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Fifteen Borehole Water Samples from Ebonyi State, Nigeria treated with locally produced coagulant – disinfectant – adsorbent for Potability.

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ABSTRACT

Synthesized inorganic coagulant – disinfectant - adsorbent for home water treatment was produced using iron (III) tetraoxosulphate (VI) (coagulant) from scrap metal, calcium hypochlorite (disinfectant) from carbide sludge and unripe banana peels ash extract as an adsorbent and applied in powdered form on one cycle water treatment. The efficacy of the product was investigated on fifteen borehole water samples, five each from each of the three locations namely Abakaliki, Ohaukwu and Onicha Local Government Areas of Ebonyi State, Nigeria from November, 2018 to January, 2019 and May to July, 2019. The physico-chemical parameters were analyzed before and after treatment with the powdered product using approved standard methods. Results obtained showed, total dissolved solids, turbidity, biochemical oxygen demand, chemical oxygen demand were reduced in the treated samples when compared with the untreated, while all the treated samples have sufficient free chlorine according to WHO's guideline limit. The results suggested that the product is well suited to be administered in the treatment of 1L of different sources of water for potability.

Keywords: Fifteen, borehole, coagulant, disinfectant, adsorbent, potability.

INTRODUCTION

Since Kfir and his colleague's work in (1989) on the use of flocculent–disinfectant formulations for home water treatment, a number of publications have appeared on the subject matter [1]; [**2];** [3]; [4]. Most of the formulations like the one of CDC contain mixtures of iron (III) tetraoxosulphate (VI), bentonite, sodium trioxocarbonate (IV), chitosan, polyacrylamide, potassium tetraoxomanganese (VII) and calcium hypochlorite [5]; [6], and some with aluminium tetraoxosulphate (VI) and dichloro –s –triazine-trione. Although some are effective in home water treatment, the drawbacks in using these formulations for home water treatment include high residue chlorine [7] in treated water and prohibitive cost applications [8].

The present work aimed at tackling these problems by formulating a cost effective inorganic coagulant – disinfectant - adsorbent using iron (III) tetraoxosulphate (VI), calcium hypochlorite and unripe banana peels ash prepared from locally available raw materials of scrap metal from Abakaliki mechanic village, carbide sludge waste derived from oxy-acetylene welder's shop and unripe banana from Eke market in Ezzamgbo. The efficacy of the formulation was investigated on fifteen borehole water samples, five each from Abakaliki, Ohaukwu and Onicha LGAs in Ebonyi State, eastern Nigeria used as sources of drinking water by fifteen communities between Nov. 2017 to Jan. 2018 and May to July, 2018.

MATERIALS AND METHOD

All reagents used were of analaR grade (Merck products) and were supplied by Cobaxy chemicals, Enugu.

Preparation of $Fe_2(SO_4)_3$, $Ca(OCl)_2$ and potash from waste (raw materials):

$Fe_2(SO_4)_3$: The method of [9] was followed where granulated and degreased scrap metal (300.0g) were weighed into 500cm^3 glass beaker and enough 35% tetraoxosulphate (VI) acid was added into the beaker and stirred which dissolved the scrap metal after about two 2hrs.

$$Fe + H_2SO_4 \longrightarrow FeSO_4 + H_2$$

The solution was filtered after 2hrs and the filtrate concentrated by evaporation for 30mins using water bath at 80°C, then cooled to room temperature and allowed to stand for 24hrs to form enough green crystals of $FeSO_4.7H_2O$. The crystals were removed by decanting the liquid and transferred to a desiccator having calcium chloride pellets to dry the crystals.

Accurately weighed 100.0g of $FeSO_4.7H_2O$ was put into 250cm^3 beaker and 35% conc. H_2SO_4 and 30% conc. H_2O_2 added in the ratio 2:1:1 of $FeSO_4$:H_2SO_4:H_2O_2 according to the method of the Columbia Encyclopedia (2008) and heated on a water bath.

$$2FeSO_4 + H_2SO_4 + H_2O_2 \longrightarrow Fe_2(SO_4)_3 + 2H_2O$$

Reddish brown crystals were crystallized out of the solution and the liquid decanted, while the crystals were washed and dried to constant weight and weighed. The crystals were analyzed for both Fe^{2+} and Fe^{3+} according to Ababio's [10] and found to be iron (II) and iron (III) tetraoxosulphate (VI) respectively.

