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Waste Water Treatment with Conventional Materials (Chlorine, Aluminium Sulphate, Polyelectrolyte) as Well as Local Materials (Activated Charcoal and Burnt Bricks) in Makurdi Benue State Nigeria: A Comparative Study

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Abstract
Used water from restaurants hands and utensils washing was collected for pilot treatment. Red burnt bricks known to contain a small amount of iron oxide and activated charcoal crushed together were used as traditional means of water coagulants .The impurities in water became suspended particles and gradually settled to the bottom of the container used .Large heavy particles settled out readily, smaller and lighter particles settled down more slowly . Conventional water treatment chemicals (0.25% aluminum sulphate solution and 0.25 % polyelectrolyte) were added to another sample of the same waste water and the impurities were brought together into larger, heavier masses of solids called floc which also settled down . In both samples chlorine as sodium hypochlorite in granular form was added 2.5g while softening was achieved by adding 0 .25 % Soda ash -sodium trioxocarbonate (iv) Na_2CO_3 . In both samples results show the values of the physicochemical parameters (Conductivity Turbidity Odour Temperature ^oC Colour Suspended Solids mg/L Oil in Water mg/L Total Dissolved Solids mg/L and Total Solids mg/L) reduced almost to zero levels and close to WHO/NIGERIA Allowable Standards 2005. This renders credibility to the use of both conventional and local materials for water treatment effectively and the need to source for more environmentally local materials for such purpose .
Keywords: Physico-Chemical, Waste Water, Heavy Particles, Sustainability, Turbidity

1. Introduction

An International Conference held in Paris, France, 21-23 June 2004 had a brainstorming week on the theme "CHEMISTRY FOR WATER" Perspectives and Recommendations . Several contributors drew attention to the dreadful reality that globally 5000 children die daily due to lack of water and it became imperative to synergize all available resources especially basic research technological , environmental and sociological to fight this menace. Alan, Smith. (2004). Effective management of water resources was outlined as an important strategy for sustainable socio-economic development, which is especially critical for developing countries. This is also captured in the Nigeria Water Resources Vision 2025, which is itself an offshoot of the larger African Vision that has water quality and sanitation as key component . The Conference drew attention to the need for a new chemistry-integrated water management in the overall National Millennium Development Goals project aimed at poverty reduction and improved community health. Onyido and Sha'Ato (2006) . In South Africa water is supplied almost freely to all citizens in both urban and the rural areas. The policy and rendition are quite attractive and envious especially if one goes through much difficulty in tracing this equivalence in Nigeria. Now, lack of funds occasioned by diminishing political will has affected the sustainability of this project. Elsewhere in the world the story is not different. A report by the World Economic Forum WEF, says that lack of water, will soon tear into various parts of the global economic system and start to emerge as a headline geopolitical issue.

The National Water Policy lays emphasis on the introduction of reforms especially Public Private Participation PPP. The African Development Bank ADB carried out Water Schemes of Taraba and Oyo States in 2009, the two states were selected based on the very low water coverage (approximately 30%) and their commitments to improve the provision of water and sanitation service to their inhabitants . The majority of the beneficiary population, about 70%, live in areas that are poorly served by modern water and sanitation infrastructure. In Makurdi Benue State , sources of water include the River Benue . The State Government uptakes the water for treatment tagged greater Makurdi Water Works(working at half its capacity for now) as well as two other water works in Gboko and Otukpo still not sufficient to the end users . Beetseh, C.I., Adulugba, M. (2013) . Bore holes , hand dug wells and water hawkers seen all over the metropolis carrying water in 20 litre containers packed in hand driven trucks for sale, others fetch direct from the river.

This work looks at waste water obtained from simple restaurant activities considered in good quantity and explores possibilities of obtaining potable water by treating it to fill the gaps of needs like reuse in restaurant washings , laundry, agricultural production and recreational projects .Conventional treatment materials are quite expensive and not easily attainable and so the experience from past traditional ways of treating and preserving water comes to focus . Water pollution is the degradation of water quality by human activities. Causes of this pollution have been dumping of industrial wastes and discharge of untreated sewage into water courses.

Wastewater is water that has been used for washing, flushing, or in manufacturing processes also is generated by residential, institutional, commercial and industrial establishments. It includes household waste liquid from toilets, baths, showers, kitchens, sinks and so forth that is disposed of via sewers. Water quality is influenced by natural factors and by human activities, both of which are the subject of much hydrologic study. The natural quality of water varies from place to place with climate and geology, with stream discharge, and with the season of the year. After precipitation reaches the ground, water percolates through organic material such as roots and leaf litter, dissolves minerals from soil and rock through which it flows, and reacts with living things from microscopic organisms to humans. Water quality also is modified by temperature, soil bacteria, evaporation, and other environmental factors.

