

Application of Coagulation-Disinfection Adsorbent Formulated From Locally Available Materials For Treatment of Pond Water Samples for Potability

John J,

**Department of Industrial Chemistry, Ebonyi State University, PMB 053 Abakaliki.
Ebonyi State, Nigeria**

ABSTRACT

A coagulation-disinfection adsorbent for home water treatment prepared using iron (III) tetraoxosulphate (VI) derived for scrap metal as a coagulant, calcium hypochlorite from carbide sludge as a disinfectant and banana unpeel ash as an adsorbent and applied in powdered form on one cycle water treatment. The effectiveness of the product was investigated on fifteen pond water samples located at Abakaliki, Ohaukwu and Onicha , Ebonyi State, Nigeria from 1st November, 2013 to 31st January, 2014. The physico-chemical parameters, metal concentrations and bacteriological analysis were carried out before and after treatment with the powdered product using approved standard methods. Results obtained showed total and calcium hardnesses, TDS, turbidity, BOD and COD, Al, Ca, Mg, Cd, Cr, Pb, Zn, Cu were reduced in the treated samples when compared with the untreated. All the treated water samples have increase free chlorine and improved pH as against the untreated samples in accordance with WHO guideline limit. The results suggested that the formulated product is well suited to be administered in one sachet with sufficient free chlorine for disinfection and flocculating for potability and provided information about the state of pond water in the three locations..

keywords: coagulation-disinfection adsorbent, home water treatment, pond water.

INTRODUCTION

Following the advent of the Procter and Gamble Company (2001) on the use of combined treatment methods for home water treatment, a number of applications have appeared on the subject matter [1, 2, 3, 4]. Although some of them were successful and effective, and works well in developed countries, implementing them in developing and under developed countries such as Nigeria is expensive and impractical. Most of the formulations are costly and contain mixtures of iron(III) tetraoxosulphate(VI), bentonite, sodium trioxocarbonate (IV), chitosan, polyacrylamide, potassium tetraoxomanganese (VII) and calcium hypochlorite [5]. Some of the drawbacks in using these formulations for home water treatment include high free(residue) chlorine [5,6,7,8] in treated water and prohibitive cost applications [9].

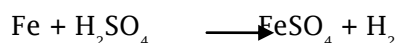
The present work has formulated a cost effective inorganic coagulation - disinfection, adsorbent using iron (III) tetraoxosulphate (VI), calcium hypochlorite and banana peels ash prepared from locally available raw materials of scrap metal from Abakaliki Mechanic Village and carbide sludge waste derived from carbide sludge in oxy-acetylene welder's shop and banana peels at Ezzamgbo, Nigeria. The efficacy of the formulation was investigated on fifteen pond water samples used as sources of drinking water by fifteen communities in Ebonyi State, Nigeria.

MATERIALS AND METHOD

All reagents used were of analytical grade (Merck products, Germany) and were used without further purifications; however, dilution was made as the need arises.

Preparation of $\text{Fe}_2(\text{SO}_4)_3$, $\text{Ca}(\text{OCl})_2$ and $\text{Ca}(\text{OH})_2$ from waste (raw materials):

$\text{Fe}_2(\text{SO}_4)_3$: The method of CR Scientific [6] was followed in which granulated and degreased scrap metal (100.0g) were weighed into 250cm³ glass beaker and enough 35% tetraoxosulphate (VI) acid into the beaker which dissolved the scrap metal.



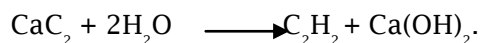
The solution was filtered after 2h and the filtrate concentrated by evaporation for 30mins using water bath at 80°C, then cooled to room temperature and allowed to stand for 24h to form enough green crystals of $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$. The crystals were removed by decanting the liquid and transferred to a desiccator having calcium chloride pellets to dry the crystals.

Accurately weighed 30.0g of $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ was put into 250cm³ beaker and 35% dilute 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 and heated on a water bath.

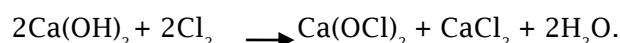


The reddish brown crystals formed was $\text{Fe}_2(\text{SO}_4)_3$ and the liquid decanted, while the crystals were washed and dried to constant weight and weighed.

Ca(OH)₂: Collected carbide sludge from welders' shops in Ezzamgbo Junction was sun dried for 7days, homogenized with lab mortar and sieved in accordance with Chukwudebelu et al, (2013). The sieved sample (1000g) were poured into 10 litres bucket, sufficient water added into the bucket, stirred, covered and allowed for 24h. After 24h, the mixture was filtered and the filtrate was dried to a constant weight in an oven at $105 \pm 3^\circ\text{C}$ which is the commercial Ca(OH)₂.



