florida: US Patent 5,306, 511)

This paper investigates the use of a locally produced alkali (palm bunch potash) for adjusting pH of water in water treatment from acidic to neutral or alkaline level.

II. MATERIALS AND METHOD

The main material used in this work is potash derived from oil palm bunch waste. The empty fruit bunch waste was obtained from the African oil palm (Elaeis guineensis). The water to be treated for disinfection and pH regulation was drawn from the municipal water supply. The investigation involved:

i. Production of stock palm bunch potash (PBP) solution from palm bunch waste: Palm bunch ash was produced by complete combustion of dried and screened empty palm fruit bunch. The ashed product (150g) was lixiviated with water (1 litre) and the leachate which is concentrated potash solution was collected and filtered with filter paper (whatman filter paper 41).

ii. Chemical analysis of PBP: Determination of the chemical composition of the stock PBP solution was carried out to analyse the concentration of the electrolytes, K^+, Mg^{2+}, Ca^{2+}, etc. using flame photometric and colorimetric methods.

iii. Determination of dosage of PBP required for treating water: The amount of stock PBP solution required to treat measured volumes of boiled and cooled water was determined and a dosage table was developed for varying targeted composition of mineral drinking water.

E. Effect of Local Potash on pH of Water

Local oil palm bunch ash (potash) was prepared and used to bring about adjustment in the pH of water from acidic to slightly alkaline level. Varying volumes of the potash were added to a specified volume of water to be treated and the resulting pH values were noted. Table 1 shows a comparison of the neutralizing effect of the local potash with that of sodium carbonate (soda ash).

From the results of the pH tests, it can be observed that the local potash from oil palm bunch ash has a similar effect on the pH of water as sodium carbonate and as such can be used for pH correction in home water treatment. Furthermore, from the results of the pH tests, it can be seen that a 1-litre volume of water requires about 1ml of 1.75% palm bunch potash solution to neutralize water from pH 6 to pH 7.

Table 1: Comparison of the effect of local potash with that of soda ash on pH of water, Sample volume = 1 litre, Initial pH of sample water = 6.0

Sample	A	B	C	D	E
Volume of 1.75% Palm bunch potash dosage (ml)	0.5	1.0	1.5	2.0	3.0
pH	6.5	7.0	7.5	7.5	8.0
Volume of 1.75% Soda ash (ml)	0.5	1.0	1.5	2.0	3.0
pH	6.5	7.0	7.5	7.5	8.0

Dosage requirements for varying targeted composition of mineral drinking water are shown in table 2.

Table 2: Dosage Requirements for producing mineral water using palm bunch potash solution of concentration 17,500 mg/l potassium.

Dosage of stock solution (ml)	1.0	1.5	2.0
Volume of tap water to be treated	1.0	1.0	1.0
K^+ content (mg/l)	17.5	27	35
Mg^{2+} content (mg/l)	0.20	0.30	0.40
Ca^{2+} content (mg/l)	0.11	0.17	0.22

Na^{+} content (mg/l)	0.05	0.08	0.10
Mn^{2+} content (mg/l)	0.00002	0.00003	0.00004
Cl^{-} content (mg/l)	7.6	11.4	15.2
HCO_3^{-} content (mg/l)	2.4	3.6	4.8
PO_4^{3-}m content (mg/l)	0.12	0.18	0.24
SO_4^{2-} content (mg/l)	1.04	1.56	2.08

Table 3: Chemical Composition of Palm Bunch Ash (PBA)

Cation/Anion	Concentration (mg/l)	Dry sample % composition
Potassium (K^{+})	35420	23.70
Magnesium (Mg^{2+})	403	0.27
Calcium (Ca^{2+})	224	0.15
Sodium (Na^{+})	101	0.07
Manganese (Mn^{2+})	0.06	0.00004
Iron (Fe^{2+})	2.25	0.002
Chromium (Cr^{3+})	-	-
Nitrate (NO_3^{-})	42	0.006
Nitrite (NO_2^{-})	8.40	0.16
Phosphate (PO_4^{3-})	242	10.20
Chloride (Cl^{-})	15,176	0.14
Fluoride (F^{-})	204	1.39
Sulphate ($SO^{2-}{}_{4}$)	2072	3.29
Total Alkalinity	2884mg/l as $CaCO_3$	16.10
Bicarbonate (HCO_3^{-}	24080 mg/l as $CaCO_3$	
Carbonate (CO_3^{2-})	94133 mg/l as $CaCO_3$	
Total Hardness	224mg/l as $CaCO_3$	
Calcium hardness	560mglas $CaCO_3$	
Magnesium Hardness	1680 mg/l as $CaCO_3$	
Total dissolved solids (TDS)	94133	
Percentage yield	62.70%	