Figure 1. Home made Water Filter Courtesy Alibaba.com products/water treatment bricks

The composition of wastewater varies widely as rainfall travels over roofs and the ground, it picks up various contaminants including soil particles , heavy metals, organic compounds, animal waste, oil and grease. Waste water may contain any of the following. Water (> 95%) which is often added during flushing to carry waste down a drain, organic particles such as, food, , paper fibers, plant material, humus, soluble organic material such as urea, fruit sugars, soluble proteins, drugs, pharmaceuticals, inorganic particles such as sand, grit, metal particles, ceramics, soluble inorganic material such as ammonia and road-salt (Byrd and Whitfield. (1984)

2.0 Materials and Methods

2.1 Reagents

The following reagents used were of Analar Grade - Perchloric acid 60% v/v, Nitric acid (conc.) (8M), Phosphoric acid – 85% w/v, Potassium permanganate 0.1M reagent solution , Sodium azide solution , Ammonium hydroxide (9M) , Sulphuric acid (18M) , Calcium chloride solution (27.5g of calcium chloride was dissolved in one litre of water to give 0.25M solution . Iron iii chloride solution (0.125g of the salt ($FeCl_3.6H_2O$) was dissolved in 1 litre of water. Molecular wt of $FeCl_3.6H_2O$ = 162.2 A buffer solution of pH = 10.1 for calibrating pH meters. 230 ml. bottle ManVer 2 Hardness Indicator Powder, 113g (contains hydroxylamine hydrochloride isopropanol propylene glycol.) **Hach 23499 EDTA Titrant, 0.035M** Magnesium sulphate

solution (25g of Magnesium sulphate heptahydrate $MgSO47H_2O$ was dissolved in 1 litre of water.) Phosphate buffer stock solution 42.5g of potassium bi-hydrogen phosphate KH_2PO_4 was dissolved in 700ml of water and then 8.8g of Sodium hydroxide. The pH was reading 7.2 then 2g of ammonium sulphate was added and diluted to 1 liter.

2.2 Instruments

Hach Company DR3900 Spectrophotometer with Radio Identification [RF I D] and a work book of testing procedures , TDS meter (model 50150 from Hach Company) , Spectrophotometer DR/2000 from Hach company was used. The program number (120) for colour ,The hardness test kit model Ha-4p-mg-l was used , pH meter from Hanna company , Dissolve oxygen meter (model 9071 made by the Hach Company) , Waste water in 20 L , 100 L and 500L containers Activated charcoal obtained from a burnt bricks kiln , Burnt bricks , Aluminium sulphate and Sodium hypochlorite HTH^{TM}

3.0 Analysis

All water treatment and measurements were carried out in the Central laboratories of the Benue State Water Board Treatment Plant and Benue State Environmental Sanitation Agency Laboratories.

3.1 Water Treatment

The percentage value of the treatment chemicals below were arrived at by trying each reagent on a 100ml waste water sample at various percentages to ascertain the best water clarity observable. Total quantity of waste water used in one treatment was 500L with 5% Aluminum sulphate solution was added as coagulant, agitated for 20 minutes and allowed to stand for an hour . Suspended particles denser than water gradually settled to the bottom of the plastic container, large heavy particles settled out readily, but smaller and lighter particles settled very slowly and in some cases did not settle at all and 5% Soda ash [Na_2CO_3 sodium trioxocarbonate (iv)] was added which is the process of removing the dissolved calcium and magnesium salts that cause hardness in water . Fine shaft sand 1mm particle size was compacted after gravel was loaded for filtration of the waste water. The next stage involved disinfection liquid Sodium hypochlorite 5g in 500L water (1g for 100ml) were added for disinfection .Total recovery time was one hour thirty minutes.

3.2 Turbidity

The program number 750 for turbidity was entered and the wavelength was adjusted to 450nm and the FTU units [Formazin turbidity unit] was displayed . A blank of deonized water was measured into sample cell and placed into cell holder and the light shield closed. Zero key was pressed, and the reading displayed 0.00 FTU units. The blank was then removed, 25ml of water sample was measured using the sample cell bottle and placed into light shield then closed.and read/enter key was pressed , The reading displaced FTU units and was recorded. This procedure was repeated for all samples.