$Ca(OH)_2$: Collected carbide sludge from welders' shops in Ezzamgbo Junction was sun dried for 7 days, homogenized with lab mortar and sieved following the method of [11]. The sieved sample (1000g) were poured into 10 litres bucket, sufficient water added into the bucket, stirred, covered and allowed for 24hrs. After 24hrs, the mixture was filtered and the filtrate was dried to a constant weight in an oven at 105 $\pm$ 3°C which is the commercial $Ca(OH)_2$.

$$CaC_2 + 2H_2O \longrightarrow C_2H_2 + Ca(OH)_2.$$

$Ca(OCl)_2$: Two stages chlorination processes were used according to the Columbia encyclopedia, (2008). Solid slaked lime sample (57.0g) and 112.0mL suspension obtained from the prepared slake lime were weighed into 250cm^3 conical flask with magnetic stirrer. $KMnO_4$ (40.0g) was weighed into another conical flask having thistle funnel through which conc. HCl was passed into the flask [12]. The flask was connected to two aspirator bottles containing water and H_2SO_4 respectively to the flask having the $Ca(OH)_2$ suspension. Cl_2 was passed into flask as shown in fig. 11 at a temperature of 50 $\pm$ 5°C and the product obtained was filtered using Buchner filter in a vaccum.

$$2KMnO_4 + 16HCl \longrightarrow 2MnCl_2 + 2KCl + 8H_2O + 5Cl_2$$

$$2Ca(OH)_2 + 2Cl_2 \longrightarrow Ca(OCl)_2 + CaCl_2 + 2H_2O.$$

Then 27.0g of the residue, 28.5mL of distilled water and 2.1g of NaOH were added to 250cm^3 conical flask with magnetic stirrer and the temperature adjusted to 35 $\pm$ 5°C and chlorine immersed for 3hrs. The pH of the suspension at the end of reaction was 9.3 and the flask removed from the reactor (thermostatically controlled bath) and the suspension filtered through Buckner filter. The solid (residue) was washed with 10.0cm^3 of distilled water and dried at 65°C and the active chlorine content was 59%

Ash from banana peels was processed following the methods of [13] [14]. Unripe banana bunch bought at Eke market, Ezzamgbo was washed with distilled water and peeled. The peels were sun dried for a week and oven dried for 2hrs at 200 $\pm$ 5°C. Weighed 150.00g of the peels were ashed using furnace and then allowed to cool for 3hrs and weighed.

Reagents for the Coagulant, Disinfectant, Adsorbent Formulation: Iron (III) tetaoxosulphate(VI) (25.0g) was dissolved in 250cm^3 volumetric flask and made to the mark with distilled water.

Calcium hypochlorite (1.0g) was equally dissolved in 250cm^3 volumetric flask and made to the mark with distilled water.

Potash: Ash of 2.0g was dissolved in 100 mL beaker with de-ionized water and allowed to stand for 24hrs, then filtered and filtrate used for the conditioning.

Formulation of the Metal Based Coagulant – Disinfectant - Adsorbent

The formulation was carried out with the three stock solutions in small volumes of 1.0 mL, 1.5 mL, 2.0 mL, 2.5 mL, 3.0 mL, etc added in this form. While two of the solutions were made constant, one will be varied in the water samples in the 10 beakers, then stirred for 30 secs and allowed to settle for 30mins. Based on clarity, low free chlorine and turbidity permissible limit of WHO, the equivalent amount in solution was calculated and used for the dosage demand of the powdered product for the treatment of 1.0 litre of water.

Application of the Metal Based Coagulant-Disinfectant-Adsorbent:

The produced and formulated product was applied to the water sample by adding the content to the 1000.0 cm^3 of borehole water in the containing vessels, stirred for 60 secs, allowed to settle for an hr and filtered with white cloth. The treated water appears clearer and cleaner. The water samples were analyzed for total and calcium hardness, total dissolved solids, free chlorine, turbidity, calcium, cadmium, chromium, copper, lead and iron before treatment with the product and after treatment for both seasons and compared.