Ca(OCl)₂: Two stages chlorination process was used in accordance with the Columbia encyclopedia, (2008). Solid slaked lime sample (57.0g) and 112.0mL suspension obtained from the prepared slake lime were weighed into 250cm³ conical flask with magnetic stirrer. KMnO₄ (40.0g) was weighed into another conical flask having thistle funnel through which conc. HCl was passed into the flask [10]. The flask was connected to two aspirator bottles containing water and H₂SO₄ respectively to the flask having the Ca(OH)₂ suspension. Cl₂ was passed into flask as shown in fig. 11 at a temperature of $50 \pm 5^\circ\text{C}$ and the product obtained was filtered using Buchner filter in a vacuum.



Then 27.0g of the residue, 28.5mL of distilled water and 2.1g of NaOH were added to 250cm³ conical flask with magnetic stirrer and the temperature adjusted to $35 \pm 5^\circ\text{C}$ and chlorine immersed for 3h. 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 10.0cm³ of distilled water and dried at 65°C and the active chlorine content was 59.6%.

Reagents for the coagulation-disinfection adsorbent formulation

Twenty-three (25.0) grams of iron (III) tetraoxosulphate (VI) was dissolved in 250cm³ volumetric flask and made to the mark with distilled de-ionized water. Calcium hypochlorite was prepared by dissolving 1.0g Ca(OCl)₂ in 250cm³ volumetric flask and made to the mark with distilled de-ionized water. Banana peels ash (5.0g) was also prepared by dissolving 2.0g of ash in 250cm³ beaker and made to the mark with distilled de-ionized water, covered and allowed to stand for 24h, filtered and filtrate used for the formulation of the product. All the reagents served as stock solutions in the formulation.

Procedure

Some of analyses were determined using Atomic Absorption spectrophotometer (AAS) (Buck Scientific, 205) on metals which include lead, manganese, chromium, cadmium, Iron, aluminum, zinc, while potassium and sodium levels were analyzed using flame photometer (Perkin Elmer: 52-A). X-ray fluorescence (XRF, Rigaku RIX, 3000, Japan) was used for the metal contents of the ash, the membrane filtration method according to [11] was

used for bacteriological examinations and complexometric method was used for total and calcium hardnesses.

RESULTS AND DISCUSSION

Table 1: Mean physico-chemical parameters of Abakaliki, Ohaukwu and Onicha pond water samples between 1st Nov.2013 – 31st Jan. 2014 compared with WHO standard

Location	Abakaliki		Ohaukwu		Onicha		WHO
Parameters	BT	AT	BT	AT	BT	AT	-
Temp (°C)	31.0±0.02	32.0±0.00	31.4±0.10	31.8±0.00	30.6±0.01	31.9±0.00	10 – 15
Ph	6.10±0.11	7.60±0.06	6.10±0.02	7.30±0.09	6.20±0.03	7.80±0.04	6.8 – 8.5
T. hardness(mgL ⁻¹)	133±0.32	48.9±0.12	126±0.23	45.3±0.07	115±0.11	42.4±0.08	100 – 250
Ca hardness(mgL ⁻¹)	85.6±0.17	30.8±0.11	77.3±0.32	28.5±0.04	73.3±0.18	24.5±0.21	75 – 100
Mg hardness(mgL ⁻¹)	46.8±0.09	17.8±0.18	48.0±0.12	16.8±0.14	41.0±0.60	14.9±0.26	50 – 75
TDS (mgL ⁻¹)	718±0.56	277±0.23	517±0.41	192±0.24	414±0.25	140±0.14	500 – 1500
F. chlorine (mgL ⁻¹)	0.04±0.00	0.96±0.00	0.04±0.11	0.90±0.02	0.06±0.04	1.04±0.08	0.2 – 2.0
Turbidity (NTU)	10.00±0.11	1.60±0.04	14.00±0.21	0.40±0.09	8.60±0.07	ND	5 – 15
BOD (mgL ⁻¹)	2.70±0.04	0.73±0.21	1.31±0.03	0.12±0.05	0.36±0.04	0.10±0.00	0.75
COD (mgL ⁻¹)	4.20±0.15	0.90±0.00	5.31±0.08	0.26±0.00	3.80±0.06	0.16±0.01	-
Total coliform (TCL/100mL)	23.0±0.19	ND	11.0±0.02	ND	14.0±0.04	ND	100/100 mL

where BT = before treatment, AT = after treatment, ND = not dictated

Tables 1 presented the mean physico-chemical parameters of pond water samples from Abakaliki, Ohaukwu and Onicha compared with WHO's standard. The result of the analysis showed that seven parameters were reduced after treatment with the prepared product, except free chlorine which increased in all the water samples. It agrees with PUR Water Purifier developed by Procter and Gamble Company in reducing turbidity and improving the water quality. However, the quantity of free chlorine was reduced from 3.0mgL⁻¹ to between 0.9 – 1.04mgL⁻¹. This an added advantage since excess free chlorine adds odour and taste to water, and may react with organic matters in water to form by-products such as trihalomethane and chloroethanoic acid which are carcinogenic [12].

