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The Quality and Disposition of Treated Wastewater at Alcorn State University, the Use of Wastewater for Energy Production and other Benefits

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Abstract

Considering the small amount of freshwater we have on earth, only a small portion is potable. In some areas or places, water is scarce and treated wastewater is being reused. The objectives of this study were to determine the quality of wastewater being released into the environment after it has been treated at the Alcorn State University (ASU) Wastewater Treatment Facility (WWTF); to compare it with the Mississippi Water Quality Criteria (MSWQC); to find out the fate of the treated wastewater; and to discuss how wastewater is used as a renewable energy and other benefits and to discuss wastewater situation in Nigeria. Between October and November of 2015, water samples were obtained at 3 different times from ASU WWTF. The samples were tested according to the methods indicated in the LaMotte water pollution detection kits. Biological tests were also conducted. The treated wastewater met the MSWQC with the exception of hardness and phosphate. There were no coliform bacteria showing that the treated wastewater was pollution free. ASU is encouraged to reuse the treated wastewater if occasion requires it. The treated wastewater was channeled to the Mississippi River via Mammy Judy Bayou. Wastewater as a source of energy (electricity) was discussed as well as other uses. It is recommended that wastewater treatment/ management in Nigeria which is presently minimal be augmented.

Keywords: ASU wastewater, quality, disposition, energy, benefits, Nigeria.

1.0 Introduction

Water is one of the most essential factors for sustaining life. It is the material that makes life possible on earth. Of less than 3% that is freshwater, only a tiny fraction is available for human use (Enger and Smith 2016). Shier *et al.* (2016) observed that an average adult living in a moderate environment takes in about 2,500 milliliters of water daily. Obanude (2015) added that it is generally accepted that 100 liters of water per day is the average requirement by a human being to live healthily. These statements vividly bring out the importance of water for the sustenance of life and the fact that water could be said to be *pari passu* with life. With the relatively small amount of freshwater bodies we have on earth, only a small portion of it is **potable**. In addition, water is needed for domestic, agricultural, industrial, in-stream and aesthetic uses. In some parts of the world, water is so scarce that treated wastewater is now being reused. The drought and growing public acceptance have turned a process once derided as toilet-to-tap into something politically palatable, and water officials across San Diego County are planning to make reused wastewater **drinkable** and widespread within a matter of years (Rivard, 2015). **Wastewater** is used water that may include substances such as human waste, food scraps, oil, industrial wastes, chemical wastes etc. Domestically, this includes water from sinks, showers, bathtubs, toilets, washing machines, and dishwashers.

Burton and Stensel (2003) said that, any water that has been adversely affected in quality due to human activities can be regarded as wastewater. It includes domestic liquid waste from residences, industries or agriculture. It encompasses a wide range of contaminants which include soaps and detergents from bathrooms, food scraps, and oil from kitchens and other human activities that involve the use of water.

Potable water becomes wastewater after getting contaminated. (Idris- Nda et al., 2013). Wastewater that comes from human waste (feces, urine or other body fluids), is known as **black water**. It includes

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water from lavatories, septic tanks, or soak away, and washing water. While wastewater that comes from urban rainfall runoff from roads, roofs, and sidewalks is known as **grey water**. Wastewater can be contaminated with different components which mostly include pathogens, synthetic chemicals, organic matter, nutrients, organic compounds, and heavy metals. These occur in solutions or as particulate matter (*loc. cit).*

But "wastewater is a complex resource that is both advantageous and inconveniencing in its use. It is a renewable resource that once used can be reclaimed and used again for different beneficial purposes. (*loc. cit*). The reclaimed wastewater can be used for purposes other than drinking, such as irrigation for public parks, athletic fields, recreation centers, school yards and playing fields, reservations of highways, irrigation of landscaped area surrounding buildings (Hespanbol, 1992). This will greatly reduce the overstretching of potable water. The lack of freshwater resources large enough to meet the demand of a burgeoning population led to the emergence of wastewater reclamation and reuse as components of wastewater management (Asano *et al.* 1998).

