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Decolorising, Deodourising and Detasting of Delta State School of Marine Technology Coloured and Odorous Borehole Water

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Abstract: ***Burutu is a coastal town in Delta State, south-south region, an island that is surrounded by swampy and mangrove forest. Due to its swampy nature, both its surface and ground/borehole water are highly coloured. The colour is due to decayed organic matters over the centuries. The water has objectionable appearance, colour, odour and tastes, and as a result the water is unfit for drinking and other domestic uses. But when sodium hypochcorite, NaOCl, was added to the borehole water and made to pass through organic resins and activated carbon, these disagreeable qualities were effectively and efficiently taken care of. The NaOCl acted as a bleaching agent and as disinfectant, the organic resins trap the organic constituents, while the activated carbon also doubled as decolorizing and deodorizing agent. These three materials teamed up to produce water of agreeable quality.***

Keywords: Coastal town, mangrove forest, surface water, borehole water, colour, odour, taste, sodium hypochlorite, organic resins, and activated carbon.

1. Introduction

Delta state school of marine technology is located in Burutu town in Delta state south-south geopolitical region. It is an island that is surrounded by swampy and mangrove forest. One of its neighboring towns is Forcadoes; it is a coastal town with many creeks that empty their contents into the Atlantic Ocean. The rivers surrounding it are highly silted and colored throughout the year. Waters from the borehole and surface water channels are highly colored, odorous and tasteful. As a result of these objectionable parameters this water is, thus, unsuitable for drinking and other domestic purposes. Burutu and its neighboring towns have to rely heavily on sachet and bottle waters that are brought from Warri and other upland towns and cities that packaged portable water from boreholes. During the rainy season the town, Burutu, dwellers store rain water in surface tanks.

Water

Water is a very simple molecule that is made up of two hydrogen atoms covalently bonded to an oxygen atom, and it is extremely vital and important in our world (Joes ten et al, 2004). Water is one of the most important abundant commodities in nature, but is also the most misused one. Our earth is a blue planet and $4^{th}/5^{th}$ of its surface is covered by water, but the hard fact is that 97% of it is locked in oceans, that is too salty/saline to drink and for direct use for agricultural or industrial purposes. 80% of the remaining 3% is trapped in polar ice caps and giant glaciers out of which ice Berg break off and slowly melt at sea. Another 10% of the 3% is locked in rock crevices and minerals lying as deep as 500 meters below the earth crust which is very expensive to pump out. This, therefore, leaves only 0.3% of the world's water resources that man can access for his use: domestic, agriculture and industrial uses, before economically viable technologies are developed for utilizing water from oceans, iceberg, and water trapped in rock crevices, etc. (Dare, 2007).

Why is Water Coloured?

Surface water is mostly coloured, but shallow well waters, springs and deep wells may also be occasionally coloured. The colours of natural water ranges from pale straw through yellowish brown to dark brown. The colours and minerals that cause it are often objectionable in which the water comes into contact with. The colour of natural waters is often as a result of the presence of dissolved or colloidally dispersed organic matters (Dara, 2007). Many coloured organic materials (also coloured water) are made up of large molecules that contain alternate double and single carbon to carbon bonds. An example is lycopere, the compound that give tomatoes their bright red colour.

The bracket and the subscript 2 mean that the formula within the brackets is doubled. Think of the structure shown here as the complete formula folded over from right to left, the right hand bracket is like a hinge. When you open the hinge, you get the complete formula. Chemist often uses space saving devices like this to represent complex formula. The interesting feature of the lycopere molecule is the series of alternating double and single bonds that are shown in colour. This feature is called a conjugated system and such system often confers the property of colour to organic compound and, thus, in water (hill et al, 2005).