RESULTS

The results of the analyses for both Nov. 2018 – Jan. 2019 (dry season) and May – July, 2019 (rainy season) were compared and presented in a bar chat in figures 1 – 8.

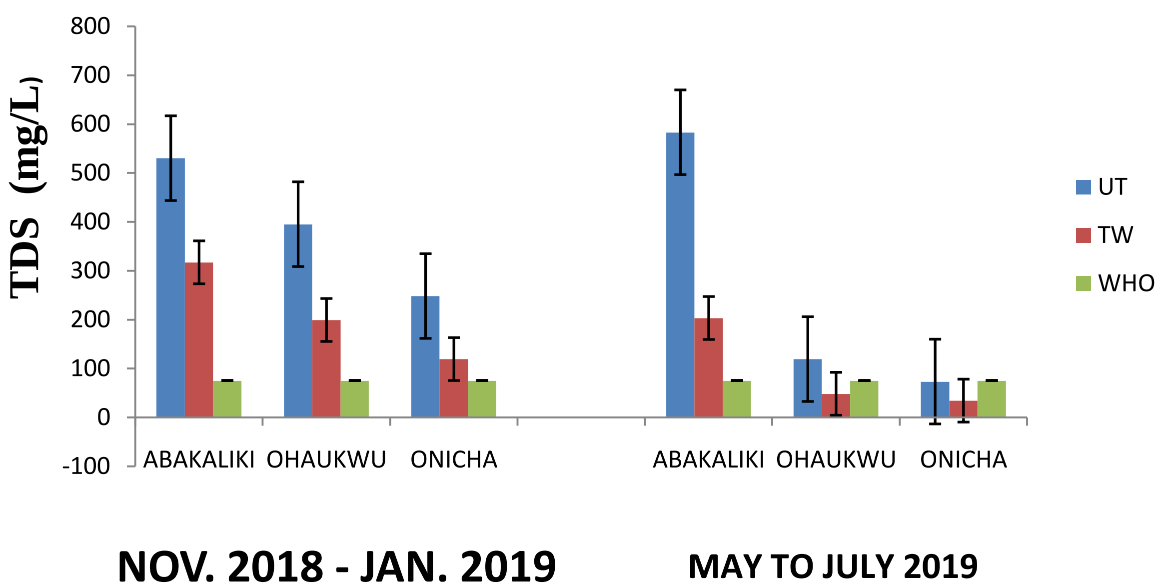

Fig. 1: Total Dissolved Solids Concentration of Borehole Samples (UT = treated, TW = treated)