2.0 Objectives

One of the objectives of this study is to determine or assess the quality of the wastewater being released back into the environment after it has been treated at Alcorn State University (ASU) Wastewater Treatment Facility (WWTF). The others are to compare the treated wastewater with the Mississippi Water Quality Criteria (MSWQC)/Environmental Protection Agency (EPA) Standards, to know the fate of the treated wastewater, to discuss how wastewater is used as a renewable energy or to produce electricity and to discuss other benefits of treated wastewater, and to discuss wastewater situation in Nigeria.

3.0 Materials and Methods

3.1 Wastewater Treatment at ASU

Wastewater treatment is a process used to remove as much of the suspended solids and impurities as possible before the remaining wastewater called effluent is discharged back into a water body like river or channel to be used again by a city or county. A wastewater treatment facility or plant, also called sewage treatment plant or water pollution control plant is where this water is purified. It is where most pollutants from wastewater is removed before it is released to local water ways (The city of New York, 2016). Alcorn State University has a wastewater treatment facility that is located on the Lorman campus.

Wastewater from all over the ASU campus (Figures 1 and 2) (from sinks, health- care facility or infirmary, laboratory sinks, commodes, dormitories, cafeteria, etc.) are channeled to the wastewater treatment facility. From there the first port of call is the **bar screen** (Figure 6b) where a sorting occurs. That is, all solid materials that cannot decompose easily are strained and removed. They are eventually disposed of through the use of garbage trucks and taken to landfills. The wastewater now containing organic digestible matter goes to the **aeration basin or oxidation pond** (Figures 7a and b) (not the former lagoon (Figure 5) which was controlled naturally or aerobically by microorganisms). So, this is like using machine to duplicate nature's process for decaying organic matter under controlled conduction. This means that the process is quickened or is facilitated mechanically. Here, it is mixed with oxygen by the aerator for 30 to 35 minutes. It next goes into a **clarifier** (Figures 8a and b) where solid particles settle at the bottom as sludge, with the wastewater on top. Next, it goes to the **detention chamber** (Figure 9) where it is disinfected with chlorine for another 30 minutes and then, sulfur dioxide is put in to remove the chlorine before going to the **effluent stage** (Figures 10a, b and c). At the effluent stage the chlorine reading has to be 0.0 ppm before leaving the treatment plant. It is at this stage that we collected our water samples for this study for testing (Figures 10 a, b and c).

3.2 Experimental Procedure

During the months of October and November, 2015, treated wastewater samples were obtained for 3 consecutive times at intervals of one week from the Alcorn State University wastewater treatment facility (WWTF) (Figure 3). The samples were then taken

Figure 1: Map of Mississippi. Mark shows location of ASU (✦).

Figure 2: Front gate wall showing ASU inscription.

Figure 3: Alcorn State University waste water treatment faculty.

Figure 4: Prof. Acholonu (middle), Mr. Jack Williams, Director of WWTF (left), and some Field Biology Students involved in the Wastewater.

Fgure 5: ASU Lagoon.

Figure 6a: Inlet pipe to Wastewater treatment plant.

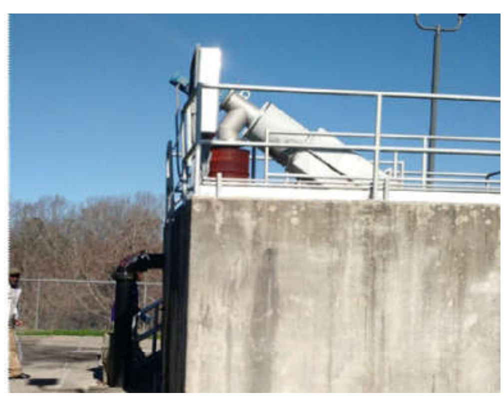

Figure 6b: Bar Screen

Figure 6c.

Figure 7a: Aerator

Figure 7b: Part of Aerator (Aeration Basin).

Figure 8a: Clarifier (top and bottom empty).

to the laboratory and tested as was done by Acholonu and Harris (2011) and according to the methods indicated in the various LaMotte Water pollution detection kits supplied by Carolina Biological Supply Co. (Figures 11,12,14,16) These chemical tests included alkalinity, ammonia-nitrogen, carbon dioxide, copper, dissolved oxygen, hardness,

Figure 8b: Shows Clarifier in operation.

Figure 9: Detention Basin in which chlorine is.

Figure 10a: Collection of treated wastewater (effluent) for testing.