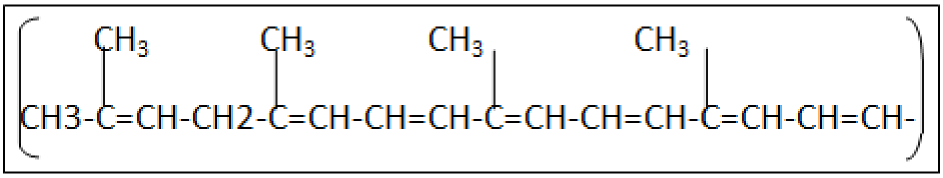
The measurement of colour is usually done using a tintometer and the result is expressed in "hazen units" or "standard units of colour". In determining the colour of water, it is the true colour as expressed in the standard units that is of interest and not the apparent colour (Dara, 2007). When solution of potassium chloroplatinate tinted with small amount of cobalt chloride give colours similar to the colour of natural waters. The standard unit of colour is taken to mean the colour produced by 1mg/litre (1ppm) of platinum (used as K_2PtCl_6). To determine the colour we first remove suspended matter by centrifugation. The standards are usually made by dissolving 1.2545g of K_2PtCl_6 (containing 0.5g of Pt) and 1g of crystallized cobaltious chloride ($CoCl_2.6H_2O$) containing about 0.248g of cobalt in water with 100ml of concentrated HCl and diluting to 1 litre with distilled water. This solution is taken to have 500units of colour, as per the American Public Health Association's books of standard methods of water analysis (Dara, 2007). Colour can be taken care of by the use of organic resins and activated carbon. The use of sodium hypochlorite, NaOCl, also destroys colour in water.

Tastes and odours

With the exception of H_2S, most of the odours in natural water are as a result of organic matter. When water is chlorinated, the observed odours and tastes are due to compounds that are formed by the reaction of chlorine with traces of organic matter present in the water. These organic matters are confined to surface waters and as well to shallow well water, but very low or totally absent in deep well waters. Some deep well waters contain H_2S, which has a very repulsive odour of rotten eggs, while others have taste described as inky, astringent, or metallic that is occasioned by the presence of ions of iron in them. Disagreeable odours and tastes are objectionable for various industrial purposes such as beverages, food products, paper and textiles, and laundry processes. These odours and tastes can be removed using activated carbon, aeration followed by activated carbon treatment. Removal of inorganic odours and tastes caused by H_2S or iron is accomplished by oxidation, chlorination or chlorine compounds or precipitation (Dara, 2007).

Oxidation – Reduction in bleaching and in colour/stain removal

Many coloured organic material (also coloured water) are made up of large molecules that contain alternate double and single carbon-to-carbon bonds. an example is lycopene, the compound that gives tomatoes their bright colour.



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Bleaching agents oxidize coloured molecules such as lycopene by destroying the conjugated system. Nearly any oxidizing agent can be used as a bleach to remove unwanted colour from fabrics, hair, water and other materials. However, some are two explosive. Some harm fabrics, some produce undesirable products and some are simply unsafe. Thus lycopene is oxidized by aqueous hypochlorite ions to colorless organic compounds, and also destroying the colour in coloured water by oxidizing the organic molecules that impact colours in water to colorless compounds. The hypochlorite ion is reduced to chloride ion:

$$C_{40}H_{56}|_{\text{coloured water}} + OCl^-(aq) \longrightarrow Cl^-(aq) + \text{colorless organic products}|_{\text{colorless water}}$$

The OCl^- ions decompose to release oxygen which is the actual oxidizing agent. A redox reaction in which the same substance is both an oxidizing and a reducing agent is called a disproportionation reaction. Thus, when H_2O_2 disproportionate, half the H_2O_2 is oxidized to O_2 (g) and half is reduced to H_2O (l) (Melvin et al, 2004).