3.3 Colour

Direct reading on the spectrophotometer DR/2000 from Hach Company was used. The program number (120) for colour was entered and wavelength was adjusted to 455nm and the unit of colour was displayed. A blank of 25ml of deionized water was measured into sample cell and placed into the cell holder,then light shield was closed. When zero key was pressed, the reading displayed, and the blank was then removed. 25ml of water sample was measured using the sample cell bottle and placed into the light shield and closed. The read/enter key was pressed and the reading was displayed and recorded. This procedure was repeated for all water samples.

3.4 Suspended Solids (SS)

Suspended solids are made up of non filterable matter emanating from different sources depending on the processes involved. Suspended solids of industrial nature consist mainly of solid particles which do not only cause turbidity but decreases the amount of dissolved oxygen in water and light penetration. A well-mixed sample was filtered through a weighed standard glass-fiber filter and residue retained on the filter was dried to a constant weight at 103 to 105°C. Increase in weight of the filter represented the total suspended solids.

Calculation

Calculate the concentration of total suspended solids in the sample using the following formula:

$$Total\ suspended\ solids,\ mg/L = \frac{A-B}{Sample\ volume,\ mL} \times 1000$$

Where:

A = Sample and filter weight, mg

B = Filter weight, mg

3.5 Determination of Total Dissolved Solids (TDS)

Total Dissolved Solids is a measure of the combined content of all inorganic and organic substances contained in a liquid in: molecular, ionized or micro-granular suspended form. The TDS meter (model 50150 from Hach Company) was switched on and the probe immerged into distilled water and agitated. The reading displayed 0.00mg/l . The probe was removed and then immersed into the water sample, the result displayed was recorded. This procedure was repeated for all the water samples.

3.6 Determination Total Solids

Total Solids was calculated from the addition of suspended solids (SS) and Total Dissolved Solids (TDS)

3.7 Determination of Oil in Water

The amount of oil in water was determined by extracting a measured sample with 1,1,2trichloroethane and directly measuring the color in the extract . A separating funnel was filled with 350ml of sample and 35ml of 1, 1, 2 trichloroethane was added. This was stoppered and vigorously shaken for one minute and kept on a stand where separation began and ended after 10 minutes . The lower layer – the 1,1,2 trichloroethane- was set aside for testing. A blank made of 25 ml of 1,1,2 trichloroethane was inserted in the spectrophotometer and the reading zeroed. The sample was finally measured.

3.8 Conductivity (µMHOS)

Conductivity meter (model 50150 from Hach Company) was switched on and the probe immersed into distilled water and agitated. The probe was removed and then immersed into water sample and result displayed was recorded. This procedure was repeated for all water samples.

3.9 Determination of pH

A pH meter was used here, both indicator and references electrodes are fused into one and the process involves dipping electrode into the sample. A pH meter from Hanna company was switched on and the probe immersed into a buffer 7 solution and cleaned before dipping in the water samples. The reading displayed was recorded on stabilization.

3.10 Determination of Total Hardness

Hardness test kit model HA-4P-MG-L was used, water sample 5 ml was measured using a plastic tube and poured into the mixing bottle. Three drops of buffer hardness solution was added and swirled to mix followed by a drop of manver hardness indicator solution EDTA titrant was added drop by drop into a mixing bottle and mixture swirled to allow for uniform mixing as each drop of EDTA solution was added until the mixture colour changed from pink to blue. The hardness in mgl^- as calcium carbonate ($CaCO_3$) was calculated by multiplying the number of drops added by a factor of 20.

Total Hardness = Volume of EDTA * N * 50 * 1000 / Volume of sample taken

Volume of EDTA = 29.8mL Normality of EDTA = 0.02 N Volume of Sample = 20.0 mL Equivalent weight of $CaCO_3$ = 50

The plastic tube was level filled again with water to be tested and content poured into the mixing bottle. Two drops of potassium hydroxide solution was added. One calcium indicator powder pillow was added and titrated with EDTA by adding drop-wise until the pink colour of mixture was changed to blue. The calcium hardness in mgl^- was calculated to be equal to number of EDTA added multiply by a factor of 20. Magnesium hardness was calculated by subtracting the calcium hardness value from total hardness value.