Figure 10b: Director of ASU Wastewater Treatment facility (WWTF) collecting effluent

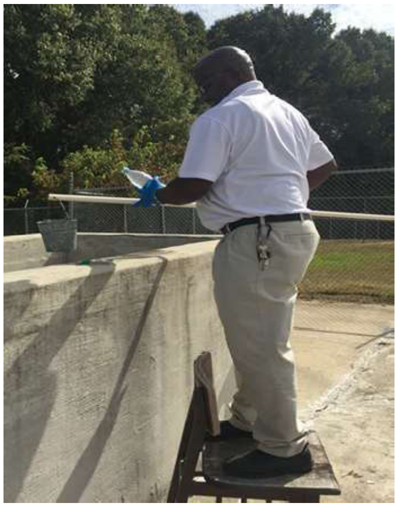

Figure 10c.

iron, nitrate, pH, phosphate, and salinity. The test results were recorded and analyzed (see Table 1, Figure 18). Next, the biological tests for coliform bacterial presence were conducted and the results recorded (Figures 13, 15, 17, 19).

Figure 11: Prof. Acholonu and some students involved in the study.

Figure 12: Krystain Coleman testing collected effluent.

Figure 13: Jivarre Hunt doing bacterial colonies count after culture and incubation for 24 hours.

Figure 14: Student performing chemical tests on wastewater sample collected.

Figure 15: Student checking Incubator for coliform bacterial growth

Figure 16: Inuyat Ullah performing test on wastewater sample.

Figure 17: Prof. Acholonu confirming student's bacterial colony count.

4.0 Results

A comparison between the average readings of the test results and the MSWQC/EPA Standards showed that the ASU treated wastewater (effluent) met the MSWQC with the exception of hardness (300/ 50ppm) and phosphate (1.67/0.1ppm) (see Table 1 and Figure 18). The biological tests conducted showed no coliform bacterial growth in the MacConkey agar plate (see Figure 19) and confirms the fact that the treated wastewater is of good quality and free from pollution.

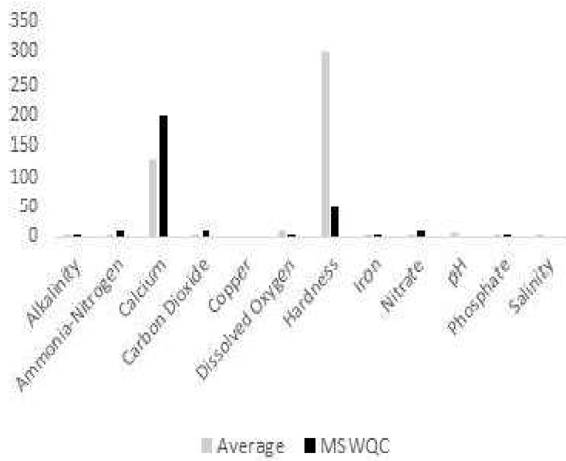

Figure 18: Comparison between ASU Effluent and MSWQC.

4.1 Biological Test Results

(Bacterial pollution of treated wastewater test results).

5.1 Fate of ASU Treated Wastewater

Once the treated wastewater (or effluent) leaves the treatment plant, it is discharged into the small Mammy Judy Bayou and from there to the big Mississippi River where it is once again safe for the environment (Personal comm., Jack Williams).

Table 1: Parameters Tested, Results and Comparison with MSWQC/ EPA Standards

Tests	Sample 1 10/22/15	Sample 2 11/3/15	Sample 3 11/5/15	Average	MSWQC
Alkalinity	0.276 ppm	0.260 ppm	0.244 ppm	0.260	3.08
Ammonia-Nitrogen	0.25	0.1	0.1	0.15	10
Calcium	148	120	123	130.3	200
Carbon Dioxide	5	4.5	3	4.17	10
Copper	0.0	0.0	0.0	0.0	8.85/6.25
Dissolved Oxygen	10	9	7	8.7	5
Hardness *	300	300	300	300	50
Iron	0.02	0.01	0.02	0.017	0.2
Nitrate	1.0	1.0	1.0	1.0	10.0
pH	7.0	8.5	8.0	7.83	6.0/9.0
Phosphate *	1.0	3.0	1.0	1.67	0.1
Salinity	0.6	0.3	0.4	0.43	N/A

Figure 19. Nutrient Agar and MacConkey Agar Plates.