F. Chemical Composition of Local Potash

Chemical analysis of palm bunch ash was conducted in a standard laboratory and the result is presented in table 3 (Okoloekwe et al, 2015).

G. Recommended Procedures for Home Water Treatment

1. Use a big size pot. The size of the pot aids the efficiency of the process by:
   (i) allowing for retention of heat for a prolonged period of time to ensure complete extermination of bacteria as a result of prolonged thermal stresses.
   (ii) providing sufficient treated water to serve the daily needs of the household. Fig 2 is a sample of a 20 - litre pot which can serve a family of 8 based on a an average consumption of 2.5 litres per person per day

Fig 2: Sample 20-litre pot for boiling drinking water

2. Pour the water into the container and add the required amount of alkali (palm bunch) depending on the volume of the pot (see table 2 for dosage requirement). Bring to near boiling point and immediately put off the heat source to reduce energy costs.
3. Allow to stand for at least six hours for prolonged thermal effect on bacteria and also for cooling of the water to take place.
4. Transfer cooled water to small containers and refrigerate where required.

III. RESULTS AND DISCUSSION

Water treated using the procedures recommended above is bacteria free, palatable and has the appropriate pH of 7 to 7.5 required for drinking water. This work highlights the need for close monitoring of pH of drinking water since a delicate balance of pH is required for proper functioning of the human body. It is reported that the human body tends to maintain body fluid (blood) at pH 7.35 to 7.45, as a result of homeostasis function of the body (Biology Encyclopaedia).

Consistent acidic constitution will result in lowering the body's self-protection function. Chronic over acidity corrodes body tissues, and if left unchecked will interrupt cellular activities and functions. In other words, over acidity interferes with life itself. (www.emedcine...). Achieving the desirable pH for drinking water can be done by neutralizing the water using a suitable alkali. The alkali most commonly used for this purpose is soda ash (sodium carbonate). In this work, however, an alkali that is locally produced from oil palm bunch waste has been observed to act as an effective chemical for pH regulation. This local alkali (palm bunch potash, PBA) from chemical analysis was found to consist mainly of potassium carbonate (Okoloekwe, 1987). A chemical analysis of the local alkali is presented in this work in table 3. This local potash has stood the test of time as an edible salt and from investigation of its effect on the pH of water, it was found to be effective for adjusting the pH of water (see table 1). It can therefore be safely used in water treatment in place of imported pH regulating chemicals for boosting pH of drinking water. It also has the advantage of containing the element, potassium, which is essential for human metabolism but is rarely found in natural water (WHO, 2004).

Quite a number of work on the merits of slightly alkaline water or mineral water on body chemistry can be found in literature (Rubenowitz, et al, 2001; Arik et al 2001, Rylander and Arnaud, 2004; WHO 2004; Alkaline water 2010; Food and Nutrition Board 2005). Regulating the body's pH is something that the body does automatically, but for some people a boost in the pH of drinking water may be necessary for the body's optimal metabolic processes.

IV. CONCLUSION

There is a need for quality assurance of drinking water. This can only be guaranteed by giving water a polishing treatment at the point-of-use. In this paper, an efficient process for disinfection and pH control of drinking water on a small scale was presented. The process can provide safe and healthful drinking water for households at reasonable costs. This recommended procedure is in line with the "Boil Order" statement usually issued by Water Authorities at periods of short falls in water treatment processes at the treatment plant. The only addition is that the procedure recommended in this work is like a "Standing Boil Order" which states that you should boil your drinking water just like you cook your food before consuming it. And in addition, neutralize your water with potash instead of soda ash to obtain healthful drinking water.

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