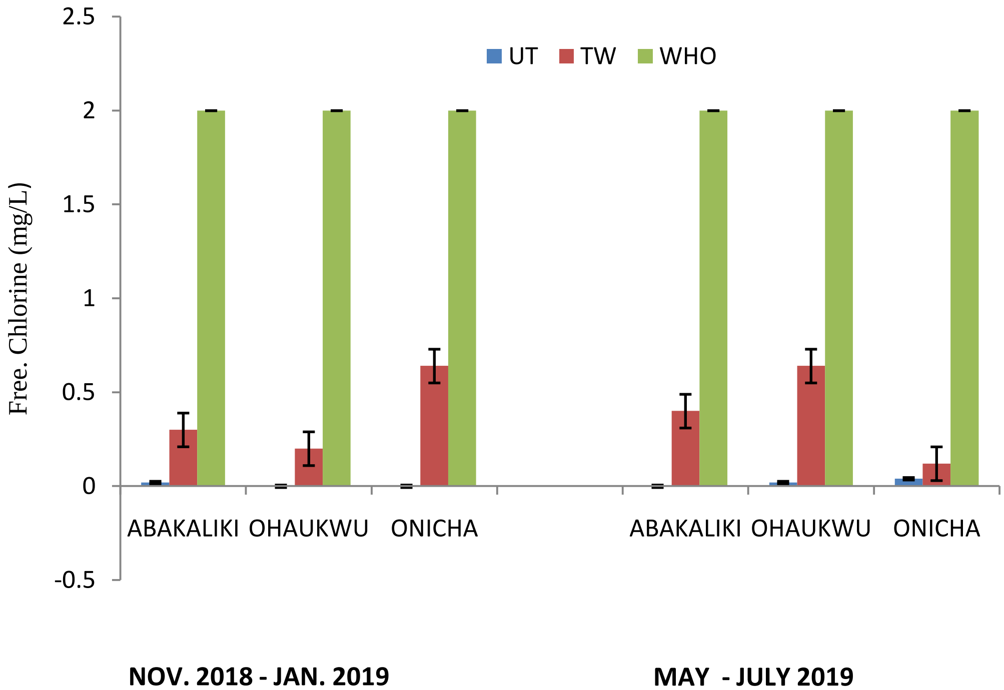

Fig.2: Free Chlorine Concentration of Borehole Samples (UT = untreated, TW = treated)

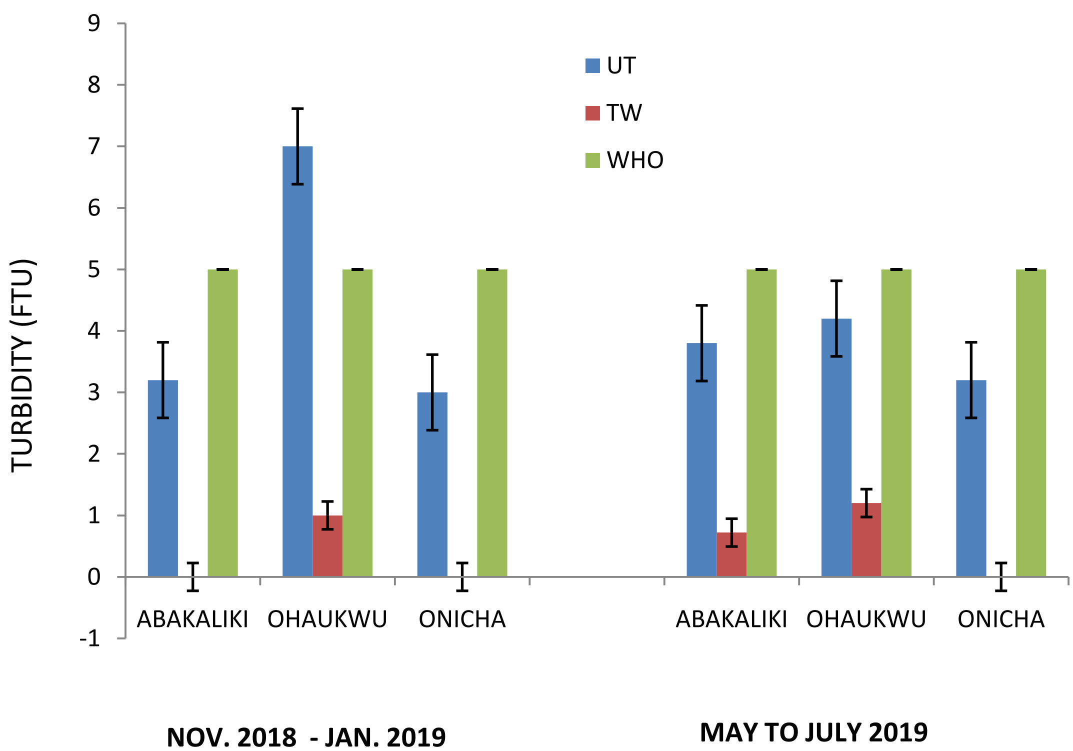

Fig. 3: Turbidity Distribution of the Borehole Samples (UT = untreated, TW = treated)