5.2 Where the treated wastewater (effluent) goes in several other places or cities in the US

Treated wastewater is recycled or reused in various ways by several cities and/or states instead of directing it to a water source as it is done at ASU and many other cities and/or states. The following is a list of some cities, counties, or states that reuse treated wastewater in the U.S.

5.3 List of some Cities, Counties, States Using Treated Wastewater or Recycled Wastewater in the USA

1 Orange County, CA
2 Daly City, CA
3 New York City, NY
4 San Diego, CA
5 Austin, TX
6 Fort Worth, TX
7 Wichita Falls, TX
8 Tucson, AR
9 Los Angeles, CA
10 Ventura, CA
11 Portland, OR
12 Atlanta, GA
13 Santa Monica, CA
14 San Francisco, CA
15 Phoenix, AR
16 Santa Fe, New Mexico
17 Some Oklahoma cities
18 Dallas-Fort Worth, TX
19 Delaware-
20 Florida-
21 California-
22 San Diego County, CA
23 Minnesota reusing storm water

Government Accountability Office (GAO) reported that 36 states used reclaimed water in 2013, up from 23 states in 2003. (Moulden 2014) NASA has reduced the need for freshwater in space by turning astronauts urine and sweat into clean drinking water (loc lit)

6.0 Energy Production from wastewater

There is currently a great deal of interest in renewable forms of energy. Biomass and wastes (crop residues and animal wastes) are considered as renewable energy sources. "Renewable energy is provided by processes that replenish themselves or are continuously present as a feature of the solar system. So water in the form of hydroelectricity is a renewable energy source. It is plausible and logical to consider wastewater as a source of renewable energy. There is a possibility that in the future the wastewater from the sink, bathtub, and toilet may do more than just go down the drain. It may become a source of electricity Flowing water has energy that can be captured and turned into electricity. This is called hydroelectric power. As the world's population continues to grow, two big challenges are (1) generating enough electricity for everybody and (2) dealing with all the sewage we produce. Wastewater is a renewable resource that once used can be reclaimed and used again for different benefits (Logan, 2004).

Microbial fuel cells (MFC) can produce electricity directly from wastewater. It will produce significant amounts of electricity while effectively cleaning the wastewater. Bacteria utilizes the organic matter and in the process, produces electrons the anode sends to the cathode within the fuel cell, creating an electrical current. A MFC is a device that uses bacteria to oxidize organic matter and produce electricity. The bacteria (attached to the anode) produce electrons that travel to the cathode (as current). (Logan, 2004) Bacteria that can produce electricity in a MFC are abundant in wastewater.

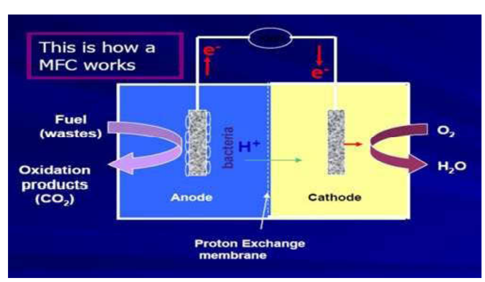

Figure 20: How MFC works

MFC Bacteria

The MFC (microbial fuel cell) is created with easily accessible and cheap materials. It consists of an anode and cathode chamber. The anode chamber is filled with wastewater and yogurt containing lactobacillus. This chamber is attached to the cathode chamber by using PVC pipe segments with proton exchange membrane in it. The cathode membrane is filled with tap water and a phosphate buffer to maintain pH levels. The MFC utilizes the wastewater and lactobacillus to create hydrogen peroxide. This hydrogen peroxide (H, O,) is forced through a proton exchange membrane. The proton exchange membrane separates from the hydrogen peroxide molecules and allows only hydrogen ions to pass. Free electrons go through a carbon rod anode and is utilized as electricity. This process creates electricity cleanly and cheaply (see Figure 20). A multimeter is attached to the anode and cathode in order to test and record electrical output.

7.0 Possible uses of wastewater or recycled water

Flowing through purple pipes so plumbers can distinguish it from other utility lines, recycled water is used in a variety of ways (Moulden 2014).