Table 2: Mean metal concentrations of Abakaliki, Ohaukwu and Onicha pond water samples between 1st Nov.2013 – 31st Jan. 2014 compared with WHO standard

Location	Abakaliki		Ohaukwu		Onicha		WHO
Metals (mgL ⁻¹)	BT	AT	BT	AT	BT	AT	-
Al	0.070±0.01	0.020±0.04	0.026±0.04	0.004±0.01	0.030±0.12	0.008±0.02	0.02
Ca	40.50±0.22	13.50±0.09	34.80±0.24	17.40±0.09	24.66±0.21	9.68±0.09	75
Cd	0.044±0.06	0.010±0.02	0.260±0.15	0.020±0.00	0.030±0.01	0.006±0.01	0.05
Cr	0.034±0.00	0.004±0.00	0.180±0.11	0.010±0.00	0.026±0.00	0.002±0.00	0.05
Cu	0.540±0.04	0.044±0.11	1.010±0.21	0.230±0.04	1.000±0.15	0.100±0.17	1.0 – 1.5
Fe	0.560±0.17	0.030±0.00	0.520±0.12	0.180±0.17	0.340±0.09	0.010±0.02	0.30
K	2.880±0.12	3.160±0.08	5.880±0.42	6.610±0.18	3.380±0.02	3.840±0.07	-
Mg	10.60±0.23	4.360±0.21	8.040±0.08	3.160±0.07	7.920±0.21	3.540±0.02	50
Mn	0.052±0.12	0.010±0.04	0.030±0.07	0.008±0.13	0.290±0.01	0.030±0.01	0.05
Na	2.940±0.08	0.300±0.07	1.770±0.09	0.560±0.08	2.680±0.23	1.380±0.20	100
Pb	0.060±0.11	0.010±0.00	0.170±0.23	0.040±0.12	0.380±0.09	0.030±0.00	0.05
Zn	5.010±0.09	0.034±0.02	4.640±0.23	1.160±0.00	4.220±0.02	0.210±0.11	5.0

All the metals were reduced after treatment by the product except potassium, K.

Table 2 showed mean metal concentrations of Abakaliki, Ohaukwu and Onicha towns pond water samples from 1st November, 2013 to 31st January, 2014. The summary of the result revealed that in Abakaliki, Al (0.070±0.01), Cd (0.044±0.06), Fe (0.560±0.17), Mn (0.052±0.12), Pb (0.060±0.11) and Zn (5.010±0.09), in Ohaukwu, Al (0.026±0.04), Cd (0.260±0.15), Cr (0.180±0.11) and Fe (0.520±0.12), and in Onicha Al (0.030±0.12), Fe (0.340±0.09), Mn (0.290±0.01) and Pb (0.290±0.01) were above WHO standard limit before treatment with the prepared product. After treatment, all the metals were reduced to the guideline limit of WHO and agrees with PUR Water Purifier in reducing the level of metals in treated water [13]. From the result, it is seeing that Abakaliki, Ohaukwu and Onicha pond water samples have high metal concentrations in various levels and should not be taken without treatment and the prepared product could serve the purpose.

Table 3: Waterborne pathogens between 1st Nov.2013 – 31st Jan. 2014

Bacteria	BT			AT		
	Organism/litre			Organism/litre		
	AB	OH	ON	AB	OH	ONI
<i>Echerichia. Coli</i>	2.3×10^5	1.2×10^4	3.4×10^2	ND	ND	ND
<i>Salmonella typhi</i>	1.5×10^6	1.0×10^5	1.4×10^3	ND	ND	ND
<i>Vibro cholera</i>	1.1×10^8	1.5×10^6	3.2×10^5	ND	ND	ND
<i>Shigella sonnei</i>	1.0×10^5	2.4×10^4	1.0×10^2	ND	ND	ND
<i>Klebsiella terrigena</i>	1.0×10^3	1.0×10^5	ND	ND	ND	ND
<i>Campylobacter jejuni</i>	4.2×10^5	1.0×10^4	1.0×10^3	ND	ND	ND
<i>Shigella flexneri</i>	1.3×10^6	3.5×10^3	1.1×10^5	ND	ND	ND

AB = Abakaliki, OH = Ohaukwu, ON = Onicha, BT = before treatment, AT = after treatment

Table 3 presented seven bacteria pathogen with the number of organism per litre at Abakaliki, Ohaukwu and Onicha pond water samples before treatment (BT) and after treatment (AT). The study shows that the product inactivated the pathogens. This is an indication that the metal based product is effective in destroying disease causing bacteria organisms.