In coloured water the organic compound in it are in most cases responsible for the colour. The molecular structure of the organic substance absorbs portions of the visible spectrum of light. The colour is created by the absorption of the light by electron in these bonds. Bleach disrupts the alternating pattern by breaking or converting double bonds to single bonds. The result is loss of the ability to absorb visible light. Hypochlorite bleaches are safe and effective. Hypochlorite bleaches also react with molecules on the surface of micro organisms like bacteria and viruses, thus causing their death (adisinfectant is able to disrupt the structure of the cells and kill them) (Melvin et al, 2004). The chlorite ions in the solution of bleach are responsible for its bleaching action. For example, colour organic materials, like grass or some clothing dyes are decolorised if they are put into chlorine water. The chlorate (I) ion is able to lose it oxygen fairly readily, which is used in the oxidation process. Chlorine water and bleach will give off bubbles of oxygen if they are left in sunlight, owing to the decomposition of the chlorate (I) ions.

$$2ClO^- (aq.) \longrightarrow 2Cl^- + O_2 (g)$$

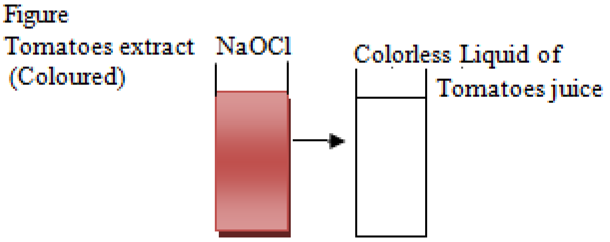
The most familiar uses of chlorine and its compound e.g. NaOCl, is in disinfecting water. Treatment of water supplies with chlorine/Naocl eliminates water borne diseases such as typhoid fever. However, this application of chlorine and

Naocl has a disadvantage in that it converts some dissolves substance into tiny quantity of chlorinated compounds that are suspected of causing cancer (Matt, 2011). These trace quantities can be detected only by highly sophisticated methods of analysis, and potential problems with the use of chlorine/Naocl have become apparent only in recent decades.

Demonstrating the bleaching action of Naocl/Ca $(ocl)_2$

The red colour of tomatoes is extracted into water at room temperature, then a few drops of Naocl were added to the extract, and then shaken. After a few second the red colour of tomatoes extract was discharged. The molecule that causes the red colour contains alternating double single bonds. When the Naocl is added to this colour the conjugates system is destroyed. This conjugated double single bonds system is also known as chromophoric group, and is responsible for the colour of the lycopene in the tomatoes berry. It absorbs a portion of the visible region of the electromagnetic radiation.

Figure



Action of NaOCl on tomatoes juice (extract)
The NaOCl bleaches the tomatoes juice and become colorless.

Activated carbon

Activated carbon is formed by heating carbon black to 800^0 to 1000^0c in the presence of steam to expel all volatile matters. This form of carbon is highly porous, like sponges or honey combs. Because of its high ratio of surface area to volume, activated carbon has great capacity to absorb substance from liquid and gases. Activated carbon is used in gas mask absorb poisonous gases, in water filters to remove organic contaminants, in sugar processing to remove coloured impurities, in air condition systems to control odours, and in industrial plants for the control and recovery of vapour (Matt, 2011)

Regeneration of spent activated carbon (thermal regeneration)

One of the benefit of activated carbon is that it is capable of being restored, meaning that spent carbon, or carbon saturated with the adsorbed components, can be desorbed of the components to yield an activated carbon that is ready for use. Powder activated carbon (PAC) is not regenerated, but granular activated carbon (GAC) is regenerated. Regeneration of activated carbon is often referred to as reactivation. In this process, the adsorbed components contained on its surface is destroyed thermally (Carrie et al, retrieved 2020).

Alternatively, the spent carbon can be regenerated chemically. This process could be (i) batch desorption test and (ii) column test (Gupta et al, 2009). The regeneration chemicals could be ketone - type solvents as acetone and hydroxyl - type solvents such as methanol, ethanol etc. (Chern and Wu, 2001)

Organic Traps Resin

Organic traps are used primarily in two applications, one as colour removal from drinking water and, two as protection for demineralizers to reduce fouling. Resins used in organic traps are strongly basic anion resins operated in the chloride cycle andto reduce colour in water. The colour causing substances are naturally occurring organic matters, primarily tannic and humic acids. For this resin, the terms tannin removal, colour removal and organic removal are used interchangeably (Michael, 1999).