Municipalities use it in the following ways:

1. To water golf courses, Parks, School yards and Road Medians
2. To fill Lakes and to enhance natural wetlands
3. To Fight fires
4. To serve as irrigation for crops, commercial nurseries and grazing pastures.
5. Energy producers use it for freshwater cooling towers
6. Manufacturers can use recycled water throughout the production process
7. In the northeast, reclaimed water is sometimes used to make snow at ski resorts (Moulden 2014).

8.0 Benefits of using treated wastewater

1. Treated wastewater effluent (or reclaimed water) gives succor or solace to cities overwhelmed by drought or water shortage. It is drought proof.
2. It supplements drinking water supplies or increases it.
3. It can be used for flushing toilets in office buildings.
4. It reduces demands for potable water.
5. A major reuse benefit is its reduced cost when compared to treated drinking water"
6. It stops water conservation restrictions enforced during drought.
7. It has potential for delaying future water treatment plant expansions.
8. It provides for efficient use of a city's water resources
9. It preserves current water supplies
10. It postpones a need to develop additional supplies to meet the demands of a growing city. (Moulden, 2014; Carman, 2016).

9.0 Locations of Wastewater treatment facilities in Nigeria

A review of literature revealed the existence of a comparatively few wastewater treatment facilities in Nigeria. They are located in

1. Asaba, Delta State (Omenka, 2010).
2. Lagos, Lagos State (Crowther *et al.*, 2009)
3. Ota, Ogun State (Isiorho Oginni, 2008)
4. Abuja, FCT (Doughari et. al., 2007)
5. Minna, Niger State (Idris-Nda *et al.*, 2013)
6. Tinapa, Cross River (Adewale, 2014)

This list is not exhaustive. It is hoped that subsequent investigators will add those, if any, inadvertently omitted.

10.0 Discussion and Conclusion

The quality of water refers to its degree of worth, its grade of fineness and usability. Global freshwater resources are threatened by rising demands from many areas. Growing populations need more water for drinking, sanitation, food production, and industry. (Enger and Smith. 2016) the ways things are going and climate change occurring, it is becoming essential to source other way of getting usable fresh water or potable water. Wastewater treatment and reuse can serve as welcome company for water use and a disaster risk mitigation measure. Wastewater is a renewable source that can be treated and reused for various benefits. This includes prevention of pollution of surface and ground water.

The results of this study show that chemically the ASU treated wastewater met the Mississippi water quality criteria with the exception of hardness and phosphate.

The biological tests revealed that the treated ASU wastewater was of good quality. The MacConkey agar test did not show any coliform bacterial growth. So, their presence was ruled out. It was concluded that the treated wastewater was thus of good quality.

It was found through Mr. Jack Wilson, Director of the ASU wastewater treatment facility that eh treated wastewater (effluent) is channeled through mamma Judy River to the big Mississippi River.

The process for the production for electricity from wastewater is outlined. The benefits that accrue from it, tantamount to waste-to-wealth. The technology is highly encouraged. As observed by both Bob Hirshon, in the future the wastewater form the sink, bath tub and toilet, may do more than just go down the drain. The energy potential contained in wastewater and its bio solid/biogases exceeds by 10 times the energy used to treat it.

Nigeria with the population over 7 million people (the highest in Africa) has a wastewater management problem, Perhaps the worst is pollution of fresh water bodies (rivers, streams) by channeling untreated wastewater into them through the construction of gutter and possibly pipes, water runoffs, and sludge production. The water quality of the fresh water bodies is affected by untreated wastewater discharged into them. To remedy the situation more wastewater treatment facilities should be constructed and subsequently treated wastewater (effluent) channeled to rivers and streams. But more importantly, effort should be made to reuse the treated wastewater as it is been done in many cities in the United States. The few found and listed in this study need to, of necessity, be increased as quickly as possible.

Overall, the tests showed that the ASU wastewater (effluent) that made its way to the Mississippi River through Mama Judy Bayou is not unsanitary. This study gives encouragement for ASU to consider recycling or reusing the treated wastewater instead of channeling it to the Mississippi River if, in the future, it is found that the two wells that supply groundwater to the campus are not providing enough water for use at the campus.

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