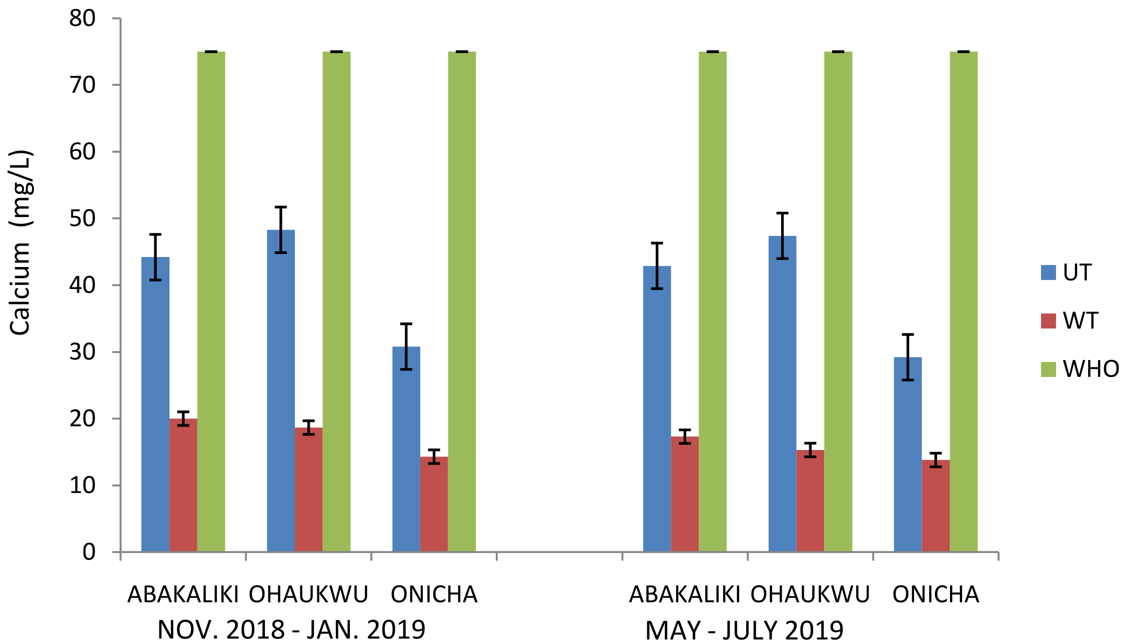

Fig.4: Calcium concentration of the Borehole Samples (UT = untreated, TW = treated)