Regeneration of anionic resins

Regeneration is the process whereby anionic or cationic resins functional groups are restored to the spent resin matrix. This is done through the application of chemical regenerant solution. There are two types of regeneration, the co-flow and the reverse flow regeneration process. In the co-flow process the regenerant solution follows the path as the solution/water to be treated, which is usually top to bottom of the resins column.CFR is used when large flows is required for the treatment or high quality is needed, for strong acid cation and strong base anion resin beds as excessive quantities of regenerant solution would be required to uniformly regenerate the resin. If the is not fully regenerated, it may leak contaminants ions into the treated stream on the next service run. In the reverse flow or counter-flow regeneration, the regenerant is introduced counter to the service flow. This can be up flow loading/down flow regeneration or down-flow loading/up-flow regeneration cycle. In either way, the regenerant solution contacts the less exhausted resin layers first, thus making the regeneration process more efficient. Less regenerant solution is required in this case, leading to less contaminant leakage. The RFR is only effective if the resin layers stay in place throughout the regeneration. RFR is only employed with packed bed columns, or if some kind of retention device is deployed to prevent the resin from moving within the column.

Regeneration involves three steps viz backwash, regenerant injection, regenerant displacement, and rinse.

The following chemicals are used in regeneration.
(I) strong acid cation regenerants. Example is sodium chloride, NaCl, or alternatively, potassium chloride, KCl when NaCl is undesirable in treated solution. Ammonium chloride is used for hot condensate softening applications. HCl is the most efficient and widely used regenerant for decationization. Sulpuric acid is a substitute to HCl, is more affordable, less hazardous, and has a lower operating capacity. It can lead to calcium phosphate precipitation if if applied in too high a concentration (www.Samco.com. Retrieved 21/10/20)

Process materials | chemical and equipment
1) Sodium hypochlorite (Naocl)
2) Organic trap resin (polymeric material)
3) Activated carbon | charcoal
4) 5 plastic 50cl bottles.