In conclusion, all the pond water samples from Abakaliki, Ohaukwu and Onicha towns before treatment were unfit for drinking. However, after treatment with the metal based product, all the parameters analyzed in treated water samples met WHO's guideline limit, thus making the waters fit for drinking.

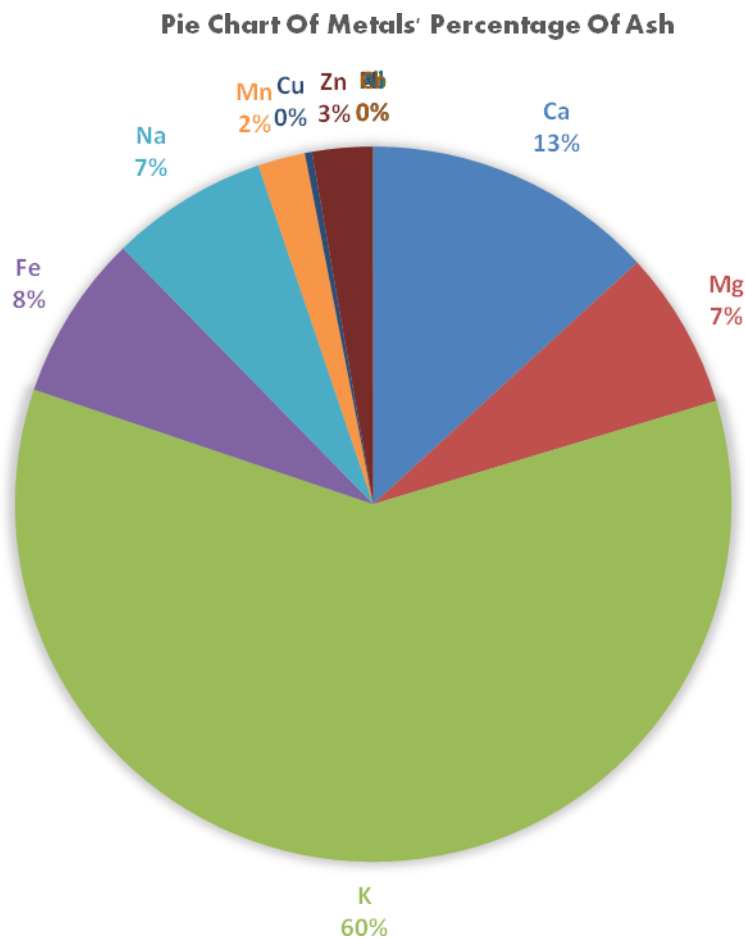


Fig 1: Metals Concentration of Ash of Banana Peels in percentages

Figure 1 presented the metal contents of the ash in the pie chart form. The chart indicates that potassium was highest and the presence of potassium in excess is a welcome development since high level of potassium decreases high blood pressure and muscle cramp [13]. According to the Figure 1, the metals in the banana peel ash were in the order $K > Ca > Fe > Na > Mg > Zn > Mn > Cu$ and differs from the report of [14]. However, [15] informed that unripe banana peels may have the metals in slight difference because of the nature of the soil and diversities in agricultural practices in different places. A metal such as Ca is important in bones and teeth formations, while Mg is essential constituent of chlorophyll in plant and Fe is the oxygen carrying pigment in the haemoglobin of the blood and as such both are important for growth and development and in building up the red blood cells. Zn and Mn promote the activities of many enzymes in the body [15].

Statistical Analysis Using One-Way ANOVA

Summary of the results were presented in mean and standard deviation. Statistical Analysis was carried out using statistical package for social sciences (SPSS) software for Microsoft excel.

The results obtained were subjected to one-way analysis of variance (ANOVA) using Student Newman Keuts (S-N-K) post hoc test. The results were tested at $p < 0.05$ at 95% confidence level to determine significance difference of variations between multiple variables.

Results at $P < 0.05$ were considered significant.

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