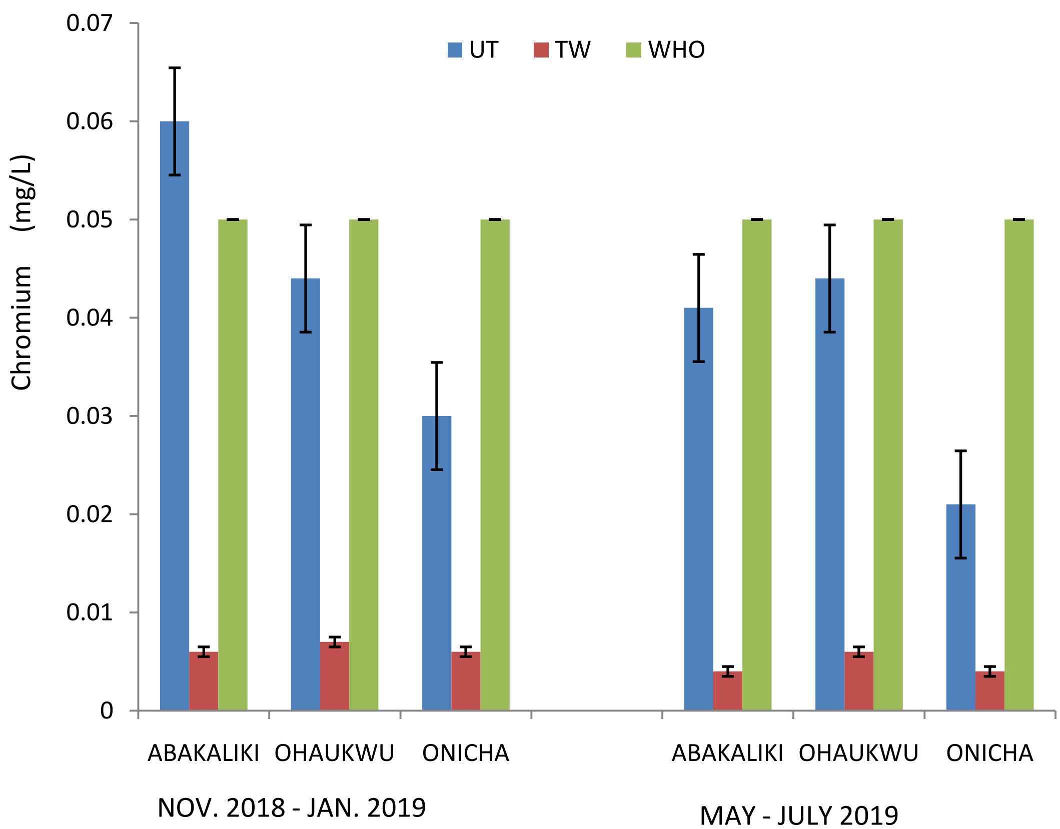

Fig. 5: Chromium Concentration of Borehole Samples (UT = untreated, TW = treated)

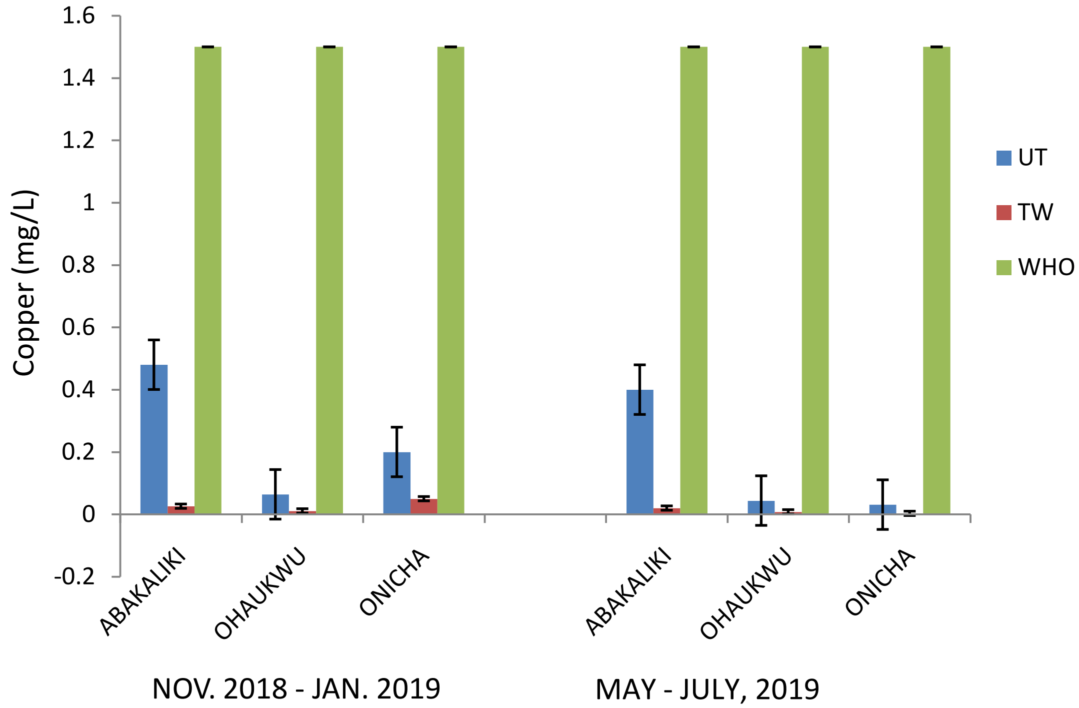

Fig. 6: Copper Concentration of Borehole Samples (UT = untreated, TW = treated)