Process Flow Chart

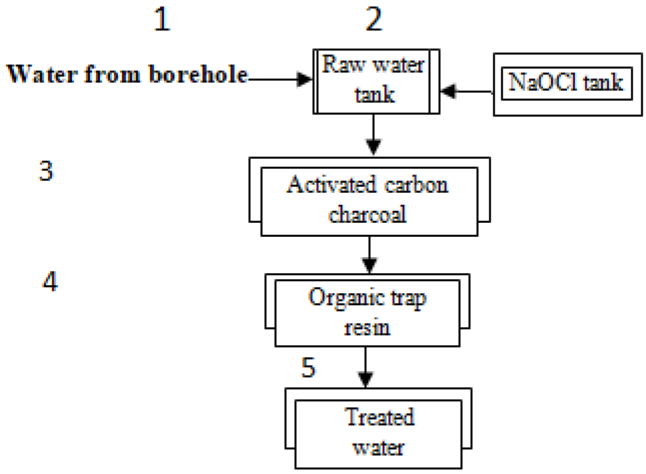


Figure 2: Flow chart

Process Diagram and Description

Process Diagram

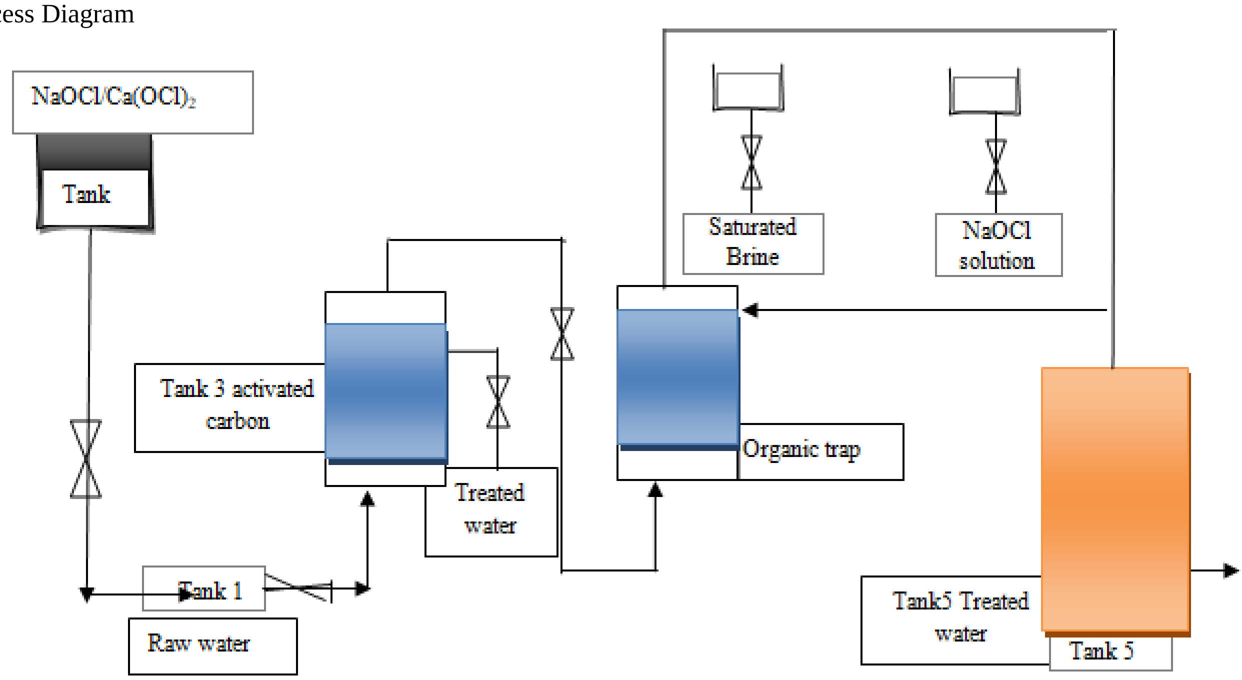


Figure 3: Water treatment Units
Adapted from Engineering Chemistry by B. K. Sharma

Process description

The raw water enters into the first tank where the NaoCl is added from the 2nd tank. The water then move into tank 3, activated carbon/charcoal bed; then into tank 4 containing the organic trap. Finally, the colorless, odorless, and tasteless water flows into tank 5, treated water tank. The water in tank 5, when allowed to stand for four days is observed to have no biofilm on the side of the container, indicating the absence of microorganisms (the NaoCl also plays the role of biocide, as a disinfectant). There was no shiny film on the surface of the water (the absence or near absence of hydrated iron (iii) oxide).

2. Result

Physical observation indicates that the water in tank 5 is colorless, odorless, and tasteless.

The absence of microorganisms in the water in tank 5 was confirmed by sampling the water into another plastic bottle and left to stand for about three days. Another plastic bottle containing raw water was also left to stand for three days. At the end of the third day when the sides of these containers were felt by the finger it was observed that there was no biofilm on the side of the containers with treated water, but there was biofilm on the side of the container containing raw water. The absence of the biofilm/slime on the treated water bottle indicates the absence of organic matters and microorganisms in the water. The biofilm in the raw water container shows the presence of organic matters and microorganisms in the raw water (the microorganisms in the raw water make use of the organic matters as substrate for metabolism and for growth and multiplication/ increase in population, hence the biofilm on the side of the bottle).

The activated carbon/charcoal remove the colour and odour in the water, it also remove the taste. The organic trap resins remove any traces of colour left in the water. While the sodium hypochlorite, NaOCl, destroys the colour and any pathogens before the raw water enters tanks I and 3 respectively.

3. Conclusion

The coloured water contains organic molecules with conjugated systems/ chromophoric groups that confer the property of colour to organic compounds and, thus, in coloured water. The water also contains microorganisms. The NaOCl, activated carbon/ charcoal, and organic resins team up to remove the colour, odour and taste. The NaOCl acts as a disinfectant/biocide.

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