4.0 Discussion

In both samples results show the values of the parameters (Conductivity Turbidity Odour Temperature ^oC Colour Suspended Solids mg/L Oil in Water mg/L Total Dissolved Solids mg/L and Total Solids mg/L) reduced almost to zero levels and close to WHO/NIGERIA Allowable Standards 2005 Education on the benefits of disinfected water is essential, but is currently lacking in many parts of the world. Here in Makurdi we are dealing with restaurant operators busy with their activities and so may have to be persuaded to receive the correct orientation and the need for test kits to measure level of waste so they know what they are being exposed to . For the benefit of all, research needs

5 0 Conclusion

The study and research into waste water generated has brought knowledge closer to the promoters of restaurants and various water activities, making it easier to implement policies that may arise if they are well informed about consequences of especially waste water splashing on the streets .The treated water can be reused inside

the restaurant for washing and outside activities as gardening , car washing and watering of lawns . The government should launch a National Campaign for household water treatment to prevent future preventable deaths through water borne diseases such as guinea worm, cholera . As a people also we owe ourselves a duty, while the government is doing all it can to address the shortfall in water supply we must do our best to be prudent in the use of water. Adam Hadhazy (2008).

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Conventional Water Treatment Results

Table 1

Parameters	Units	Waste water	Treated Waste water	WHO//NIGERIA Guidelines for Drinking Water Standards 2005.
Conductivity	mhos	355	61	1.4
Odour	unobj	Ectionable		
Temperature	Oc	28	27	28-29
Color	Pt.co	530	0	50
Turbidity	FTU	450	0	25
Suspended Solids	mg/L	465	0	0
Oil in water	mg/L	51	0	0.3
Total Dissolved Solids	mg/L	250	18	150
Total Solids	mg/L	690	21	

Results of Treated Wastewater with local materials and WHO /Nigeria Guidelines for Drinking Water standards 2005 side by side for easy comparison.

Table 2

Parameters	Units	waste water	Treated water	WHO/NIGERIA GDW Standards 2005.
Conductivity	Mhos	360	62	1.4
Odour			Unobjectionable	
Temperature	^{O}c	29	28	28-29
Color	Pt.co	524	0	50
Turbidity	FTU	500	0	25
Suspended Solids	mg/L	460	0	0
Oil in water	mg/L	49	0	0.3
Total Dissolved Solids	mg/L	251	18	150
Total Solids	mg/L	690	19	
pH		6.9	6.6	6.5-8.5
Total Hardness	mg/L	270	16	14

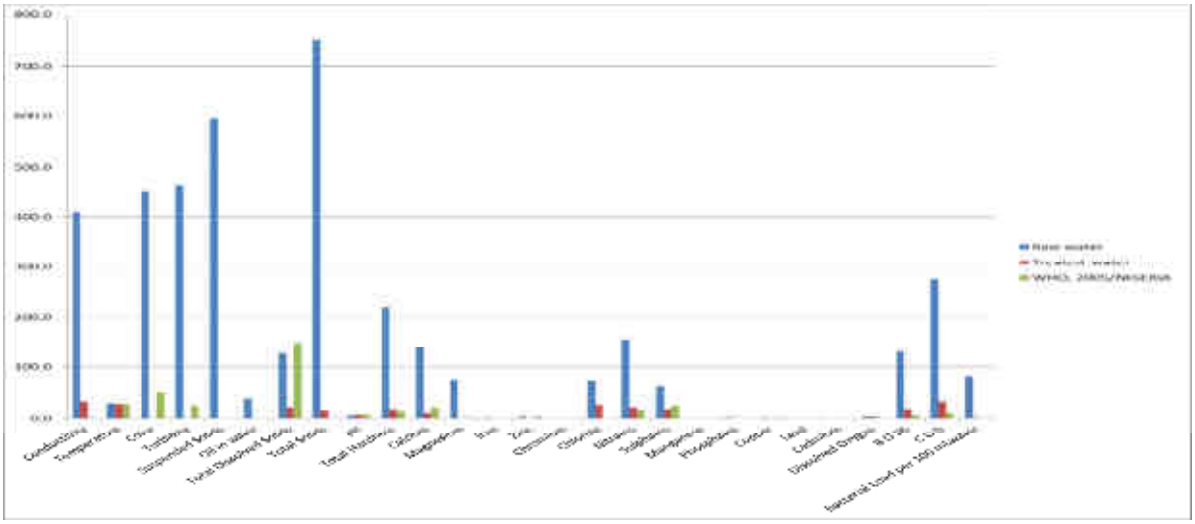

Figure 2 Graph of Wastewater and Treated water