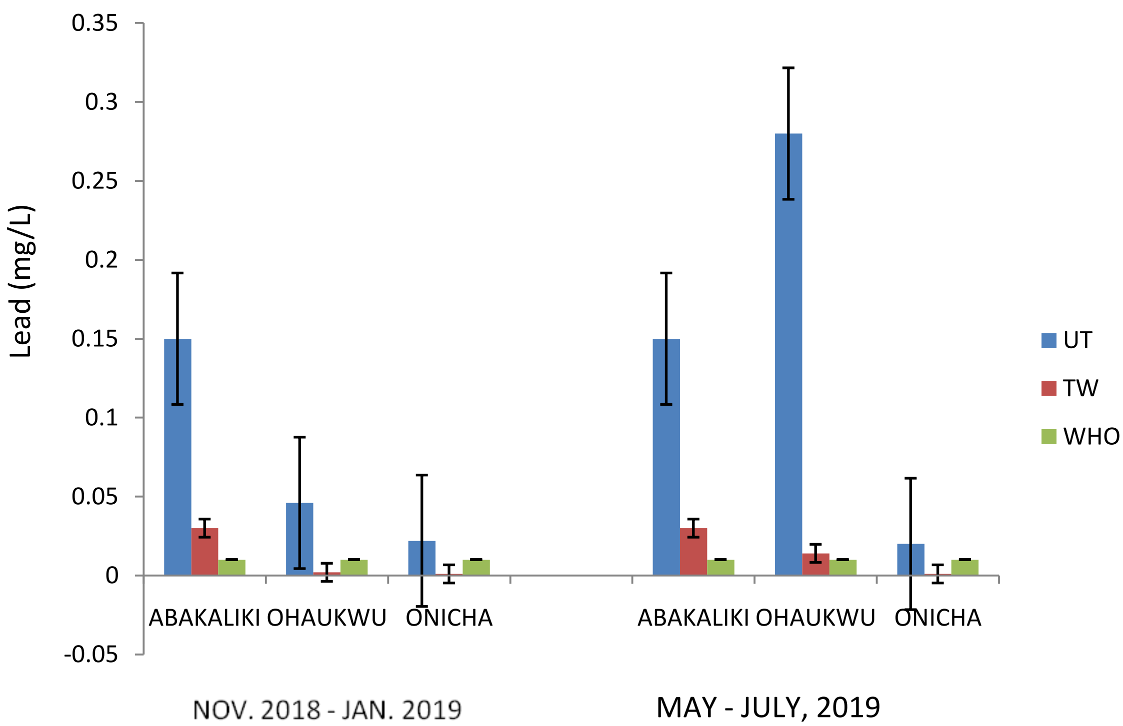

Fig. 7: Lead Concentration of the Borehole Samples (UT = untreated, TW = treated)

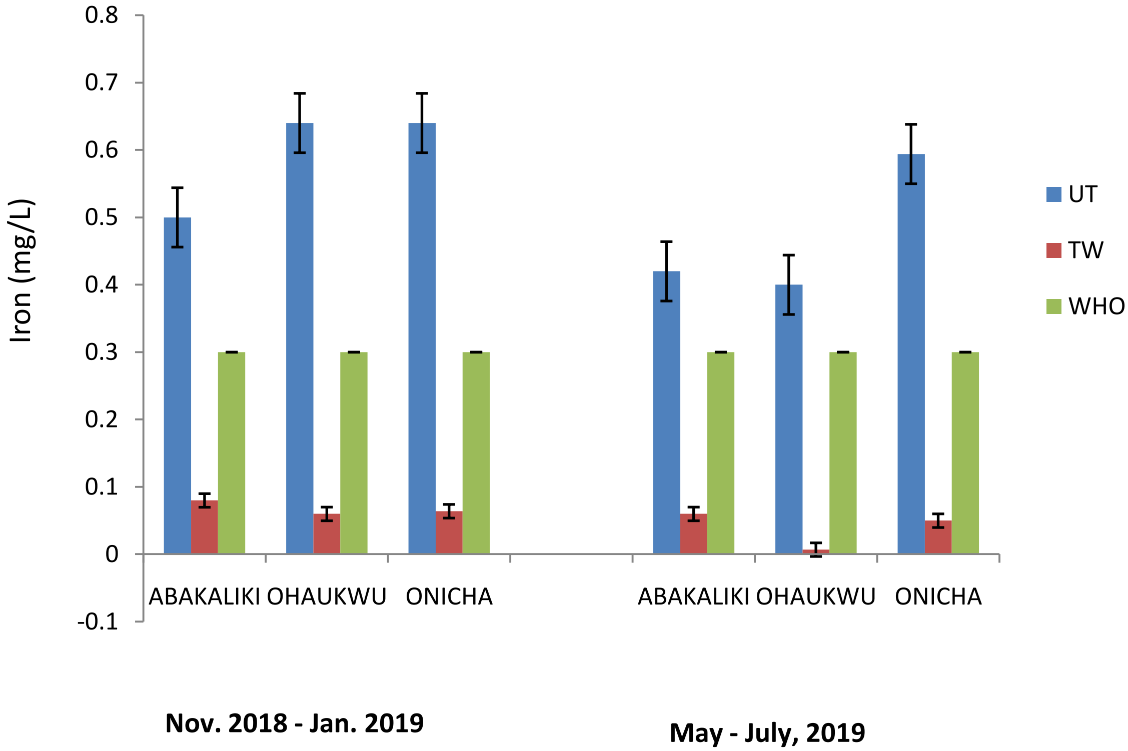

Fig. 8: Iron Concentration of Borehole Samples (UT = untreated, TW = treated)

DISCUSSION

Treatment given to water depends on the nature of the water, period and the purpose in which the water is meant for. In this case, it is for potability (drinking) (Wikipedia, 2019). The two periods under considerations were November, 2017 – January, 2018 (dry season) and May – July, 2018 (rainy season) which were chosen to compare and investigate the effect of whether interference such as rain and non - interference as in the dry season on the selected parameters. Figures 1-8 present the bar chart of the eight analyzed parameters of the fifteen borehole water samples, five each from Abakaliki, Ohaukwu, and Onicha. The mean of the five boreholes from each local government were taken and represented as one for each of the local government. The key shows that UT stands for untreated water samples, TW for treated water samples and WHO for World Health Organization limit.

Figure 1 compared the mean total dissolved solid (TDS) of both seasons – Nov. 2018 to Jan. 2019 (dry season) and May to July, 2019 (rainy season) where there were significant variations. Abakaliki TDS was higher during rainy season when compared to dry season, while the other two Ohaukwu and Onicha TDSs were higher in the dry season when compared to rainy season. This could be as result of leaching of rocks though underground water to the boreholes. However, all were within the WHO guideline limit of 500 – 1500mgL^{-1}, but after treatment with flocculent-disinfectant-adsorbent product, TDSs were below WHO's limit for TDS. Figure 2 showed that free chlorine was not detected in all the water samples before treatment except for Onicha boreholes, an indication that borehole waters in Abakaliki, Ohaukwu and Oniccha have no protection against re – contamination since water can be contaminated at any point from source to point of drinking [6]. After treatment with the product, all the water samples had free chlorine within the range of WHO of 0.2 – 2.0 mgL^{-1} for both seasons showing that the product is effective in combating re – contamination of the treated water any point. Figures 3, presents turbidity for both periods (dry and rainy seasons), which revealed significant variation between the two seasons which could be due to seasonal changes. After treatment with product, turbidity was completely reduced in all the treated samples, an indication of potability and fitness of treated water samples for drinking caused by the treatment with the prepared product.

Figures 4 – 8 present the bar chart of Ca ion and four heavy metals namely Cr, Cu, Fe and Pd investigated between the two both seasons – Nov. 2018 to Jan. 2019 (dry season) and May to July, 2019 (rainy season). Calcium ion contents of the three areas vary both for Nov. 2018 to Jan. 2019 (dry season) and May to July, 2019 (rainy season). However, Ca^{2+} in all were within WHO recommended value. The heavy metals were not so. Chromium was $0.06mgL^{-1}$ at Abakaliki and is above the WHO value of $0.05mgL^{-1}$. Ohaukwu and Onicha values were within WHO's before treatment, while after treatment with the product, all the water samples were reduced, showing that the product was effective in removing Cr from the water samples. The product also reduced Cu, Fe and Pd from the treated water when compared untreated water samples.

CONCLUSION

The flocculent – disinfectant – absorbent product removed/ reduced TDSs, turbidity, Ca2+, Cr, Cu, Fe, Pd from the treated water samples and increased free chlorine concentration in all the treated water samples. Thus, the prepared product is effective in removing heavy metals from heavy metal invested water and overall improvement of water quality.

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